frontiers | Frontiers in Sustainability

TYPE Original Research
PUBLISHED 30 July 2024
DOI 10.3389/frsus.2024.1366129

OPEN ACCESS

EDITED BY
Yanchao Feng,
Zhengzhou University, China

REVIEWED BY
Sorinel Capusneanu,
Titu Maiorescu University, Romania
Xiaoyu Qu,
Dalian Polytechnic University, China
Yue Gao,
Zhengzhou University, China

*CORRESPONDENCE
Lei Chen
sjmchenlei@163.com

RECEIVED 05 January 2024
ACCEPTED 03 July 2024
PUBLISHED 30 July 2024

CITATION
Zhou Y, Chen L, Zhou X and Hu S (2024) Key factors and path selection for enterprise digital transformation: configuration analysis based on fsQCA. *Front. Sustain.* 5:1366129. doi: 10.3389/frsus.2024.1366129

Key factors and path selection for enterprise digital transformation: configuration analysis based on fsQCA

Yanqiu Zhou[1,2], Lei Chen[3]*, Xu Zhou[4] and Shihua Hu[5]

[1]School of Economics and Management, Tsinghua University, Beijing, China, [2]Institute for State-Owned Enterprises, Tsinghua University, Beijing, China, [3]School of Finance and Taxation, Capital University of Economics and Business, Beijing, China, [4]School of Finance and Taxation, Inner Mongolia University of Finance and Economics, Hohhot, China, [5]Thinkingbiomed (Beijing) Co. Ltd, Beijing, China

The new digital technology revolution is spurring corporate digital transformation. Presently, the majority of enterprises are still in the digitalization stage. They have yet to pinpoint the key factors and suitable paths for their transformation. Therefore, this study aims to determine which and how factors affect this transformation to improve the current enterprise's digital transformation. We extract key elements affecting corporate digital transformation. Taking 98 representative businesses as examples, we utilize the fuzzy-set qualitative comparative analysis approach (fsQCA) to investigate how different factors combine to achieve digital transformation. The results show that: (1) No single factor can achieve digital transformation for enterprises, as it requires a combination of multiple factors. (2) Four configuration paths can lead to corporate digital transformation. (3) A business can equivalently substitute resource consolidation with strategic planning and human resources to drive digital transformation. This study offers multiple paths for achieving corporate digital transformation to guide businesses in their choice of digital transformation pathways.

KEYWORDS

digital transformation, digital economy, technological shock, organizational response, fsQCA

1 Introduction

The transition of human society from the industrial era to the digital era is driven by newly emerging digital technologies, such as artificial intelligence, blockchain, cloud computing, digital twins, big data, and 5G (Yoo et al., 2010). Digital transformation enhances enterprise intelligence, connectivity, and predictive analytics, which ultimately results in value creation (Lenka et al., 2016; Cheng et al., 2023). At the micro level, this alters the "R&D—production—exchange—distribution—consumption" links in the industrial economy, as well as its related production techniques and management models (Zhao et al., 2023). At the macro level, digital transformation alters the endogenous drivers of economic growth by leveraging new economic growth points and fostering a novel economic development process (Yadav and Pavlou, 2014; Ling et al., 2023; Liu et al., 2024). Furthermore, the growth of cutting-edge digital technology accelerates competition in supply and creates a new scale advantage (Qi and Xiao, 2020).

Therefore, digital transformation is becoming an unavoidable future trend in enterprise development, adaptation and survival (Bongiorno et al., 2018; Crișan and Stanca, 2021). Strategic digital economic development plans have been implemented in Germany, the US, Japan, and other nations (CAICT, 2022). Moreover, China has entered a new stage of digital research. In particular, the "Made in China 2025," which was announced in May 2015, proposed the implementation of intelligent manufacturing and the promotion of industrial transformation and upgradation (Council, 2015).

However, according to research conducted by Accenture (2022), only 17% of large enterprises have adopted digital technologies and are continuing to effectively drive digital transformation. Up to 80% of enterprises have unsuccessfully attempted this transition (Institute, 2021). Coupled with the slow response, the speed and efficacy of digital transformation were hampered in these enterprises (Deline, 2018). The majority of enterprises are still in the stage of enterprise digitalization (Institute, 2021), despite the appearance of several typical digitally transformed enterprises, such as China Power Grid, China Aviation Development, and SINOMACH. This is due to the enterprise's partial understanding of digital transformation, which involves a biased understanding, an unclear sense of direction, a lack of strategies, and so on (Morakanyane et al., 2017; Udovita, 2020; Margiono, 2021).

An enterprise's digital transformation requires more than a simple mechanically inputs and the application of new digital technology; rather, it entails adjustments to elements such as digital strategy, digital human resources, digital resources consolidation, digital platform, and so on Kane et al. (2015), Hinings et al. (2018). It is clear that enterprise digital transformation is a comprehensive and systematic project (Trenkle, 2019). Therefore, such transformation has become crucial for determining how to most effectively combine the elements affecting digital transformation to ensure a comprehensive digital transformation process. Much of the current research is focused on how a single element, or numerous elements acting independently of one another, affects an enterprise's digital transition (Fiss, 2007; Chen et al., 2021; Yin and Ran, 2022; Fan et al., 2023). From a holistic aggregation perspective, relatively little research has been conducted to reveal the interaction of these elements with one another to exert an integral effect on the digital transformation of an enterprise (Cheng et al., 2023). Fortunately, qualitative comparative analysis (QCA) can be used to take a configurational perspective, thus enabling the exploration of multiple equivalent paths that emerge under the combination of various conditions, which greatly improves the compatibility of the theories and methodologies used for analysis (Fiss, 2011). QCA and configurational analysis posit interdependence among factors rather than independence, rendering them apt for elucidating complex concurrent causal problems amidst various conditions (Douglas et al., 2020).

Given the above, the study aims to determine which and how factors affect this transformation to improve the current enterprise's digital transformation. We extracted key elements affecting corporate digital transformation and utilized a configurational framework and a fuzzy-set qualitative comparative analysis approach (fsQCA) to investigate how different factors combine to achieve digital transformation. We chose this method as it can handle complex causal relationships and identify multiple configurations that lead to digital transformation within organizations. FsQCA allows for the examination of both necessity and sufficiency of various elements, providing a nuanced understanding of how different combinations of factors contribute to successful digital transformation. This study makes three primary contributions to the literature. Firstly, in theory terms, based on a configuration perspective, this work developed a model framework of the enterprise digital transformation, to determine the optimal combination of technological and organizational factors for achieving corporate digital transformation. This study aims to serve as a source of ideas for longer-term studies on the topic. Specifically, no single factor can independently promote enterprise digital transformation, and QCA offers methodological direction for further investigation into the intricate digital transformation phenomenon. The conclusions of this study enhance the symbiotic connection among organizational response elements and address existing literature gaps regarding potential substitutive relationships among these factors. Secondly, in practice terms, four different types of enterprise digital transformation paths are discussed. These four paths each have different areas of emphasis. Businesses should concentrate on determining a digital transformation development pathway based on their own current resources, organizational structure, and external environment to create a competitive advantage. Thirdly, the digital transformation paths shown in the research conclusions of this article cover large-scale Internet enterprises, large-scale manufacturing enterprises, SMEs, and technology-intensive companies. These findings provide valuable insights for companies globally that are undergoing digital transformation, especially in terms of the factors that need to be considered during the transformation process.

2 Literature review and model construction

In terms of the academic community's perception of enterprise digital transition, this perception has progressed from shallow to profound. Early research mostly saw enterprise digital transition as the adoption of production processes that relied on digital technologies (Kim et al., 2010). Newer research has show phenomenon to be a profound transformation affecting corporate overall behavior (Fitzgerald et al., 2014; Vial, 2019; Kaganer et al., 2023). To adapt to the general digitalization trend, businesses face the impact of technological shock by through corresponding changes and innovations (Yoo et al., 2010; Nambisan et al., 2017; Ciriello et al., 2018; Hinings et al., 2018; Lokuge et al., 2019; Scuotto et al., 2020; Zhang et al., 2022), which is an organizational response (Verstegen et al., 2019; Kaganer et al., 2023). The technological shock refers to the effects of emerging new technology on businesses and socio-economics (Luftman et al., 2017; Nambisan, 2017; Verstegen et al., 2019; Warner and Wäger, 2019), especially the input and application of new digital technologies (Yoo et al., 2010; Majchrzak and Markus, 2012; Wareham et al., 2014). The organizational response refers to a series of adjustments enterprises adopt in response to changes in the external environment (Yoo

TABLE 1 Description of elements of technology shock and organizational response.

Elements type	Elements	Definitions	Representative literature
Technological shock	Digital technology inputs	Introduce digital technology to improve data analysis and usage capabilities.	Yoo et al., 2010; Pagani and Pardo, 2017
	Digital technology applications	Apply digital technology to R&D, production, sales and other links to reduce costs and increase efficiency.	Ciriello et al., 2018; Simsek et al., 2019
Organizational response	Digital strategic planning	Digital strategy planning defines concrete, short-, medium- and long-term digitalization goals and initiatives.	Lipsmeier et al., 2020; Cheng et al., 2023
	Digital human resources	Digital human resources is the collaboration of simple labor by machines, creating employees and employing users.	Yoo et al., 2012; Qi and Xiao, 2020; Ainunnisa, 2021
	Digital resource consolidation	Digital resource consolidation enhance the ability to resist risks by integrating internal and external resources.	Nambisan, 2017; Logg et al., 2019; Timoshenko and Hauser, 2019
	Digital eco-platforms	The digital eco-platforms fosters collaboration, sparks creativity, and trims costs effectively.	Dahl et al., 2014; Gorwa, 2019; Teece, 2020

et al., 2012; Morakanyane et al., 2017; Kaganer et al., 2023), including corporate strategic planning, human resources, resource consolidation, and digital ecological construction (Kane et al., 2015; Hinings et al., 2018; Verstegen et al., 2019; Iansiti and Lakhani, 2020; Corsini et al., 2021; Barr Pulliam et al., 2022). We define each of these elements mentioned above (see Table 1).

Next, the essay will describe more details about digital transformation mentioned above in the following:

2.1 Digital technology

Digital technology inputs and digital technology applications are two key technical factors influencing the digital transformation of enterprises (Yoo et al., 2010; Wareham et al., 2014). First, digital technology input can become an enterprise core competency (Qi and Xiao, 2020). The analysis and use of data is at the heart of digital technology inputs (Yoo et al., 2010; Ciriello et al., 2018). Enterprises can employ digital technology to gather heterogeneous information from customers, homogenized industry data, and other types of information for analysis and mining (Newell and Marabelli, 2015; Pagani and Pardo, 2017). These individual consumer data are combined to form a type of collective awareness that is represented in the products to satisfy customers' needs, thereby improving the level of R&D and product supply (Dahl et al., 2014). Second, as a new green technology (Niu et al., 2023; Zhang et al., 2023), enterprises can improve production efficiency and reduce costs by applying digital technology (Ciriello et al., 2018; Constantinides et al., 2018). For instance, digital twin technology can lower the number of failures encountered, shorten the production cycle, and reduce costs, and achieve green transformation and sustainable development of enterprises (Lyytinen et al., 2015; Simsek et al., 2019; Niu et al., 2023). Furthermore, consumption data can reflect the market response to products to make adjustments during the product update phase and improve the efficiency of business operations (Swan and De Filippi, 2017). It is evident that, as a new green technology, digital technology aims to promote sustainable development (Niu et al., 2023; Zhang et al., 2023), to facilitate the efficient utilization of resources for streamlining business processes, enhancing production efficiency, and ultimately bolstering the overall competitive advantage of enterprises.

