Windows of opportunity, strategic cognition and enterprise digital transformation

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Received 23 September 2023
Revised 8 January 2024
Accepted 6 February 2024

Abstract

Purpose – The purpose of this paper is to discuss how enterprises can effectively perceive and use the digital opportunities brought about by digital technologies and dynamic environments and how they can enhance their capabilities to realize digital transformation and adapt to the development of the digital economy era.

Design/methodology/approach – Based on the windows of opportunity theory and strategic cognition theory, this paper conducts an empirical analysis of the questionnaire data of 268 enterprises and discusses the influence of external windows of opportunity and internal windows of opportunity on the digital transformation of enterprises, as well as the action mechanism of strategic cognition and entrepreneurship.

Findings – The results show that both the external windows of opportunity and the internal windows of opportunity have significant positive effects on the digital transformation of enterprises. Strategic cognition plays a partial mediating role in the external windows of opportunity and the internal windows of opportunity influencing the enterprise digital transformation process. Entrepreneurship plays a positive regulatory role in the process of external windows of opportunity and internal windows of opportunity influencing strategic cognition.

Originality/value – This paper deepens the relationship between internal and external windows of opportunity and enterprise digital transformation and contributes a new theoretical cognition. This paper integrates the strategic cognition theory to clarify the complex process mechanism of digital transformation using external situational opportunities and internal capabilities. This paper introduces entrepreneurship into the path mechanism of digital transformation and expands the characteristics of the study of digital transformation antecedents to the individual level within the enterprise.

Keywords Windows of opportunity, Strategic cognition, Digital transformation, Entrepreneurship

Paper type Research paper

JEL classification – O31, D22, L2

This research was supported by the National Natural Science Foundation of China [72102117] and Shandong Provincial Natural Science Foundation [ZR2020QG016].

Competing interest: The authors of this publication declare there are no competing interests.

Introduction

With the rapid development of emerging digital technologies, including big data, blockchain and artificial intelligence, the world has entered the era of the digital economy (Del Giudice and Della Peruta, 2016). Amidst the digital economy wave, enterprises have embarked on the path of digital transformation, aiming to provide diversified information and forward-looking insights for enhancing management decisions and fostering business model innovation (Bresciani *et al.*, 2018). Furthermore, the outbreak of the COVID-19 pandemic has plunged enterprises into a dilemma of resource scarcity and transportation disruption, further intensifying the imperative for digital transformation (Ye *et al.*, 2022). In this context, the issue of how enterprises can successfully execute digital transformation and the internal and external factors influencing this process have become prominent topics of discussion in both industry and academia (Kraus *et al.*, 2021).

Digital transformation entails the digitalization of all aspects and components within an enterprise's business activities, facilitated by digital technology, thereby driving the reorganization and evolution of business processes and production methodologies (Broekhuizen *et al.*, 2021; Matt *et al.*, 2015). Scholars have recently concentrated on multiple facets of digital innovation, including digital product innovation (Boudreau, 2012; Lyytinen *et al.*, 2015), digital process innovation (Nambisan *et al.*, 2017), digital organizational innovation (Hinings *et al.*, 2018) and digital business model innovation (Henfridsson *et al.*, 2018). These studies explore both the conceptual underpinnings and the outcomes of these innovations (Ferreira *et al.*, 2019; Zaoui and Souissi, 2020). It is noteworthy that digital transformation poses significant challenges for enterprises. The absence of thorough consideration of the technology market's realities and introspective assessment of their own capabilities can result in enterprises falling into transformation pitfalls (Ye *et al.*, 2022). Nonetheless, existing research frequently overlooks the investigation into the precursors of digital transformation. While several studies have examined the influence of technological evolution and market trends on enterprises' digital transformation, the majority are from an external enterprise perspective, often neglecting the effects of internal factors such as crucial innovation capabilities and team cognition (Ciampi *et al.*, 2021). Previous scholarly work in innovation management has highlighted that successful innovation hinges on a firm's capacity to assimilate external resources, integrate them with existing ones and create new value (Roper *et al.*, 2008). Consequently, it is imperative to delve into the intrinsic relationship between a firm's internal capabilities and digital transformation and further investigate the interplay between internal and external opportunities influencing digital transformation (Helfat and Winter, 2011; Lee and Malerba, 2017).