2.2 Strategic deployment alterations

Digital technology changes the way goods are made and promotes production growth, which, in turn, supports the transformation and upgrading of businesses (Nambisan, 2017). Digital technology also exerts an impact on corporate behavior and strategic corporate decision-making (Gobble, 2018). Trailblazing adjustments in corporate strategy are needed to adapt to the trends in digitization (Cheng et al., 2023). For starters, businesses need to modify their strategic thinking, transitioning from competitive thinking to cooperative thinking. Collaboration between enterprise departments is needed because of the speed required for data mining and analysis (Barr Pulliam et al., 2022). In the digital economic system, co-creation of value becomes the fundamental goal of businesses (Lokuge et al., 2019). Thus, such transformation establishes a "spiritual contract" as well as a model contract of collective cooperation (Guiso et al., 2015). The next step is the adjustment of strategic deployment, or corporate strategy, which includes general adjustments to business operations, organizational management, and business ecology in addition to technical innovation (Warner and Wäger, 2019; Teece, 2020). That is, enterprises are required to maintain the capability to constantly align and strategically synergize their technological strategy, business strategy, organizational structure, and eco-structure (Gerow et al., 2015; Teece, 2018). To ensure the orderly execution of enterprise digital transformation, businesses should change and implement the strategies at the appropriate point (Lipsmeier et al., 2020). Additionally, to secure the achievement of an enterprise's strategic goals through digital transformation, preventing the creation of solely mechanical applications and other mechanistic processes is necessary (Luftman et al., 2017).

2.3 Modifications to human resources

In regard to the cultivation of human capital spurred by digital technology, a fundamental change has occurred (Felten et al., 2019; Rai et al., 2019). First, in the digital economic system, the use of digital technologies such as machine learning has enabled the substitution of certain simple labor with digital labor (Ainunnisa, 2021). For instance, in the same way that a position with a high level of risk is replaced, machine learning has the potential to significantly lower the cost of accumulating human capital in an organization (Felten et al., 2019). Second, the consolidation of staff positions within firms is fueled by digital technology (Banalieva and Dhanaraj, 2019). Technical employees holding traditional business jobs, for example, are better able to adapt to shifts in consumer demand and effectively translate such shifts into product improvement initiatives, thus improving the proprietary nature of human capital (Yoo et al., 2012; Banalieva and Dhanaraj, 2019). Third, through the strategy of "creating employees and employing users" businesses in the midst of digital transformation implementation can turn customers and employees into company "partners" and share the value created with them, thereby effectively mobilizing the enthusiasm of both internal and external "manpower" (Qi and Xiao, 2020). Additionally, human-computer interaction has also changed as a result of the intelligent application and updated iteration of digital technology (Yoo et al., 2012). For example, through the use of code editing, employee awareness can be included in digital systems (Felten et al., 2019).

2.4 Resource consolidation adjustments

Digital technology assists in adjustments to resource consolidation and improves a company's capacity to manage production risk (Logg et al., 2019). Digital technology alters how all parts of product conception, R&D, production, testing, and upgrading are presented, which, in turn, greatly enhances the capacity to coordinate resources in pursuit of affordable innovation (Goldfarb and Tucker, 2019; Qu et al., 2023). For instance, applying virtual judgment and manufacturing process prediction through the use of digital simulation and digital twin technology during the product conceptualization phase can lower the number of failures and shorten the product's production cycle (Simsek et al., 2019). The cost of internal communication is minimized throughout the R&D stage, during which diverse company departments employ digital technology to achieve inventive combinations across time and space (Matt et al., 2015). Digital technologies, such as blockchain, are used in the production stage to make the production process more standardized and traceable and to digitalize the relevant infrastructure, such as production equipment (Simsek et al., 2019). The use of a virtual client environment during the testing phase can reduce expenses and shorten the test period (Lyytinen et al., 2015). Furthermore, user feedback can be utilized to make adjustments during the product update phase and make ongoing enhancements to the product (Swan and De Filippi, 2017).

In particular, the supply of use value to consumers is at the heart of the digital economic system (Nambisan, 2017; Llopis-Albert et al., 2021). Consumers should be given the power to engage in business R&D to raise the value of enterprise products (Timoshenko and Hauser, 2019). There are two distinct methods to accomplish this. One is the use of digital technology models, such as machine learning, to estimate customer demand with greater accuracy than can be achieved through traditional models (Bajari et al., 2015). The other is bringing customers directly into the production chain so that they can voice their needs and use digital technology to indirectly infer consumer demand (Franke et al., 2009; Dahl et al., 2014; Yupeng et al., 2016).

2.5 Development of digital eco-platform

Digital technology boosts digital platforms (Constantinides et al., 2018), which improves information coupling and provides interconnectivity among R&D, production, sales, and other subplatforms (Dahl et al., 2014). The platform's size grows as a larger number and more types of subjects are added and resource sharing and value exchange begin to occur (Wang et al., 2018). This leads to the formation of a digital ecological platform (digital eco-platform; Franke et al., 2009).

The capacity of each subject to realize their value is facilitated by the digital eco-platform, which can improve both the stability of the digital system and its capacity to withstand market risks (Ryoo et al., 2006). A digital eco-platform can also create a coordination system for its subplatforms (Ryoo et al., 2006; Panico and Cennamo, 2015). On the one hand, the goal of a digital eco-platform is to create symbiotic relationships within the digital ecosystem and improve the ability of subplatform enterprises to survive on their own (Nambisan et al., 2019). On the other hand, solidifying the continuity and stability of the digital ecological platform and clarifying the rights and obligations of the value network are also important goals of a digital ecosystem (Gorwa, 2019; Teece, 2020). Therefore, to create an enterprise ecosystem through the process of enterprise digital transformation, businesses should cooperate extensively with other businesses both inside and outside the industry (Rai et al., 2019). Such cooperation is conducive to expanding enterprise scale, boosting the potential for enterprise innovation, and lowering the cost of enterprise collaboration (Marion et al., 2014; Nambisan et al., 2019; Cennamo, 2021).

2.6 Configuration framework

In summary, businesses should not be constrained by a mechanical single technological investment in the face of "technology shock." To achieve systemic digital transformation, firms should take numerous "organizational response" actions in the digital strategic planning, digital human resources, digital resource consolidation, and digital eco-platforms. In other words, digital technology not only is a commonly used tool for boosting productivity but also increases the pace of the technological change involved in organizational transformation. Technology shock and organizational response are mutually dependent, symbiotic, and interactive factors during the digital transformation process (Foerster-Metz et al., 2018; Cheng et al., 2023). Therefore, determining how the close linkage between organizational response and technological shock further affects digital transformation is still an issue that must be addressed.

The configuration theory is focused on examining the synergistic relationships and combinations among elements, making it useful for investigating the non-linear relationship between causes and effects and appropriate for mining multiple equivalent paths in pursuit of the digital transformation of enterprises (Fiss, 2011; Douglas et al., 2020; Park et al., 2020; Yin and Ran, 2022; Cheng et al., 2023; Fan et al., 2023; Qu et al., 2023). Thus, the configurational perspective is taken in this paper to assimilate digital technology inputs, digital technology applications, digital strategic planning, digital human resources, digital resource consolidation, and digital eco-platforms into a single research framework. Within such an integrated framework, intricate relationships among the aforementioned dynamics are explored and the following queries are addressed. First, whether the existence of a single component of digital technology inputs and applications can serve as a necessary condition for the digital transformation of organizations is determined. Second, the number of routes and transformation models that are needed to model the digital transformation of businesses under the combined action of several factors is calculate. The paper's research model is shown in Figure 1.

3 Research methods and data collection

3.1 Research methods

Qualitative comparative analysis (QCA), through the use of set theory and Boolean algebra, can be used to evaluate how combinations of these components affect the system as a whole from a configuration perspective (Fiss, 2011). Meanwhile, using the QCA approach sidesteps several statistical methodologies' presumptions, including the assumptions of homogeneity, variable factor independence, consistency, and symmetry of causality (Cheng et al., 2023). This approach is used to resolve issues with concurrency, asymmetry, multiplicity, etc., and is appropriate for conducting research using small samples (Pagliarin et al., 2019; Qu et al., 2023). Currently, data on the digital transformation of Chinese businesses are still lacking. The QCA approach has strong validity and reliability in small-scale research. The robustness of the QCA analytical findings is unaffected by the sample size, and the methods offer the capacity to analyze intricate the causal relationships that form in the process of a company's digital transformation.

Furthermore, there are three different varieties of QCA (Yin and Ran, 2022): fuzzy set QCA (fsQCA), multivalue set QCA, and crisp set QCA (csQCA). For each partial affiliation score, which falls between the values of 0 and 1, fsQCA can display continual changes in the data (Cheng et al., 2023). The fsQCA method offers the benefits of both qualitative and quantitative assessments since it can precisely indicate the membership of the set (Park et al., 2020; Chen and Tian, 2022). Thus, we finally opt to use the fsQCA methodology to create a digital transformation configuration model to analyze how the combined influence of multiple antecedent conditions affects the digital enterprise transformation and to summarize its primary modes.

3.2 Variable measure

3.2.1 Antecedent conditions

To identify and select the antecedent conditions of enterprise digital transformation, a comprehensive review of existing literature and empirical studies was conducted. We divide the antecedent elements that influence the digital transformation of enterprises from the previous analysis into either organizational or technological aspects from technological shock-response perspective. Two of these, namely, digital technology inputs and digital technology applications, which describe the effects of digital technology shocks on organizations, are included among the technology aspects. Digital strategic planning, digital human resources, digital resource consolidation and digital eco-platforms, are four components of the organizational characteristics that describe the measures taken by businesses in response to the influence of digital technology.

Digital technology inputs (DTI) can cross-industrial boundaries and exert a significant impact on the increases in total factor productivity and industry structure upgrading, among other things (Yoo et al., 2010). Simultaneously, such inputs can effectively support the industry structure and promote enterprise digital transformation and upgrading (Nylén and Holmström, 2019). Moreover, DTI facilitate green innovation, enhance competitive advantage, and drive sustainable growth across various sectors (Fan et al., 2023; Niu et al., 2023; Zhang et al., 2023; Feng et al., 2024). Through reference to the current research (Eiteneyer et al., 2019; Scuotto et al., 2020), we chose the frequency of digital technology use to quantify digital technology inputs. This approach allows for a nuanced understanding of how digital integration influences operational efficiencies and strategic initiatives.

Digital technology applications (DTA) reduce the barriers to data sharing, improve the level of information consensus across departments, and exert a significant impact on the company's business model innovation, competitive advantage differentiation, and changing market value orientation (Swan and De Filippi, 2017; Simsek et al., 2019). As a new green technology, digital technology can lower expenses, boost efficiency, and drive the eco-friendly evolution and sustainable progress of businesses (Niu et al., 2023; Zhang et al., 2023). For example: such technology promotes enterprise digital transformation by broadening the technical resource base available to the firm and increasing product innovation (Nambisan et al., 2019). These advancements facilitate more agile and responsive business processes, enabling firms to swiftly adapt to dynamic market conditions and customer demands. On the basis of the above studies (Zhang et al., 2022), we chose the utilization of digital technologies as a measure of digital technology applications, recognizing its pivotal role in driving strategic and operational efficiencies across various organizational dimensions.

Digital strategic planning (DSP) is forward-thinking; it is used to predict an organization's internal regulations and to prompt an appropriate reaction (Cheng et al., 2023). At the same time, such

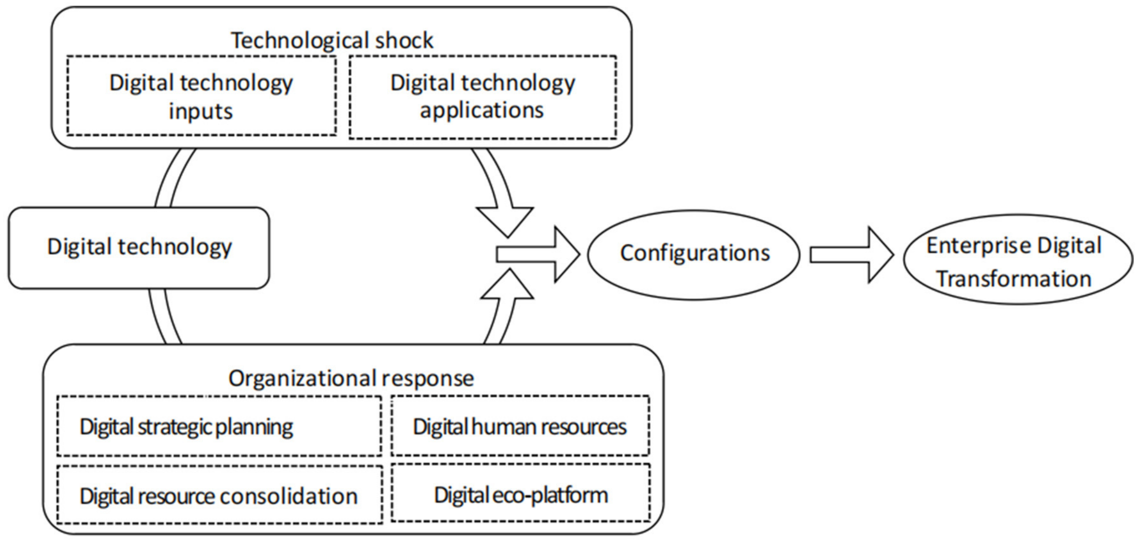

FIGURE 1
The configurational framework of the enterprise digital transformation.

planning can help corporate staff adapt to the new model, provide basic assurance for digital technology exploration, and research and development and innovation in regard to digital technology (Tilson et al., 2010). Through reference to the extant research, we selected the ratio of R&D investment to operating income as a measure of digital strategic planning (Aryanto and Chrismastuti, 2011). This metric not only reflects the organization's commitment to innovation but also indicates the alignment of its financial resources with its strategic digital objectives, ensuring that the digital initiatives are adequately funded and prioritized to foster long-term growth and competitiveness.

Digital human resources (DHR) are used for the effective development of an organization's internal and external digital talent (Yoo et al., 2012; Qi and Xiao, 2020; Ainunnisa, 2021). By leveraging DHR, organizations can significantly enhance their human resource endowment and fortify their competitive edge amidst a dynamic environment (Qi and Xiao, 2020). In line with prior research (Li and Cao, 2022), we selected the proportion of R&D staff as a representative metric for digital human resources. This choice reflects the critical role that research and development personnel play in driving innovation and digital transformation within organizations.

Digital resource consolidation (DRC) enables the combination of internal and external resources and facilitates their coordination in the development of digital resource pools (Timoshenko and Hauser, 2019). This synergy between resources enhances operational efficiency and innovation capabilities, providing a robust foundation for competitive advantage. Ultimately, such exchanges support the digital transformation and upgrading of businesses by balancing the supply of digital products with their demand (Scuotto et al., 2020). According to previous research, digital resource consolidation is directly reflected in enterprise profit. Therefore, we measure digital resource consolidation through supernormal profit to minimize the impact of the enterprise's original size, ensuring that the analysis is not skewed by pre-existing disparities and reflects the true efficiency gains attributable to DRC (Liu et al., 2021). This approach offers a nuanced understanding of how effectively digital resources are leveraged for enhanced profitability.

A digital eco-platform (DEP) realizes value generation through interaction. Enterprises are assisted in their transition to digital enterprises through the sharing of R&D resources and patents, fostering innovation and efficiency (Müller et al., 2018). This collaborative approach enables businesses to leverage collective knowledge and technological advancements, thus accelerating their digital transformation. Accordingly, based on prior studies, we use the number of patent applications that have been filed by businesses as a measure of the development level of digital eco-platforms (Miao, 2019). This metric reflects the platform's ability to facilitate and support innovation, indicating its maturity and effectiveness in promoting digital advancements.

3.2.2 Outcome variable

An organization's annual report, which importantly relates its business direction and summary, more clearly reflects information about the degree of digital transformation of the enterprise. Therefore, we analyze the annual reports of 98 listed companies in the Juchao Information Network using Python crawler software. Drawing on current studies (Eiteneyer et al., 2019), we collated the frequency of the phrases associated with digital transformation and utilized them as indicators to measure the degree of digital transformation of firms.

3.3 Data collection

Samples were selected on the basis of three screening standards. First, selected enterprises have been operating for longer than 3 years and have more distinct enterprise digital transformation

TABLE 2 Introduction of 98 representative digital transformation companies.

Industry type	Sample	Percent (%)
Computer, communications and other electronic equipment manufacturing	32	33%
Electrical machinery and equipment manufacturing	14	14%
Telecommunications, radio and television broadcasting and satellite transmission services	6	6%
Internet and related services	15	15%
Software and information technology services	31	32%

activities. Second, selected enterprises have a wealth of available first-hand information. Third, attention is given to the variations between samples, and an effort is made to cover as many aspects of the industry as possible. Based on the aforementioned criteria, we ultimately chose the manufacturing and service industries as the research samples. The necessary information is retrieved from the WAND database (WIND), the Cathay Pacific database (CSMAR), and the Juchao Consulting Network. Table 2 displays the statistical data covering the percentage of industry categories among the 98 representative businesses, and the sample businesses exhibit the typical traits of digital transformation. This sampling strategy aimed to capture a broad spectrum of organizational characteristics and experiences with digital transformation.

3.4 Calibration

The most important step when using the fsQCA method is the calibration of the measurement conditions because uncalibrated data lack broad significance (Yin and Ran, 2022). The goal of this calibration is the conversion of conventional variables into fuzzy variables that take values between 0 and 1. Due to the lack of theoretical support and knowledge base, we mainly conducted calibration in this study through the use of quantiles to avoid errors caused by limitations in theory (Yin and Ran, 2022). Thus, using the fsQCA3.0 tool and referring to prior studies (Andrews et al., 2016; Fan et al., 2017; Feng et al., 2024), we performed direct calibration of the six condition variables and the single outcome variable, using the 95% quantile values as anchor points that fall completely within the threshold, the 50% quantile values as crossover locations, and the 5% quantile values as anchor points that fall completely outside the threshold values. The calibration anchors for antecedent conditions and outcome variables are shown in Table 3.

TABLE 3 Fuzzy set calibration.

Sets	Fuzzy set calibration		
	Full in	Crossover point	Full out
Digital technology inputs	2.157	1.279	0.301
Digital technology applications	1.792	0.813	0.050
Digital strategic planning	1.435	0.835	0.459
Digital human resources	1.780	1.373	0.874
Digital resource exchange	9.436	8.485	4.312
Digital eco-platform	9.436	8.485	4.312
Degree of digital transformation	2.377	1.525	0.597

4 Analysis results

4.1 Analysis of necessary conditions

4.1.1 Analysis of necessary conditions by QCA

In determining whether single antecedent conditions serve as sufficient or necessary conditions for the outcome variable, fsQCA method requires a single antecedent condition necessity analysis to be conducted following calibration. In other words, this fsQCA is conducted to determine whether the necessary conditions for the results to occur have been met (Nylén and Holmström, 2019; Feng et al., 2024). In a necessity analysis, a causal condition is deemed necessary for the outcome if the consistency score is >0.9 (Manny et al., 2021; Feng et al., 2024). Table 4 shows that the consistency coefficients of all single antecedent conditions are <0.9. This shows that there is no single antecedent condition for the digital transformation of enterprises. In other words, digital technology inputs, digital technology applications, digital strategic planning, digital human resources, digital resource consolidation, and digital eco-platforms cannot independently promote the digital transformation of enterprises. Consequently, analyzing the combinations of multiple antecedent conditions is necessary.

4.1.2 Analysis of necessary conditions by NCA

To further confirm these results, we used the necessary condition analysis (NCA) method. The necessary conditions for NCA require the satisfaction of two criteria (Dul et al., 2018): (1) the effect size must exceed the threshold value ($d = 0.1$); (2) Monte Carlo simulations of permutation tests should demonstrate significant effect sizes. Table 5 presents the results of the NCA necessary conditions. No variable satisfies the above two conditions at the same time. Thus, each condition variable independently does not suffice as a necessity for digital transformation. Rather, digital transformation results from the combined effects of all condition variables. Consequently, it is necessary to analyze multiple antecedent conditions in combination.

Table 6 provides a bottleneck analysis, indicating the minimum (%) level required for condition variable x to achieve a certain (%) level of result variable y (Dul et al., 2023). As shown in the table, the analysis shows that to reach maximum performance, a 65.3% level of digital technology inputs, a 93.9% level of digital technology applications, a 40.6% level of digital strategic planning, a 13.2% level of digital human resources, a 70.4% level of digital resource consolidation, and a 20.9% level of digital eco-platform are needed. The above analysis results once again show that

TABLE 4 Results of necessary conditions of NCA.

Conditions	Method	C-accuracy	Ceiling zone	Scope	Effect size	*P*-value
Digital technology inputs	CR	95%	0.115	0.920	0.124	0.089
	CE	100%	0.046	0.920	0.050	0.028
Digital technology applications	CR	97%	0.071	0.910	0.078	0.005
	CE	100%	0.063	0.910	0.069	0.002
Digital strategic planning	CR	100%	0.000	0.950	0.000	1.000
	CE	100%	0.000	0.950	0.000	1.000
Digital human resources	CR	98%	0.029	0.930	0.310	0.573
	CE	100%	0.045	0.930	0.048	0.068
Digital resource consolidation	CR	97%	0.062	0.910	0.068	0.002
	CE	100%	0.044	0.910	0.048	0.022
Digital eco-platform	CR	100%	0.000	0.910	0.000	1.000
	CE	100%	0.000	0.910	0.000	1.000

$0 \leq d < 0.1$ is low level, $0.1 \leq d < 0.3$ is medium level, $0.3 \leq d < 0.5$ is medium high level, and $0.5 \leq d$ is high level.