Previous research has identified strategic cognition, as the logical process through which an enterprise converts its cognitive framework into decision-making actions, involving systematic information filtering and processing based on the understanding and analysis of contextual information (Bundy *et al.*, 2013). Strategic cognition guides enterprises in analyzing and understanding various windows of opportunity, leading to the adoption of appropriate innovation strategies, resource absorption, integration and related behaviors (Eggers and Kaplan, 2013; Raffaelli, 2019). It increasingly serves as a crucial intermediary linking opportunities with digital transformation in enterprises. Therefore, examining the mediating role of strategic cognition in how windows of opportunity influence enterprise digital transformation can elucidate the inherent factors promoting digital transformation and their mechanisms. Additionally, entrepreneurship encompasses traits such as innovation, risk-taking and risk management inherent in entrepreneurs, serving as the driving force and foundation for resource allocation and technological innovation in enterprises (Covin and Slevin, 1991; Miller, 1983; Venkatraman, 1989). Entrepreneurship,

molded by long-term and specific business contexts, embodies distinct experiences (Wrede *et al.*, 2020) that enable firms to embed innovation strategies into actions influencing their organizational logic (Li Q, 2021) and to proactively discern internal and external environmental factors, making strategic decisions to capitalize on windows of opportunity (Adner and Helfat, 2003; Hitt *et al.*, 2011). Consequently, this paper delves further into the moderating role of entrepreneurship on the interplay between windows of opportunity and firms' strategic cognitions, aiming to explore deeper into the internal drivers of digital transformation and extend the boundary conditions of the related findings.

In summary, enterprise digital transformation has emerged as a focal point in contemporary academic discourse. While existing research primarily concentrates on its conceptual definition, characteristics and outcomes (Ferreira *et al.*, 2019; Kraus *et al.*, 2021; Matt *et al.*, 2015; Zaoui and Souissi, 2020), investigations into the antecedents of enterprise digital transformation, especially from internal drivers such as strategic cognition and entrepreneurship, require further development and refinement (Van Veldhoven and Vanthienen, 2022). Consequently, this study develops a model of the antecedents and pathways of enterprise digital transformation. It does so by conducting a questionnaire survey involving 268 digitally transformed enterprises, grounded in an extensive review of literature, to thoroughly explore the relationship between internal and external windows of opportunity and enterprise digital transformation. The primary contributions of this research are as follows: the division of the antecedents of enterprise digital transformation into external and internal windows of opportunity (Helfat and Winter, 2011; Lee and Malerba, 2017), and an in-depth exploration of their interrelation, addressing the current research gap in internal antecedents of digital transformation (Ciampi *et al.*, 2021) and extending the scope from merely external factors to include the comprehensive interplay between environmental opportunities and organizational capabilities; the novel development of the "window of opportunity-strategic cognition-enterprise digital transformation" research framework. This framework methodically elucidates the intricate influence of both internal and external windows of opportunity on enterprise digital transformation and the complex mechanisms involved (Lee and Malerba, 2017; Love *et al.*, 2014), thereby enriching the application of strategic cognition theory in digital transformation studies; the analysis of the moderating effect of entrepreneurship on the relationship between window of opportunity and strategic cognition in digital transformation. This aspect brings the study of digital transformation antecedents to an individual level, offering fresh insights into how digitally transformed firms can develop a cognitive model at the strategic level to make informed decisions by recognizing environmental opportunities, such as market and technological trends, and leveraging organizational capabilities to capitalize on these opportunities and integrate resources (Helfat and Peteraf, 2015; Hodgkinson and Healey, 2011).

Theoretical basis and research hypothesis

Windows of opportunity and enterprise digital transformation

Effectively capitalizing on windows of opportunity is crucial for firms aspiring to achieve transformation and leapfrog development (Kang and Song, 2017). Firms must navigate the challenges of rapidly evolving market environments and technological advancements and possess the capability to reconfigure, integrate and transform both existing and new resources to develop innovative and complex resource portfolios (O'Reilly and Tushman, 2013). Building on the insights of scholars Lee and Malerba (2017), as well as Helfat and Winter (2011), this study aims to expand and deepen the understanding of the windows of opportunity for digital transformation in enterprises, encompassing both external and internal opportunities. The external opportunity window centers on market opportunities emerging from shifts in market

demand or business cycles and technological opportunities presented by new technologies or disruptive innovations (Lee and Malerba, 2017). Meanwhile, the internal opportunity window highlights the traditional capacity to optimize internal management and enhance enterprise efficiency using existing resources, alongside the advanced capability to identify opportunities and threats and integrate digital resources (Helfat and Winter, 2011). Based on these insights, this paper endeavors to establish the relationship between external and internal opportunities and enterprise digital transformation. The detailed analysis is as follows.