TABLE 5 Necessary condition bottleneck level of NCA/%.

Degree of digital transformation	Digital technology inputs	Digital technology applications	Digital strategic planning	Digital human resources	Digital resource consolidation	Digital eco-platform
0	NN	NN	NN	NN	NN	NN
10	NN	NN	NN	NN	NN	NN
20	NN	NN	NN	NN	NN	NN
30	NN	NN	NN	NN	NN	NN
40	NN	NN	NN	NN	NN	NN
50	NN	NN	NN	NN	NN	NN
60	NN	NN	NN	1.9	NN	NN
70	13.9	NN	NN	4.7	NN	NN
80	31.0	NN	NN	7.6	NN	NN
90	48.2	37.3	NN	10.4	33.9	NN
100	65.3	93.9	40.6	13.2	70.4	20.9

digital transformation hinges on the collective interplay of multiple conditional variables.

4.2 Configuration analysis

The goal of conditional configuration sufficiency analysis, in this case, is to analyze how the antecedent conditions mentioned above can be configured to enable a company's digital transformation. These many configurations showcase various combinations of the antecedent conditions that lead to the same result.

According to existing research (De Crescenzo et al., 2020; Feng et al., 2024), the frequency threshold can be set to 1 for a limited sample size. A large sample size enables an increase in the frequency threshold and the retention level in at least 75% of the cases. The sample size used in this paper is 98 firms, which qualifies as a large sample size. Thus, in accordance with previous studies, the case frequency threshold in this paper is set to 3 (Müller et al., 2018), the original consistency threshold is set to 0.8 to ensure the strength of the configuration's interpretation (Feng et al., 2024), and the inconsistency (PRI) is set to 0.75 to remove interference from the "simultaneous subset relation" (Müller et al., 2018).

The findings of the fsQCA analysis involve three types of solutions: complex solutions, intermediate solutions, and reduced solutions. Typically, an antecedent condition is regarded as a core condition if it exists in both the intermediate solution and the reduced solution and as an auxiliary condition only if it appears in the intermediate solution (Furnari et al., 2021). In light of this, Table 7 presents the outcomes of the fsQCA conducted for this study.

Table 7 reports the results of the configuration analyses. The findings indicate that there are four configurations (H1a, H1b, H2, and H3) that enable the enterprise's digital transformation. Among them, H1a and H1b are second-order equivalent configurations since they have the same core criteria. The overall solution consistency of these four configurations of enterprise digital transformation is 0.885, and the overall coverage is 0.688. This explains why the significance level of the configurations is relatively high overall.

We propose three enterprise digital transformation conditional paths as follows: the technology-driven (H1a, H1b) platform-pull (H2), and light assets-oriented (H3). Below, we further detail about our analysis of the four configurations.

The path of strategic planning and human resources driven by digital technology is configuration H1a (DTI*DTA*DSP*DHR). With the configuration path of digital technology inputs and digital technology applications serving as core conditions and complementary digital strategic planning and digital human resources serving as auxiliary conditions, enterprises can achieve digital transformation. This path demonstrates that businesses can still achieve digital transformation as long as they have a certain level of digital technology inputs and digital technology applications, as well as exhibiting appropriate levels of digital strategic planning and digital human resources. For digital transformation, in particular, sufficient financial resources are needed to support firm's digital technology inputs and digital technology applications. Digital strategic planning and digital human resources offer the opportunity to match and coordinate digital technology in the early stages of business digital transformation. Typically, larger companies that can tolerate some level of transformation risk are good candidates for this path.

For example, Tencent is a leading Internet company with a certain foundation in financial and human resources (Globaldata, 2022). In the early twentieth century, Tencent introduced digital technology (digital technology inputs) by using digital technology as its engine and applying digital technology (digital technology applications) to achieve intelligence from company management to market promotion. It also formulated a comprehensive digital strategic planning and implemented a reform to flatten the corporate governance structure. Especially in terms of talent training, from company leaders to employees, a team with digital thought was built. Finally, the company has achieved its digital transformation. Similarly, Internet giants such as Alibaba and Baidu have also adopted a similar transformation path, which focused on long-term, mid-term and short-term strategic adjustments and the introduction and cultivation of digital talent (Li, 2020).

TABLE 6 Necessity analysis of single antecedent conditions.

Number	Antecedent condition	Consistency	Coverage
1	Digital technology inputs	0.842024	0.868786
2	~ Digital technology inputs	0.567657	0.461126
3	Digital technology applications	0.785258	0.808015
4	~ Digital technology applications	0.612541	0.498657
5	Digital strategic planning	0.700330	0.706548
6	~ Digital strategic planning	0.638284	0.527934
7	Digital human resources	0.746975	0.718823
8	~ Digital human resources	0.570517	0.491378
9	Digital resource exchange	0.650165	0.657397
10	~ Digital resource exchange	0.686029	0.566394
11	Digital eco-platform	0.482948	0.552479
12	~ Digital eco-platform	0.787239	0.593662

The absence of the outcome or condition is denoted by the sign (~).

TABLE 7 Configuration results of the enterprise digital transformation.

Antecedent condition	Digital transformation of enterprise			
	H1a	H1b	H2	H3
Digital technology inputs	●	●	⊗	●
Digital technology applications	●	●	●	
Digital strategic planning	•	⊗	⊗	•
Digital human resources	•	⊗	⊗	•
Digital resource exchange		•	⊗	⊗
Digital eco-platform		⊗	•	⊗
Raw coverage	0.465	0.299	0.249	0.381
Unique coverage	0.119	0.089	0.060	0.055
Consistency	0.960	0.964	0.801	0.939
Overall consistency	0.885			
Overall coverage	0.688			

● shows that the core condition is present, • shows that the auxiliary condition is present, ⊗ shows that the auxiliary condition is absent, blank shows that the condition are optional (present or absent).

The path of digital resource consolidation as driven by digital technology is configuration H1b (DTI*DTA*∼DSP*∼DHR*DRE*∼DEP). With the configuration path of digital technology inputs and digital technology applications serving as core conditions and digital resource consolidation serving as an auxiliary condition, enterprises can achieve digital transformation. This path demonstrates that even in the absence of digital strategic planning, digital human resources, and digital eco-platforms, businesses are still capable of achieving digital transformation as long as they have a certain level of digital technology inputs and applications, as well as an appropriate digital resource consolidation capacity. With the input and application of digital technology, the ability to coordinate resources is improved, which can reduce information asymmetry both within and outside production departments, operations, markets, and customers of the firm. Large enterprises have the capacity to manage complex supply and demand networks. Following this path can help them improve market supply and demand matching, customer satisfaction, and corporate market share.

For example, BYD (Smith, 2021), as China's leading new energy vehicle manufacturer, takes full advantage of the inputs and applications of digital technology through the consolidation of digital resources, successfully achieving its corporate transformation goals. BYD installed IoT sensors on the production line to realize real-time monitoring and data collection of the automobile production process, conduct in-depth mining of the collected data, and optimize the production process and supply chain management. At the same time, the data and information flow in the supply chain are analyzed; for example, based on market demand, seasonal changes, weather, and other factors, the procurement plan and production plan of the supply chain are intelligently formulated to achieve rational allocation of supply chain resources and production efficiency maximization. Similarly, manufacturing companies such as Haier Smart Home have applied digital technology inputs to adjust and optimize upstream and downstream supply chain resources and achieve digital transformation (Di et al., 2021).

Configuration analysis can be conducted to reveal how several conditions interact with one another (Li and Chan, 2019). By contrasting two groups of technology-driven configurations (H1a and H1b), we demonstrate that digital resource consolidation has a mutual substitution effect on digital strategic planning and digital human resources. For businesses with digital technology inputs and applications, focusing on resource consolidation or strategic planning and human resources can still lead to digital transformation, as shown in Figure 2.

That is to say, from the derivation results of fsQCA, based on the introduction and application of digital technology, for Internet companies such as Tencent and Alibaba, digital transformation can be successfully accomplished by focusing on investing in the integration of the upstream and downstream resources of the enterprise (including hardware facilities, software system R&D, and customers). Digital transformation may also be effectively achieved for auto and energy corporations such as BYD and Haier Smart Home by concentrating on cultivating internal employee digitalization, bringing in outside digital expertise, and developing medium- and long-term digital strategies.

The path of digital eco-platform pull transformation driven by digital technology applications is configuration H2 (∼DTI*DTA*∼DSP*∼DHR*∼DRE*DEP). With the configuration path of digital technology applications serving as core conditions and the digital eco-platform serving as an auxiliary condition, enterprises can achieve digital transformation. This path demonstrates that even in the absence of digital technology inputs, digital strategic planning, digital human resources, and digital resource consolidation, businesses are still capable of achieving digital transformation as long as they have a certain level of digital technology applications, as well as appropriate digital eco-platforms. Digital eco-platforms are used to connect companies along the value chain through digital technologies, such as smart contracts and digital mining. Furthermore, it also serves as a vehicle for enterprises to realize their value, which can improve their stability and coping capacity for market risks of the enterprises on the platform. Due to limitations such as company size and capital, SMEs face some challenges in regard to digital transformation. However, by reshaping the form of inter-enterprise communication through the help of the digital ecological platforms that are offered by the government or other businesses, digital transformation can still be accomplished. Therefore, this path is suitable for SMEs with low-risk tolerance in regard to digital transformation.

For example, SMEs can achieve digital transformation by applying digital platforms (digital technology applications) that have been developed in the market. A typical digital ecological platform is the Xiaomi Home ecological chain (Yang et al., 2021). Xiaomi has used its own digital platform to gather a large number of SMEs. Although these SMEs do not have the ability to introduce digital technology for data analysis and mining, they have settled in and used the platform (digital technology platform) to sell their own products (digital technology applications). By cooperating with Xiaomi to integrate products and produce a series of Xiaomi-related home appliances, gradually forming the Xiaomi Home ecological chain, these SMEs also realized their digital transformation. Similarly, the connected digital ecological platform is Huawei's smart life ecological chain, which has attracted a large number of SMEs to develop smart products and achieve digital transformation (Lida, 2017).

The path of light asset-oriented transformation as driven by digital technology inputs is configuration H3 (DTI*DSP*DHR*∼DRE*∼DEP). With the configuration path of digital technology inputs serving as core conditions and digital strategic planning and digital human resources serving as auxiliary conditions, enterprises can achieve digital transformation. This finding demonstrates that even in the absence of digital resource consolidation and digital eco-platforms, businesses are still capable of achieving digital transformation as long as they have a certain level of digital technology inputs, as well as the appropriate levels of digital strategic planning and human resources. Light assets such as digital strategic planning and digital human resources play a significant role in organizational decision-making, product services, technology development, and operational management, which can help businesses gain a competitive edge in the digital transition. This path applies to most enterprise digital transformations. Therefore, businesses should place a strong

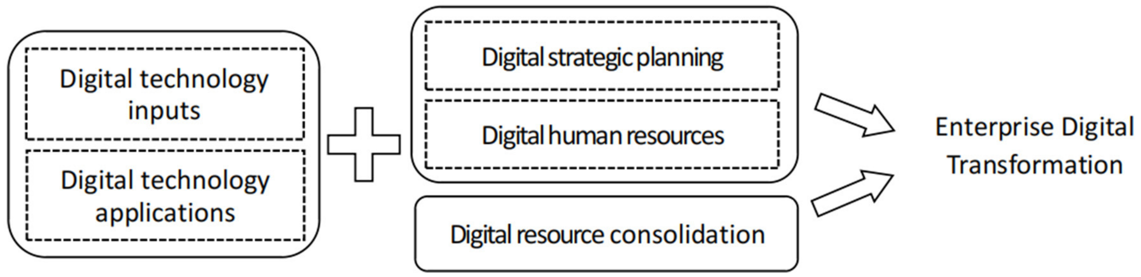

FIGURE 2
Substitution effects of resource exchange for strategic planning and human resources.

emphasis on adjusting and deploying corporate soft assets such as digital talent and strategy.

For example, Inspur Tongsoft is an enterprise specializing in software development and information technology services (Wei and Qun, 2023). By introducing digital technology inputs and formulating effective digital strategic planning and digital human resources, the company's transformation goals, were successfully achieved. First, the company formulated a mid-term and a long-term digital development strategy based on the digital market environment (digital strategic planning). Second, the company cultivated digital management and R&D talent (digital human resources). Then, the company developed and introduced digital hardware, software, and cloud computing services to achieve intelligent-product production (digital human resources). Finally, the company is now a key software company in the industry. Similarly, other information technology-intensive enterprises also achieved digital transformation through this path.

A more detailed qualitative comparison analysis of the configuration of each pathway is offered in Table 8.

4.3 Robustness test

The above analysis process focused on identifying and analyzing different configurations leading to enterprise digital transformation. fsQCA involves numerous robustness tests. Among them, one common method is the logical adjustment of the pertinent parameters, such as adjusting the consistency threshold, increasing the PRI, and changing the number of cases (Feng et al., 2024). We settled on increasing the case consistency threshold as our robustness test method and increased the consistency threshold from 0.75 to 0.8, other conditions remaining unchanged (see Table 9). Comparing the outcomes presented in Tables 7, 9 reveals that increasing the consistency threshold to 0.8 does not lead to substantial changes in the configuration results. Specifically, in configuration D1a, the digital eco-platform becomes the absence of auxiliary condition, which does not significantly impact the result analysis. In configuration D1b, the absence of digital strategic planning changes from an auxiliary condition to a core one, yet this alteration does not affect the result analysis either. In configuration D3, the presence of digital human resources changes from an auxiliary to a core condition, highlighting the significant influence of human resources on enterprises' digital transformation, without influencing the results of digital transformation path analysis.

Additionally, following the existing research (White et al., 2020), we set the frequency threshold at 2. The findings indicated strong stability, as there was no reduction in the number of solutions even when the thresholds were tightened. Thus, the results pass the robustness test and that the empirical study is confirmed as trustworthy. Thus, the results pass the robustness test and the empirical study is trustworthy.

5 Conclusions, implications, and prospects

5.1 Conclusions

Many studies have paid close attention to the role played by digital technology shocks in the promotion of enterprise digital transformation (Fiss, 2007; Chen et al., 2021; Yin and Ran, 2022; Fan et al., 2023). However, the significance of organizational response in the process of company digital transformation has only recently been recognized. Using 98 representative businesses as examples, we explore the impact of six antecedent conditions of enterprise digital transformation (i.e., digital technology inputs, digital technology applications, digital strategic planning, digital human resources, digital resource consolidation, and digital eco-platform) using the fsQCA approach. Different configurations of these six conditions are identified, and different modes of enterprise digital transformation are analyzed. The conclusions are as follows.

First, none of the antecedent conditions are sufficient to independently provide the necessary conditions for a firm's digital transformation, but they constitute key elements in the pursuit of enterprise digital transformation.

Second, there are four configuration paths that lead to corporate digital transformation, namely, strategic planning and human resources driven by digital technology, digital resource consolidation driven by digital technology, digital eco-platform-pull transformation driven by digital technology applications, and light asset-oriented transformation driven by digital technology inputs. These pathways can serve as equifinal paths for achieving a company's digital transformation.

Third, the results show a mutual substitution effect on the technology-driven configurations (H1a and H1b). A

TABLE 8 Qualitative comparison analysis of the configuration.

Configuration	Configuration	Transformational focus	Representative companies
H1a	DTI*DTA* DSP*DHR	Digital technology accelerates digital transformation; digital strategic planning and digital human resources stabilize digital transformation.	Fenghua High-Tech Co., Zhenhua Technology Co., Machinery Industry Group Ltd.
H1b	DTI*DTA* ~DSP*~DHR *DRE*~DEP	Digital technology accelerates digital transformation, and digital resource exchange stabilizes digital transformation.	Ultrasonic Electronics Co., Weaponry Equipment Group Ltd., Shipbuilding Group Ltd.
H2	~DTI*DTA* ~DSP*~DHR *~DRE*DEP	Focus on digital technology applications and participation in digital eco-platforms to enhance the ability to respond to digital transformation risks.	Desay Group Ltd., Futong Information Technology Co., Hengdian Group East Magnetic Co.
H3	DTI*DSP* DHR*~DRE* ~DEP	Focus on digital technology inputs, as well as the utilization of digital strategic planning and human resources, to enhance competitive advantages in a dynamic environment.	Oriental Electronics Group Ltd., New Media Corporation Ltd., Guizhou Radio and TV Information Network Co.

The absence of the outcome or condition is denoted by the sign (~).

TABLE 9 Robustness test result.

Antecedent condition	Digital transformation of enterprise			
	D1a	D1b	D2	D3
Digital technology inputs	●	●	⊗	●
Digital technology applications	●	●	●	
Digital strategic planning	·	⊗	⊗	·
Digital human resources	·	⊗	⊗	●
Digital resource exchange		·	⊗	⊗
Digital eco-platform	⊗	⊗	●	⊗
Raw coverage	0.203	0.159	0.249	0.381
Unique coverage	0.127	0.089	0.060	0.055
Consistency	0.970	0.971	0.801	0.939
Overall consistency	0.728			
Overall coverage	0.697			

● shows that the core condition is present, · shows that the auxiliary condition is present, ⊗ shows that the core condition is absent, ⊗ shows that the auxiliary condition is absent, blank shows that the condition are optional (present or absent).

business can equivalently substitute resource consolidation with strategic planning and human resources to drive digital transformation.

5.2 Theoretical implications

Technological shocks and organizational responses are linked, interrelated, and highly interactive from the perspective of a complex system, and they can evolve through multiple paths and reach various types of equilibrium. Therefore, from the configuration perspective, in this study, we methodically analyze how technical and organizational elements can be coupled to achieve enterprise digital transformation. This paper's findings will have theoretical significance and consequences for the current research on digital transformation.

Based on a configuration perspective, this study developed a model framework of the enterprise digital transformation, in order to determine the optimal combination of technological and organizational factors for achieving corporate digital transformation. Furthermore, we present multiple digital transformation pathways in a methodical manner, thus contributing to the analysis of the links between various digital transformation paths and enterprises. Table 10 presents a detailed analysis of this research contributions.

TABLE 10 Contributions of this research.

Characteristics of conventional regression methods	Identify findings from the configurational fsQCA	Theoretical contributions
The influencing factors of digital transformation are independent of each other	No single factor can independently promote enterprise digital transformation, analyzing the combinations of multiple antecedent conditions is necessary.	Demonstrating the benefits of QCA in uncovering relationships among different elements within the model and offering methodological direction for further investigation into the intricate digital transformation phenomenon.
	Digital resource consolidation has a mutual substitution effect on digital strategic planning and digital human resources.	Enhancing the symbiotic connection among organizational response elements and addressing the gaps in existing literature regarding potential substitutive relationships among these factors.
Digital technology is a key factor influencing digital transformation	Digital technology is one of the key factors in realizing digital transformation. The final successful transformation requires effective organizational change, which is reflected in four configurations in the sample data.	Illustrating that the fsQCA approach can break through the single symmetry assumption of causality seen in linear regression, thereby providing a more detailed clarification of complex causal factors.

5.3 Practical implications

This research is aimed at providing numerous practical benefits to guide businesses in their choice of digital transformation pathways. Specifically, four different types of enterprise digital transformation paths are discussed. These four paths each have different areas of emphasis. Businesses should concentrate on determining a digital transformation development pathway based on their own current resources, organizational structure, and external environment to create a competitive advantage.

The H1a path is typically well-suited for large-scale Internet enterprises. The specific implementation strategy for enterprises under the H1a path entails the following: In digital strategic planning, companies must establish clear digital objectives and a roadmap. This process requires drawing extensively from industry best practices and cutting-edge technologies (Fitzgerald et al., 2014), while also integrating the enterprise's unique business characteristics and developmental needs to formulate a comprehensive digital strategic plan. This involves conducting in-depth analyses of market demand, competitive landscape, to identify key focus areas and prioritize development directions for digital transformation. Regarding digital human resources, enterprises should prioritize talent cultivation and development. By recruiting individuals with digital skills and extensive experience, bolstering internal employee training and skill enhancement efforts, and establishing teams equipped with digital acumen and capabilities, companies can provide robust talent support and assurance for digital transformation, as shown in Figure 3.

The H1b path is typically well-suited for large-scale manufacturing enterprises. The specific implementation strategy for the H1b path entails focusing on the integration and optimal utilization of digital resources to enhance business efficiency and innovation capabilities. Firstly, companies need to establish robust digital infrastructure and platforms, including information systems, data centers, and cloud computing technologies, to facilitate the investment and application of digital technologies. Secondly, companies should strengthen digital collaboration and coordination with suppliers, partners, and customers, by integrating the upstream and downstream industrial chains through digital technologies to achieve resource sharing and value co-creation. Additionally, companies should prioritize data collection, analysis, and utilization, leveraging technologies such as big data analytics and artificial intelligence to harness the potential of data, optimize production processes and service experiences, and enhance product quality and market competitiveness, as shown in Figure 4.

The H2 path is particularly suitable for SMEs. The specific implementation strategies for enterprises under the H2 path are outlined as follows: Firstly, companies can gradually enhance digitalization across various business domains by leveraging existing digital tools and platforms. This can be achieved through the adoption of cost-effective basic digital tools and platforms, such as utilizing basic services offered by cloud service providers or open-source software. Secondly, enterprises should actively seek and join digital ecosystem platforms to connect with businesses along the value chain through digital technologies, fostering resource sharing and collaborative innovation (Constantinides et al., 2018). During the process of joining digital ecosystem platforms, SMEs can explore opportunities for collaboration with large enterprises to collectively build digital ecosystem systems, thereby accessing more resources and opportunities (Rai et al., 2019). Furthermore, companies need to pay attention to the sustainable development of digital ecosystem platforms, actively participating in platform construction and operation to contribute to the healthy development of the digital ecosystem. Through these measures, SMEs can engage in digital transformation at lower costs and risks, achieving sustained business innovation and development, as shown in Figure 5.