External windows of opportunity

Market opportunities. This concept underscores the impact of market demand conditions, consumer preference traits and the structure of market competition on enterprise digital transformation (Landini *et al.*, 2020). Initially, digital channels such as community media and electronic advertising have become key mediums for enterprises to disseminate product information and latest marketing concepts (Wang, 2020). The expanding internet user base and data volumes mirror market demands. Enterprises can engage with customers through various online platforms to build a stable customer base, enhance user insights, create user profiles and drive digital transformation by adeptly targeting potential markets through diverse marketing strategies (Mariani and Fosso Wamba, 2020). Furthermore, in the digital era, enterprises use digital technology for the collection, storage and processing of vast information (Mathiasen and Clausen, 2019), enabling them to accurately discern users' personalized needs and consumption preferences. This facilitates the discovery of relevant insights and value extraction, allows for rapid response to consumer demands, enhances perceived consumer benefits, targets R&D efforts and minimizes risks associated with misguided innovation (Lo *et al.*, 2020). Additionally, enterprises undergoing digital transformation analyze the market's competitive structure to comprehend the competitive hierarchy and technological disparities among market players, identify future target markets and infiltrate competitors' user groups (Guo *et al.*, 2018). Strategic priorities in digital transformation are planned accordingly, leveraging digital technology to enhance productivity, generate economies of scale and accrue digital dividends (Deichmann *et al.*, 2016), thus securing a competitive edge and a head start in digital transformation.

Technology opportunities. This concept highlights the influence of factors such as iteration rate (Augustsson *et al.*, 2019), innovation space and acquisition costs on a firm's digital transformation journey (Paoloni *et al.*, 2020). Initially, digital technologies, now integral to economic and social frameworks, are blurring the lines of innovation stages and imparting a rapidly iterative nature to digitally enhanced products and services (Mathiasen and Clausen, 2019). This evolution not only streamlines internal product and delivery processes but may also lead to novel product and service innovations, or even a fusion of both (Blichfeldt and Faullant, 2021), thereby creating new markets and securing a more sustainable competitive advantage. Furthermore, the convergence of digital innovation facilitates the ongoing expansion of technological innovation spaces. Digital technologies can be integrated into a diverse range of production activities and technological types, encompassing the entire industrial chain. This integration improves production and management efficiency, thereby enhancing the synergistic application of factors across various sectors (Adner and Kapoor, 2010), optimizing resource allocation and accelerating the efficient allocation of resources toward industrial digital transformation and development (Chen *et al.*, 2020). Additionally, the widespread adoption of data-centric production methods has transformed economic operations. This shift enables unlimited data replication and sharing, instant interconnectivity and interoperability, reduces data processing and transaction costs, enables precise resource allocation and enhances

enterprise productivity through cost reduction and increased efficiency (Goldfarb and Tucker, 2019).

In conclusion, this study proposes the following hypothesis:

H1a. There is a positive correlation between market opportunities and enterprise digital transformation.

H1b. There is a positive correlation between technology opportunities and enterprise digital transformation.

Internal windows of opportunity

Ordinary capabilities. Ordinary capabilities underscore the influence of elements such as cultural construction, organizational coordination and operational management on the enterprise's digital transformation. Cultural construction capabilities aim to maximize the utilization of human capital, consolidating the dispersed value of employees through varied and adaptable employment methods, offering digital skills training and incentives to encourage proactive problem-solving and solution proposals and fostering open and open-source innovation activities (Chen *et al.*, 2020). Organizational coordination capabilities facilitate an enhanced awareness and level of coordination among various organizational units, mitigating conflicts and discrepancies among different functional departments and stakeholders, fostering a more balanced and unified interest alignment (Van Lancker *et al.*, 2016; Haneda and Ito, 2018) and eliminating barriers in formulating and advancing the digital transformation strategy. Operational management capabilities enable companies to persistently refine and replicate existing knowledge, applying it to skills, processes and structures aligned with their original development trajectories (Zhou, 2020). Concurrently, the storage of digital resources in databases aids organization members in accessing and using these resources, enhancing the frequency and efficiency of their use in innovative activities, augmenting the existing database, digital products, services and skills (Brunswicker and Schecter, 2019) and elevating the current digital marketing channels to further enterprise digital transformation.

Higher-order capabilities. Higher-order capabilities are central to open innovation theory, which underscores the significance of integrating the innovation process with external resources (Karagiannaki *et al.*, 2017). Firms ought to leverage these capabilities in developing technologies and products, while also using internal ordinary capabilities and using both their own and external channels to collaboratively explore markets (Matarazzo *et al.*, 2021). These capabilities highlight the influence of factors such as strategic responsiveness, resource integration and value reconstruction in the digital transformation of companies. Strategic responsiveness permits enterprises to identify emerging digital trends and evolving user demands within the digital economy (Mishra *et al.*, 2019). Through the establishment of long-term digital visions, enterprises can foster a mindset of digital thinking (Martínez-Caro *et al.*, 2020), enabling them to identify appropriate digital knowledge sources, develop digital skills and management systems, support strategic adjustments and enhance their core competitiveness continuously (Wang X T, 2014). Moreover, the effective utilization of resources holds greater importance than the resources themselves (Wernerfelt, 1984). Resource integration capabilities stress the need for enterprises to assimilate and amalgamate external resources, technologies and other elements, leveraging digital knowledge to expedite the deployment of digital technology in production and service operations (Matarazzo *et al.*, 2021). Value reconstruction capabilities involve the capacity to discard outdated mindsets, business processes and management models, redefining value systems aligned with novel strategic positions and developmental concepts, fostering ongoing

innovation, balancing internal and external collaboration and crafting adaptable governance frameworks (Ciampi *et al.*, 2021). This approach enhances the efficiency of enterprises in assimilating and transforming digital resources (Karimi and Walter, 2015). Consequently, these capabilities are instrumental in the digital transformation process.

In conclusion, this study proposes the following hypothesis:

H2a. There is a positive correlation between ordinary capabilities and enterprise digital transformation.

H2b. There is a positive correlation between higher-order capabilities and enterprise digital transformation.

Furthermore, research indicates that a firm's innovative development significantly relies on its capability to assimilate external resources, amalgamate them with existing ones and, consequently, introduce new products and services (Roper *et al.*, 2008). In essence, it is imperative for firms to pinpoint, amalgamate and use both internal and external resources to optimize and perpetuate innovation upon the emergence of opportunities(Zahra and George, 2002). With increasing environmental volatility, complexity and uncertainty amid digital transformation, firms must adapt to the external milieu for recognizing new opportunities and threats (Holmström, 2018) and concurrently rely on higher-order capabilities for harnessing external resources, alongside routine capabilities for managing internal resources, to effectively respond to the dynamic environment (Helfat and Winter, 2011). Specifically, the advent of technological and market windows of opportunity introduces various resources for enterprises to undertake digital transformation and strong internal capabilities enhance the organization's capacity to discern and exploit external resources. This enables enterprises to filter essential and beneficial information from the plethora of data, mitigating behavioral selection biases caused by information overload (Mishra *et al.*, 2019), thereby accentuating the significance of external opportunities in digital transformation. The synergistic interplay between internal capabilities and external opportunities enables enterprises to effectively acquire advanced knowledge, discern novel opportunities and enhance existing resources during digital transformation. This facilitates a more efficient utilization of current innovation elements, improvement of existing products, processes and operations and fosters the creation of new products and services (Azadegan *et al.*, 2013; Matarazzo *et al.*, 2021; Warner and Wäger, 2019). Consequently, the interwoven impact of both external and internal windows of opportunity profoundly influences an organization's digital transformation process.

In conclusion, this study proposes the following hypothesis:

H3. There is a positive relationship between the interaction effect of external and internal windows of opportunity and the digital transformation of enterprises, and the interaction effect is greater than the effect of both individually.