The H3 path is particularly suitable for technology-intensive enterprises. The specific implementation strategies under the H3 path are outlined as follows: Firstly, enterprises should ensure sufficient inputs in digital technology, including the development and upgrade of hardware facilities and software systems. This requires enterprises to continuously track the development trends of digital technology, and research and develop various digital tools and technologies to enhance the competitiveness of digital technology. Secondly, in terms of digital strategic planning, enterprises should not overly rely on high-cost technological solutions, but rather should flexibly adjust strategic directions based on their actual situations and market demands, seeking the most cost-effective solutions. This includes conducting an in-depth analysis of the goals and

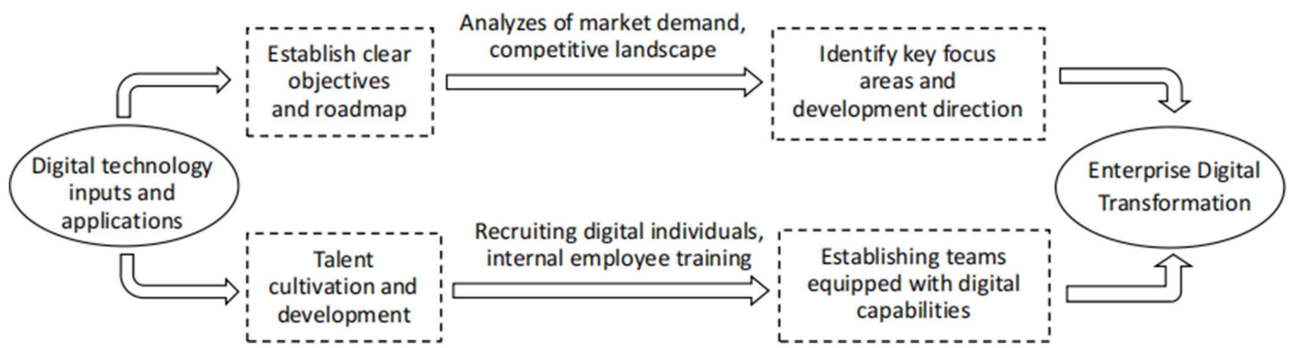

FIGURE 3
Practical application of the technology-driven path (a).

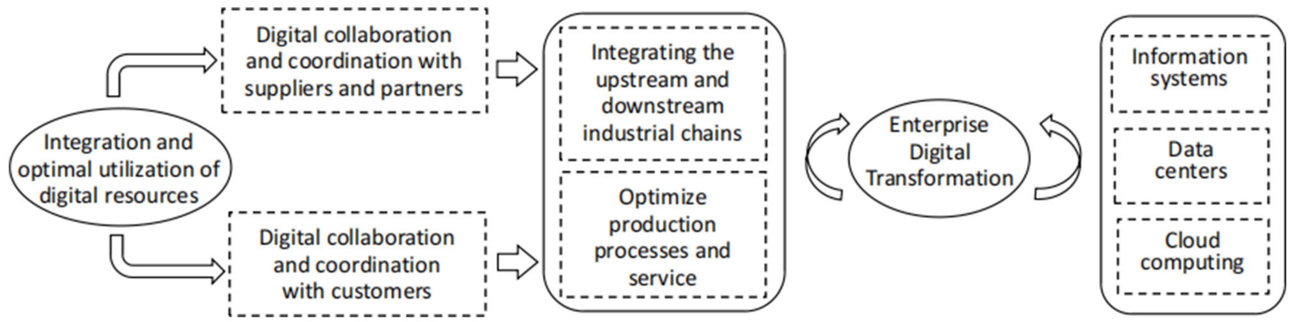

FIGURE 4
Practical application of the technology-driven path (b).

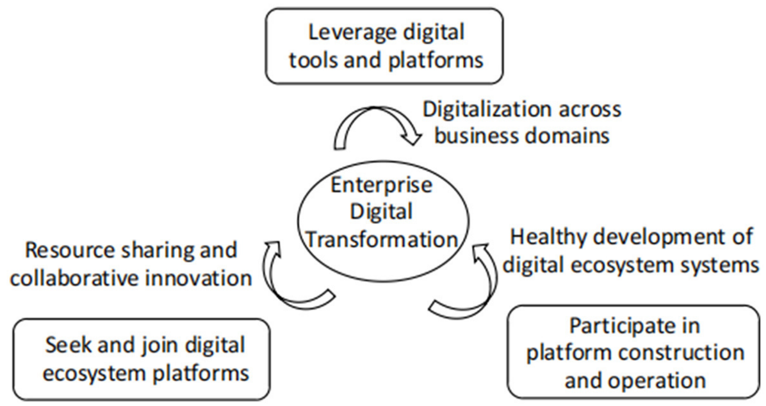

FIGURE 5
Practical application of the platform-pull path.

priority areas of digital transformation and formulating flexible implementation plans to timely respond to changes and challenges during the digital transformation process. Lastly, enterprises should prioritize the cultivation and development of internal talents, constructing teams equipped with digital thinking and capabilities. This involves not only enhancing employees' digital skills and knowledge levels but also fostering their innovation awareness and problem-solving abilities. Enterprises should establish effective internal communication mechanisms and a collaborative atmosphere, encouraging knowledge sharing and mutual learning among employees to enhance the overall digital capabilities and competitiveness of the team, as shown in Figure 6.

5.4 Limitations and prospects

This study has the following limitations. First, the data used in this study cover only a small number of industries and cannot fully represent all enterprises, making it impossible to analyze the digital transformation path of the entire industry.

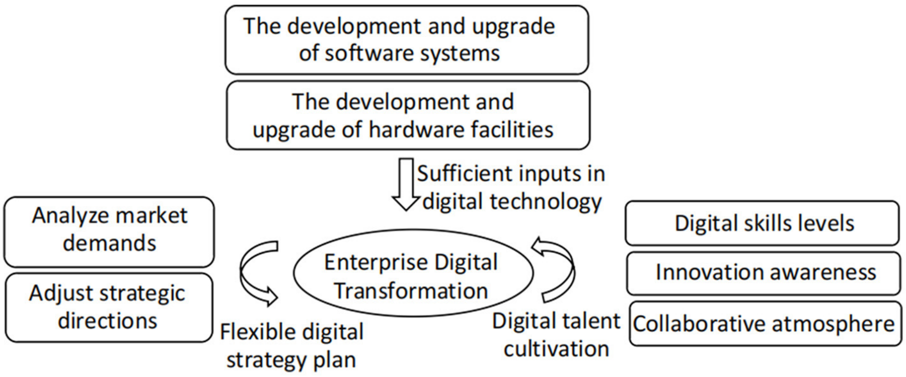

FIGURE 6
Practical application of the light assets-oriented path.

Second, the digital transformation path is analyzed from the standpoint of technological shock and organizational response in this study. When future data become available, the stages of digital technological shock can be further subdivided into the initial introduction, development and maturity of digital technology. The key elements of the organizational response in different stages can be extracted to analyze the transformation path. Third, to support the findings of this study, we rely on publicly available data. In the future, data can be collected through surveys to enhance the investigation of digital transformation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

YZ: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. LC: Formal analysis, Funding acquisition, Writing – original draft. XZ: Data curation, Resources, Software, Writing – original draft. SH: Methodology, Supervision, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This study was supported by grants from the Beijing Social Science Foundation Program (No. 22JJB012); Inner Mongolia Natural Science Foundation Program (No. 2023QN07002); Scientific Research Project of Colleges and Universities in Inner Mongolia Autonomous Region (No. NJSY23032).

Conflict of interest

SH was employed by Thinkingbiomed (Beijing) Co. Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Accenture (2022). *Accenture China Digital Transformation Index 2022*. Available online at: https://www.accenture.com/cn-en/about/newsroom/company-news-release-china-dti-2022 (accessed January 20, 2023).

Ainunnisa, R. (2021). The influence of intellectual capital on the firm's value with profitability as intervening variable (empirical study on banking subsector companies listed on the Indonesia stock exchange (IDX) of the year 2017-2019). *Turk. J. Comput. Math. Educ.* 12, 713–722. doi: 10.17762/turcomat.v12i4.555

Andrews, R., Beynon, M. J., and McDermott, A. M. (2016). Organizational capability in the public sector: a configurational approach. *J. Publ. Admin. Res. Theor.* 26, 239–258. doi: 10.1093/jopart/muv005

Aryanto, V. D. W., and Chrismastuti, A. A. (2011). Model for digital economy in Indonesia. *Int. J. Innov. Digit. Econ.* 2, 39–55. doi: 10.4018/jide.2011040104

Bajari, P., Nekipelov, D., Ryan, S. P., and Yang, M. (2015). Machine learning methods for demand estimation. *Am. Econ. Rev.* 105, 481–485. doi: 10.1257/aer.p20151021

Banalieva, E. R., and Dhanaraj, C. (2019). Internalization theory for the digital economy. *J. Int. Bus. Stud.* 50, 1372–1387. doi: 10.1057/s41267-019-00243-7

Barr Pulliam, D., Brown Liburd, H. L., and Munoko, I. (2022). The effects of person-specific, task, and environmental factors on digital transformation and innovation in auditing: a review of the literature. *J. Int. Fin. Manag. Account.* 33, 337–374. doi: 10.1111/jifm.12148

Bongiorno, G., Rizzo, D., and Vaia, G. (2018). *CIOs and the Digital Transformation: A New Leadership Role*. Berlin: Springer International Publishing.

CAICT (2022). *Policy Research Report on Promoting Digital Transformation of Manufacturing Industry in Major Countries and Regions*. Available online at: http://www.caict.ac.cn/kxyj/qwfb/ztbg/202205/t20220525_401734.htm (accessed January 20, 2023).

Cennamo, C. (2021). Competing in digital markets: a platform-based perspective. *Acad. Manag. Perspect.* 35, 265–291. doi: 10.5465/amp.2016.0048

Chen, H., and Tian, Z. (2022). Environmental uncertainty, resource orchestration and digital transformation: a fuzzy-set QCA approach. *J. Bus. Res.* 139, 184–193. doi: 10.1016/j.jbusres.2021.09.048

Chen, J., Luo, J., Du, Y., and Liu, Q. (2021). What kinds of entrepreneurial ecosystem can produce country-level female high entrepreneurial activity? *Stud. Sci.* 39, 695–702. doi: 10.3969/j.issn.1003-2053.2021.04.013

Cheng, S., Fan, Q., and Huang, M. (2023). Strategic orientation, dynamic capabilities, and digital transformation of commercial banks: a fuzzy-set QCA approach. *Sustainability* 15:1915. doi: 10.3390/su15031915

Ciriello, R. F., Richter, A., and Schwabe, G. (2018). Digital innovation. *Bus. Inform. Syst. Eng.* 60, 563–569. doi: 10.1007/s12599-018-0559-8

Constantinides, P., Henfridsson, O., and Parker, G. G. (2018). Introduction-platforms and infrastructures in the digital age. *Inform. Syst. Res.* 29, 381–400. doi: 10.1287/isre.2018.0794

Corsini, L., Dammicco, V., and Moultrie, J. (2021). Frugal innovation in a crisis: the digital fabrication maker response to COVID-19. *R&D Manag.* 51, 195–210. doi: 10.1111/radm.12446

Council, S. (2015). *Notice of the State Council on Issuing "Made in China 2025"*. Available online at: https://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm (accessed January 20, 2023).