Mediating role of strategic cognition

Strategic cognition involves the process of filtering information and constructing meaning about strategic events in the decision-making process at the firm level, as well as the systematic reception and processing of external information by firms (Hodgkinson and Healey, 2011). Research indicates that strategic cognition acts as an important bridge between internal and external organizational contexts and organizational decision-making (Menon, 2018). Furthermore, through the updating of their cognitive paradigms, managers facilitate the integration of resources toward the firm's strategic activities, significantly influencing the outcomes of the firm's strategic decisions (Kaplan, 2011). When a window of

opportunity emerges, a firm's ability to identify and recognize the innovation opportunities within it significantly influences its willingness to engage in innovation activities, which subsequently affects the firm's integration and allocation of innovation resources (Gans, 2016; Osiyevskyy and Dewald, 2015). Managers possessing robust strategic cognition can form strategic perceptions referencing the characteristics of the organization, industry and environment within their cognitive maps, leveraging their experience, values and diverse knowledge structures (Bundy *et al.*, 2013; George and Desmidt, 2018; Wayland, 2019). This, in turn, enables firms to effectively recognize and capitalize on external market and technological opportunities, integrating internal and external resources to foster innovation and development (Vecchiato, 2017).

In the context of enterprise digital transformation, when digital technologies and emerging market trends offer windows of opportunity, managers enhance their understanding of the strategic value of digital transformation by articulating and elucidating the vision and goals of the enterprise's digital transformation. This process fosters the engagement of departments and employees in advancing digital transformation (Arcidiacono *et al.*, 2022; Lokuge *et al.*, 2019). Second, managers develop a more comprehensive and precise understanding of strategic issues related to enterprise digital transformation by discerning valuable information within these windows of opportunity (Eggers and Kaplan, 2013). Consequently, they integrate resources, methodically plan digital transformation initiatives, develop digital business models and thus enhance the performance of enterprise digital transformation (Pandza and Thorpe, 2009). Finally, managers evaluate the rationality and feasibility of the enterprise digital transformation strategy by considering the internal resources, capabilities and other pertinent factors of the enterprise. They then identify the optimal path for digital transformation, gaining a comprehensive and detailed understanding of the conditions, possibilities and systemic factors involved in the strategy. This approach significantly supports the progression of the enterprise's digital transformation (Eggers and Kaplan, 2013; Raffaelli, 2019).

In conclusion, this study proposes the following hypothesis:

H4. Strategic cognition has a mediating role between external windows of opportunity and enterprise digital transformation.

H5. Strategic cognition has a mediating role between internal windows of opportunity and enterprise digital transformation.

Moderating role of entrepreneurship

The concept of entrepreneurship was initially characterized as the spirit of blazing new trails, embodying dynamic and creative activities in the face of uncertainty (Knight, 1921). Building on this, scholars have explored entrepreneurship from various dimensions (Covin and Slevin, 1991; Miller, 1983; Venkatraman, 1989). Despite the absence of a unified conceptual definition, there is consensus on certain key characteristics of entrepreneurship, specifically, the spirit of innovation and risk-taking (Covin *et al.*, 2006; Kreiser *et al.*, 2010). Furthermore, it has been noted that entrepreneurship, representing a synthesis of entrepreneurial management thinking and wisdom, varies in connotations across different institutional environments and contexts (Daniel *et al.*, 2019). Notably, the sense of mission and career-mindedness emphasized in Chinese culture imparts unique characteristics to entrepreneurship in the Chinese context (Morris *et al.*, 2005). Consequently, this study examines the moderating role of entrepreneurship on the relationship between the window of opportunity and strategic cognition, focusing on three dimensions: innovative spirit, risk-taking spirit and career-driven spirit. First, innovative entrepreneurs

exhibit heightened sensitivity to changes in markets, technologies and resources, excelling at identifying potential opportunities arising from shifts in both the external environment and internal capabilities (Singh and Hess, 2017). When the window of opportunity emerges, the spirit of innovation motivates managers to focus on digital innovation, to discern and assimilate key information and to convert it into strategic cognitive patterns at the enterprise level (Filatotchev *et al.*, 2009; Song *et al.*, 2017), thereby fostering the development of the enterprise's digital strategic cognition. Second, digital innovation activities often entail significant uncertainty (Wrede *et al.*, 2020), and managers possessing a risk-taking disposition are better equipped to actively weigh the benefits of digitalization and embrace risks during the enterprise's digital transformation process (Hirshleifer *et al.*, 2012). When a window of opportunity emerges, managers with this trait use their inherent risk-taking spirit and the consequent strategic decision-making ability to enhance the formation of digital strategic cognition, thus more effectively seizing the window of opportunity (Hirshleifer *et al.*, 2012). Finally, a robust career-driven spirit consistently prompts managers to encourage proactive communication and experience sharing among employees (Singh and Hess, 2017). This approach not only enhances team knowledge sharing and diffusion but also aids organizational members in developing *a priori* knowledge for identifying cross-domain opportunities (Filatotchev *et al.*, 2009). Furthermore, it cultivates internal legitimacy for the enterprise's digital transformation, thereby contributing to the formation of a shared digital strategic cognition within the organization.

In conclusion, this study proposes the following hypothesis:

H6. Entrepreneurship enhances the positive correlation between external windows of opportunity and digital strategic cognition.

H7. Entrepreneurship enhances the positive correlation between internal windows of opportunity and digital strategic cognition.

Figure 1 shows the theoretical framework of this study.

Research design

Sample and data collection

The scales used in this study predominantly originate from English literature, having been translated into Chinese and subsequently back-translated by bilingual experts. To guarantee

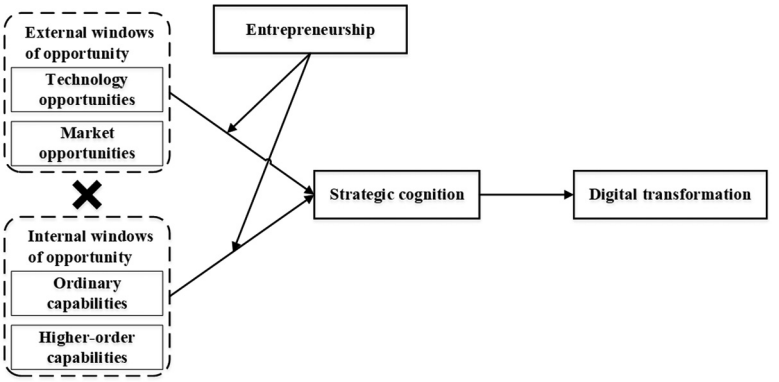

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Figure 1. Theoretical framework of this study

accurate comprehension and completion of the questionnaire, initial trials involving online interviews and questionnaire tests were conducted with various types of companies prior to the formal distribution of the questionnaire. After evaluating the service performance of various platforms, the "Questionnaire Star" platform was selected for conducting the formal research. Participation was restricted to middle and senior managers of enterprises. Data collection occurred between November 2022 and March 2023. A total of 307 questionnaires were collected, yielding 268 valid responses, resulting in an effective questionnaire recovery rate of 87.3%. This excludes questionnaires completed in an unusually short duration or those exhibiting obvious similarities. Among the valid samples, strategic emerging industries comprised 41.4%, encompassing sectors such as new-generation information, new energy, energy conservation and environmental protection, new-energy vehicles, biomedicine, high-end equipment and new materials. A majority of the surveyed enterprises were private (85.1%) and had been established within the past 10 years (85.4%). Detailed information about the samples is presented in Table 1.

Variables

To ensure the reliability and validity of the study, a comprehensive review of pertinent literature, both domestic and international, was conducted. This review facilitated the identification of frequently used and well-established variable scales. Subsequently, the Likert seven-point scale was used, where "1" indicates "strongly disagree" and "7" signifies "strongly agree", with intermediate values reflecting progressively higher levels of agreement. This study will use abbreviations for each variable in subsequent tables. Details are given in Table 2:

- Dependent variable: enterprise digital transformation. Drawing on the scale developed by Hess *et al.* (2016) as a reference, the digital transformation measurement scale in this study encompasses three dimensions: organizational strategic goal, way of value creation and ability structure matching, comprising a total of nine items. Examples of these items include, but are not limited to: "Our company endeavors to utilize digital technology to develop new products based on existing ones", and "Our company is capable of aligning new operational activities post-digital implementation with the existing organizational structure, or establishing a new structure to support these activities" (Hess *et al.*, 2016). Furthermore, digital strategic orientation refers to the deliberate strategic positioning of organizations aimed at pursuing digital opportunities to secure competitive advantages. It reflects the attitudes and perceptions of enterprises toward emerging digital technologies and guides them in undertaking digital transformation through strategic implementation activities. Consequently, this study selects digital strategic orientation as a proxy variable to perform robustness testing.
- Independent variables: external windows of opportunity and internal windows of opportunity. The external window of opportunity for enterprises is bifurcated into two primary dimensions: the market window and the technological window of opportunity. The market window of opportunity is gauged using three indicators: market demand conditions, consumer preference characteristics and market competition structure. This approach is augmented by the definitions provided by Klenner *et al.* (2013) and Lee and Malerba (2017), encompassing six question items. The technological window of opportunity is evaluated through three indicators: iteration rate, innovation space and acquisition cost, as defined by Landini *et al.* (2017) and the research of Lee and Malerba (2017), resulting in the design of six