Crișan, E. L., and Stanca, L. (2021). The digital transformation of management consulting companies: a qualitative comparative analysis of Romanian industry. *Inform. Syst/ E-Bus. Manag.* 19, 1143–1173. doi: 10.1007/s10257-021-00536-1

Dahl, D. W., Fuchs, C., and Schreier, M. (2014). Why and when consumers prefer products of user-driven firms: a social identification account. *Manage. Sci.* 61, 1978–1988. doi: 10.1287/mnsc.2014.1999

De Crescenzo, V., Ribeiro-Soriano, D. E., and Covin, J. G. (2020). Exploring the viability of equity crowdfunding as a fundraising instrument: a configurational analysis of contingency factors that lead to crowdfunding success and failure. *J. Bus. Res.* 115, 348–356. doi: 10.1016/j.jbusres.2019.09.051

Deline, M. B. (2018). Framing resistance: identifying frames that guide resistance interpretations at work. *Manag. Commun. Quart.* 33, 39–67. doi: 10.1177/0893318918793731

Di, S., Yang, N., Ding, Y., Liu, H., and Leng, J. (2021). "Research on regional collaborative innovation model of manufacturing resources based on value chain," in *2021 IEEE 5th Information Technology, Networking, Electronic and Automation Control Conference (ITNEC)* (Beijing).

Douglas, E. J., Shepherd, D. A., and Prentice, C. (2020). Using fuzzy-set qualitative comparative analysis for a finer-grained understanding of entrepreneurship. *J. Bus. Ventur.* 35:105970. doi: 10.1016/j.jbusvent.2019.105970

Dul, J., Hauff, S., and Bouncken, R. B. (2023). Necessary condition analysis (NCA): review of research topics and guidelines for good practice. *Rev. Manag. Sci.* 17, 683–714. doi: 10.1007/s11846-023-00628-x

Dul, J., van der Laan, E., and Kuik, R. (2018). A statistical significance test for necessary condition analysis. *Org. Res. Methods* 23, 385–395. doi: 10.1177/1094428118795272

Eiteneyer, N., Bendig, D., and Brettel, M. (2019). Social capital and the digital crowd: involving backers to promote new product innovativeness. *Res. Pol.* 48:103744. doi: 10.1016/j.respol.2019.01.017

Fan, D., Li, Y., and Chen, L. (2017). Configuring innovative societies: the crossvergent role of cultural and institutional varieties. *Technovation* 66, 43–56. doi: 10.1016/j.technovation.2017.05.003

Fan, X., Wang, Y., and Lu, X. (2023). Digital transformation drives sustainable innovation capability improvement in manufacturing enterprises: based on FsQCA and NCA approaches. *Sustainability* 15:542. doi: 10.3390/su15010542

Felten, E., Raj, M., and Seamans, R. C. (2019). "The effect of artificial intelligence on human labor: an ability-based approach," in *Academy of Management Proceedings: Academy of Management* (Briarcliff Manor, NY, 15784.

Feng, Y., Gao, Y., Xia, X., Shi, K., Zhang, C., Yang, L., et al. (2024). Identifying the path choice of digital economy to crack the "resource curse" in China from the perspective of configuration. *Resour. Pol.* 91:104912. doi: 10.1016/j.resourpol.2024.104912

Fiss, P. (2007). A set-theoretic approach to organizational configurations. *Acad. Manag. Rev.* 32, 1180–1198. doi: 10.5465/amr.2007.26586092

Fiss, P. C. (2011). Building better causal theories: a fuzzy set approach to typologies in organization research. *Acad. Manag. J.* 54, 393–420. doi: 10.5465/amj.2011.60263120

Fitzgerald, M., Kruschwitz, N., Bonnet, D., and Welch, M. (2014). Embracing digital technology: a new strategic imperative. *MIT Sloan Manag. Rev.* 55, 1–12. Available online at: https://hbsp.harvard.edu/product/SMR487-PDF-ENG

Foerster-Metz, U. S., Marquardt, K., Golowko, N., Kompalla, A., and Hell, C. (2018). Digital transformation and its implications on organizational behavior. *J. EU Res. Bus.* 2018:340873. doi: 10.5171/2018.340873

Franke, N., Keinz, P., and Steger, C. J. (2009). Testing the value of customization: when do customers really prefer products tailored to their preferences? *J. Market.* 73, 103–121. doi: 10.1509/jmkg.73.5.103

Furnari, S., Crilly, D., Misangyi, V. F., Greckhamer, T., Fiss, P. C., and Aguilera, R. V. (2021). Capturing causal complexity: heuristics for configurational theorizing. *Acad. Manag. Rev.* 46, 778–799. doi: 10.5465/amr.2019.0298

Gerow, J. E., Thatcher, J. B., and Grover, V. (2015). Six types of IT-business strategic alignment: an investigation of the constructs and their measurement. *Eur. J. Inform. Syst.* 24, 465–491. doi: 10.1057/ejis.2014.6

Globaldata (2022). *Tencent—Digital Transformation Strategies*. Available online at: https://www.globaldata.com/store/report/tencent-enterprise-tech-analysis/ (accessed February 10, 2023).

Gobble, M. M. (2018). Digital strategy and digital transformation. *Res. Technol. Manag.* 61, 66–71. doi: 10.1080/08956308.2018.1495969

Goldfarb, A., and Tucker, C. (2019). Digital economics. *J. Econ. Literat.* 57, 3–43. doi: 10.1257/jel.20171452

Gorwa, R. (2019). What is platform governance? *Inform. Commun. Soc.* 22, 854–871. doi: 10.1080/1369118X.2019.1573914

Guiso, L., Sapienza, P., and Zingales, L. (2015). The value of corporate culture. *J. Fin. Econ.* 117, 60–76. doi: 10.1016/j.jfineco.2014.05.010

Hinings, B., Gegenhuber, T., and Greenwood, R. (2018). Digital innovation and transformation: an institutional perspective. *Inform. Org.* 28, 52–61. doi: 10.1016/j.infoandorg.2018.02.004

Iansiti, M., and Lakhani, K. R. (2020). *Competing in the Age of AI: Strategy and Leadership When Algorithms and Networks Run the World*. Boston, MA: Harvard Business Press. Available online at: https://cir.nii.ac.jp/crid/1130849379168310272 (accessed February 10, 2023).

Institute, Z. I. F. (2021). *Digital Transformation. McKinsey: The Failure Rate of Enterprise Digital Transformation Is as High as 80%*. Available online at: https://new.qq.com/rain/a/20210309A09UF000 (accessed February 10, 2023).

Kaganer, E., Gregory, R. W., and Sarker, S. (2023). A process for managing digital transformation: an organizational inertia perspective. *J. Assoc. Inform. Syst.* 24, 1005–1030. doi: 10.17705/1jais.00819

Kane, G., Palmer, D., Phillips, A., and Kiron, D. (2015). Is your business ready for a digital future? MIT Sloan Manage. Rev. 56, 37–44. doi: 10.7551/mitpress/11859.003.0005

Kim, H., Lee, J. N., and Han, J. (2010). The role of IT in business ecosystems. *Commun. ACM* 53, 151–156. doi: 10.1145/1735223.1735260

Lenka, S., Parida, V., and Wincent, J. (2016). Digitalization capabilities as enablers of value co-creation in servitizing firms. *Psychol. Market.* 34, 92–100. doi: 10.1002/mar.20975

Li, F. (2020). Leading digital transformation: three emerging approaches for managing the transition. *Int. J. Operat. Prod. Manag.* 40, 809–817. doi: 10.1108/IJOPM-04-2020-0202

Li, J., and Cao, Y. (2022). Digital transformation driving model of manufacturing enterprises based on configuration perspective. *RD Manage.* 34, 106–122. doi: 10.13581/j.cnki.rdm.20211535

Li, T. C., and Chan, Y. E. (2019). Dynamic information technology capability: concept definition and framework development. *J. Strat. Inform. Syst.* 28:101575. doi: 10.1016/j.jsis.2019.101575

Lida, Y. (2017). *Platform, Ecosystem, and the Future Sharing the Success in the Era of Industrial Digital Transformation*. Available online at: https://e-file.huawei.com/-/media/EBG/Download_Files/Publications/en/ICT21/Platform-Ecosystem-Future%20Sharing%20Success%20with%20Digital%20Transformation.pdf (accessed February 10, 2023).

Ling, X., Luo, Z., Feng, Y., Liu, X., and Gao, Y. (2023). How does digital transformation relieve the employment pressure in China? Empirical evidence from the national smart city pilot policy. *Human. Soc. Sci. Commun.* 10:617. doi: 10.1057/s41599-023-02131-w

Lipsmeier, A., Kühn, A., Joppen, R., and Dumitrescu, R. (2020). Process for the development of a digital strategy. *Proc. CIRP* 88, 173–178. doi: 10.1016/j.procir.2020.05.031

Liu, F., Liu, G., Wang, X., and Feng, Y. (2024). Whether the construction of digital government alleviate resource curse? Empirical evidence from Chinese cities. *Resour. Pol.* 90:104811. doi: 10.1016/j.resourpol.2024.104811

Liu, J., Yang, W., and Liu, W. (2021). Adaptive capacity configurations for the digital transformation: a fuzzy-set analysis of Chinese manufacturing firms. *J. Org. Change Manag.* 34, 1222–1241. doi: 10.1108/JOCM-02-2020-0043

Llopis-Albert, C., Rubio, F., and Valero, F. (2021). Impact of digital transformation on the automotive industry. *Technol. Forecast. Soc. Change* 162:120343. doi: 10.1016/j.techfore.2020.120343

Logg, J. M., Minson, J. A., and Moore, D. A. (2019). Algorithm appreciation: people prefer algorithmic to human judgment. *Org. Behav. Hum. Decision Process.* 151, 90–103. doi: 10.1016/j.obhdp.2018.12.005

Lokuge, S., Sedera, D., Grover, V., and Dongming, X. (2019). Organizational readiness for digital innovation: development and empirical calibration of a construct. *Inform. Manag.* 56, 445–461. doi: 10.1016/j.im.2018.09.001

Luftman, J., Lyytinen, K., and Zvi, T. B. (2017). Enhancing the measurement of information technology (IT) business alignment and its influence on company performance. *J. Inform. Technol.* 32, 26–46. doi: 10.1057/jit.2015.23

Lyytinen, K., Yoo, Y., and Boland, Jr. R. J. (2015). Digital product innovation within four classes of innovation networks. *Inform. Syst. J.* 26, 47–75. doi: 10.1111/isj.12093

Majchrzak, A., and Markus, M. (2012). "Technology affordances and constraints in management information systems (MIS)," in *Encyclopedia of Management Theory*, 832–836. Available online at: https://stsroundtable.com/wp-content/uploads/TechnologyAffordancesConstraints.of_.Technology.Ann_.M.2012.pdf (accessed February 17, 2023).

Manny, L., Duygan, M., Fischer, M., and Rieckermann, J. (2021). Barriers to the digital transformation of infrastructure sectors. *Policy Sci.* 54, 943–983. doi: 10.1007/s11077-021-09438-y

Margiono, A. (2021). Digital transformation: setting the pace. *J. Bus. Strat.* 42, 315–322. doi: 10.1108/JBS-11-2019-0215

Marion, T. J., Meyer, M. H., and Barczak, G. (2014). The influence of digital design and IT on modular product architecture. *J. Prod. Innov. Manag.* 32, 98–110. doi: 10.1111/jpim.12240

Matt, C., Hess, T., and Benlian, A. (2015). Digital transformation strategies. *Bus. Inform. Syst. Eng.* 57, 339–343. doi: 10.1007/s12599-015-0401-5

Miao, L. (2019). A research on the strategic digital transformation path of Chinese insurance enterprises. *Insur. Stud.* 57–65. doi: 10.13497/j.cnki.is.2019.04.005

Morakanyane, R., Grace, A., and O'Reilly, P. (2017). "Conceptualizing digital transformation in business organizations: a systematic review of literature," in *Digital Transformation-From Connecting Things to Transforming Our Lives*, eds. A. Pucihar, M. K. Borstnar, C. Kittl, R. Clarke, and R. Bons (Bled: University of Maribor Press), 427.

Müller, O., Fay, M., and Vom Brocke, J. (2018). The effect of big data and analytics on firm performance: an econometric analysis considering industry characteristics. *J. Manag. Inform. Syst.* 35, 488–509. doi: 10.1080/07421222.2018.1451955

Nambisan, S. (2017). Digital entrepreneurship: toward a digital technology perspective of entrepreneurship. *Entrepreneur. Theory Practice* 41, 1029–1055. doi: 10.1111/etap.12254

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. (2017). Digital innovation management. *MIS Quart.* 41, 223–238. doi: 10.25300/MISQ/2017/41:1.03

Nambisan, S., Wright, M., and Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: progress, challenges and key themes. *Res. Pol.* 48:103773. doi: 10.1016/j.respol.2019.03.018

Newell, S., and Marabelli, M. (2015). Strategic opportunities (and challenges) of algorithmic decision-making: a call for action on the long-term societal effects of 'datification'. *J. Strat. Inform. Syst.* 24, 3–14. doi: 10.1016/j.jsis.2015.02.001

Niu, S., Zhang, J., Luo, R., and Feng, Y. (2023). How does climate policy uncertainty affect green technology innovation at the corporate level? New evidence from China. *Environ. Res.* 237:117003. doi: 10.1016/j.envres.2023.117003

Nylén, D., and Holmström, J. (2019). Digital innovation in context: exploring serendipitous and unbounded digital innovation at the church of Sweden. *Inform. Technol. People* 32, 696–714. doi: 10.1108/ITP-05-2017-0148

Pagani, M., and Pardo, C. (2017). The impact of digital technology on relationships in a business network. *Industr. Market. Manag.* 67, 185–192. doi: 10.1016/j.indmarman.2017.08.009

Pagliarin, S., Hersperger, A. M., and Rihoux, B. (2019). Implementation pathways of large-scale urban development projects (lsUDPs) in Western Europe: a qualitative comparative analysis (QCA). *Eur. Plan. Stud.* 28, 1242–1263. doi: 10.1080/09654313.2019.1681942

Panico, C., and Cennamo, C. (2015). What drives a platform's strategy? Usage, membership, and competition effects. *Acad. Manag. Proc.* 2015:15942. doi: 10.5465/ambpp.2015.246

Park, Y., Fiss, P. C., and El Sawy, O. A. (2020). Theorizing the multiplicity of digital phenomena: the ecology of configurations, causal recipes, and guidelines for applying QCA. *Manag. Inform. Syst. Quart.* 44, 1493–1520. doi: 10.25300/MISQ/2020/13879

Qi, Y., and Xiao, X. (2020). Transformation of enterprise management in the era of digital economy. *J. Manage. World* 36, 135–152, 250. doi: 10.19744/j.cnki.11-1235/f.2020.0091

Qu, X., Qin, X., and Wang, X. (2023). Construction of frugal innovation path in the context of digital transformation: a study based on NCA and QCA. *Sustainability* 15:2158. doi: 10.3390/su15032158

Rai, A., Constantinides, P., and Sarker, S. (2019). Next generation digital platforms: toward human-AI hybrids. *Mis. Quart.* 43, III–IX. Available online at: https://wrap.warwick.ac.uk/113653/

Ryoo, C. K., Kim, Y. H., and Tahk, M. J. (2006). Optimal UAV formation guidance laws with timing constraint. *Int. J. Syst. Sci.* 37, 415–427. doi: 10.1080/00207720500438340

Scuotto, V., Arrigo, E., Candelo, E., and Nicotra, M. (2020). Ambidextrous innovation orientation effected by the digital transformation: a quantitative research on fashion SMEs. *Bus. Process Manag. J.* 26, 1121–1140. doi: 10.1108/BPMJ-03-2019-0135

Simsek, Z., Vaara, E., Paruchuri, S., Nadkarni, S., and Shaw, J. D. (2019). New ways of seeing big data. *Acad. Manag. J.* 62, 971–978. doi: 10.5465/amj.2019.4004

Smith, S. A. (2021). Digital transformation in marketing: a BYD case study. *Acad. J. Curr. Pract. Bus. Manag.* 6, 17–27. https://topjournals.org/index.php/AJCPBM/article/view/467

Swan, M., and De Filippi, P. (2017). Toward a philosophy of blockchain: a symposium: introduction. *Metaphilosophy* 48, 603–619. doi: 10.1111/meta.12270

Teece, D. J. (2018). Profiting from innovation in the digital economy: enabling technologies, standards, and licensing models in the wireless world. *Res. Pol.* 47, 1367–1387. doi: 10.1016/j.respol.2017.01.015

Teece, D. J. (2020). Fundamental issues in strategy: time to reassess. *Strat. Manag. Rev.* 1, 103–144. doi: 10.1561/111.00000005

Tilson, D., Lyytinen, K., and Sørensen, C. (2010). Research commentary-Digital infrastructures: the missing IS research agenda. *Inform. Syst. Res.* 21, 748–759. doi: 10.1287/isre.1100.0318

Timoshenko, A., and Hauser, J. R. (2019). Identifying customer needs from user-generated content. *Market. Sci.* 38, 1–20. doi: 10.1287/mksc.2018.1123

Trenkle, J. (2019). *Survival in the Digital Age-A Framework for Formulating a Digital Transformation Strategy in SME*. Tyne. Available online at: https://aisel.aisnet.org/iceb2019/34/ (accessed February 27, 2023).

Udovita, P. V. M. V.D. (2020). Conceptual review on dimensions of digital transformation in modern era. *Int. J. Sci. Res. Publ.* 10, 520–529. doi: 10.29322/IJSRP.10.02.2020.p9873

Verstegen, L., Houkes, W., and Reymen, I. (2019). Configuring collective digital-technology usage in dynamic and complex design practices. *Res. Pol.* 48:103696. doi: 10.1016/j.respol.2018.10.020

Vial, G. (2019). Understanding digital transformation: a review and a research agenda. *J. Strat. Inform. Syst.* 28, 118–144. doi: 10.1016/j.jsis.2019.01.003

Wang, R., Liang, Q., and Li, G. (2018). Virtual agglomeration: a new form of spatial organization that is deeply integrated with the new generation of information technology and the real economy. *J. Manage. World* 34, 13–21. doi: 10.19744/j.cnki.11-1235/f.2018.02.002

Wareham, J. D., Fox, P. B., and Cano Giner, J. L. (2014). Technology ecosystem governance. *SSRN Electr. J.* 25, 1195–1215. doi: 10.1287/orsc.2014.0895

Warner, K. S. R., and Wäger, M. (2019). Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal. *Long Range Plan.* 52, 326–349. doi: 10.1016/j.lrp.2018.12.001

Wei, W., and Qun, D. (2023). Inspur Tongsoft: leading the software industry with lean management. *State-Owned Assets Shandong* 11, 30–31. Available online at: https://kns.cnki.net/kcms2/article/abstract?v=Y2wviAwYlnKNwlyp2-rlKthK29NKCC4LQ5swXp7mAw-b8NDqn-MO1ZqtCNuBa7nxStxmT9yDD7JZrOn97GT6XuNCH7KndeUQPz94eo_jA9MfJu2xPJYfq-lekNurByn1ig0OpRMeM8XrKrJhGT2qxMdrmTDvjIqC&uniplatform=NZKPT&language=CHS

White, L., Lockett, A., Currie, G., and Hayton, J. (2020). Hybrid context, management practices and organizational performance: a configurational approach. *J. Manag. Stud.* 58, 718–748. doi: 10.1111/joms.12609

Yadav, M. S., and Pavlou, P. A. (2014). Marketing in computer-mediated environments: research synthesis and new directions. *J. Market.* 78, 20–40. doi: 10.1509/jm.12.0020

Yang, H., Ma, J., and Chattopadhyay, A. (2021). *How Xiaomi Became an Internet-of-Things Powerhouse*. Available online at: https://hbr.org/2021/04/how-xiaomi-became-an-internet-of-things-powerhouse (accessed September 18, 2023).

Yin, W., and Ran, W. (2022). Supply chain diversification, digital transformation, and supply chain resilience: configuration analysis based on fsQCA. *Sustainability* 14:7690. doi: 10.3390/su14137690

Yoo, Y., Boland Jr, R. J., Lyytinen, K., and Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Org. Sci.* 23, 1398–1408. doi: 10.1287/orsc.1120.0771

Yoo, Y., Henfridsson, O., and Lyytinen, K. (2010). Research commentary-the new organizing logic of digital innovation: an agenda for information systems research. *Inform. Syst. Res.* 21, 724–735. doi: 10.1287/isre.1100.0322

Yupeng, C., Raghuram, I., and Garud, I. (2016). Modeling multimodal consumer heterogeneity in conjoint analysis - a sparse learning approach. *Market. Sci.* 36, 140–156. doi: 10.1287/mksc.2016.0992

Zhang, Z., Shi, K., Gao, Y., and Feng, Y. (2023). How does environmental regulation promote green technology innovation in enterprises? A policy simulation approach with an evolutionary game. *J. Environ. Plan. Manag.* 2023:2276064. doi: 10.1080/09640568.2023.2276064

Zhang, Z., Zhang, J., Ye, B., and Chen, Y. (2022). The impact of digital transformation on business model innovation. *Sci. Technol. Prog. Policy* 39, 114–123. doi: 10.6049/kjjbydc.2021020532

Zhao, L., He, Q., Guo, L., and Sarpong, D. (2023). Organizational digital literacy and enterprise digital transformation: evidence from chinese listed companies. *IEEE Trans. Eng. Manag.* 2, 1–14. doi: 10.1109/TEM.2023.3241411