Categories	Items	No. of samples	%
Year of establishment	5 years or less	103	38.4
	6–10 years	126	47
	11–15 years	30	11.2
	16–20 years	7	2.6
	More than 20 years	2	0.7
Employee size	50 people or less	206	76.9
	51–100 people	37	13.8
	101–500 people	16	6
	501–1,000 people	6	2.2
	More than 1,000 people	3	1.1
Annual operating revenue	1m or less	114	42.5
	1.01–10m	84	31.3
	10.01–50m	41	15.3
	50.01–100m	18	6.7
	More than 100m	11	4.1
Nature of ownership	State-owned enterprises	3	1.1
	Private enterprise	228	85.1
	Foreign and Hong Kong, Macao and Taiwan investment enterprises	7	2.6
	Joint venture	28	10.4
	Other	2	0.7
Industry	Traditional manufacturing	61	22.8
	Service industry	88	32.8
	Strategic emerging industry	111	41.4
	Other industry	8	3
Gender	Male	131	48.9
	Female	137	51.1
Age	20–30 years old	90	33.6
	31–45 years old	131	48.9
	46–55 years old	38	14.2
	Over 55 years old	9	3.4
Highest education	Under college	3	1.1
	College	96	35.8
	Undergraduate	138	51.5
	Master's degree	23	8.6
	Doctoral degree	8	3
Years of work	Within 3 years	35	13.1
	3–5 years	172	64.2
	5–10 years	55	20.5
	More than 10 years	6	2.2

Note: $N = 268$
Source: This table is created by the authors

Table 1. Descriptive statistical characteristics of the samples

items. The internal window of opportunity encompasses both higher-order and conventional capabilities. Higher-order capabilities entail strategic responsiveness, resource integration and value reconstruction, with six items derived for investigation from the scales developed by scholars such as Boccardelli and Magnusson (2006), Teece (2007) and Helfat and Peteraf (2003). The scale for conventional competence is extracted from the studies of Haneda and Ito (2018), Van Lancker *et al.* (2016) and Cavaliere and Lombardi (2015), encompassing culture-building competence, organizational coordination competence and operational management competence, with six measurement items.

Variable	Symbols	Definition
Dependent variable	DT	Digital transformation
	(DSO)	(Digital strategic orientation as a robustness test tool)
Independent variable	MO	Market opportunities
	TO	Technology opportunities
	HC	Higher-order capabilities
	OC	Ordinary capabilities
	EWO	External windows of opportunity
	IWO	Internal windows of opportunity
Mediating variable	SC	Strategic cognition
Moderating variable	En	Entrepreneurship
Control variable	EstYear	Year of establishment
	EmpSize	Employee size
	Reve	Annual operating revenue
	Natu	Ownership nature
	Indus	Industry type
	Edu	Highest education (the most advanced level of educational of respondents)
	WYear	Years of work

Source: This table is created by the authors

Table 2. Variable definition table

- Mediating variable: strategic cognition. Drawing upon the research of Nisbett *et al.* (2011), we adopted six questions, including "The company emphasizes the simultaneous consideration of customers, resources, the environment, and other factors", "the company believes that focusing on details is more crucial than an overall analysis", and "The company stresses that a specific breakthrough is more conducive to enhancing competitiveness than comprehensive improvement". These questions were used to measure strategic cognition from the perspectives of holistic and analytical thinking, respectively.
- Moderating variable: entrepreneurship. This paper examines the impact of entrepreneurial and management team characteristics on the digital transformation of companies through the implementation of digital strategies, leveraging internal and external windows of opportunity in areas such as innovation, risk-taking and career-driven spirit. The scale, developed by scholars including Vella (2001) and Goffin *et al.* (1996), was adopted, comprising a total of six items.
- Control variables. In this study, control variables include the number of years since the enterprise's establishment, employee size, annual operating income, ownership nature and industry affiliation. Furthermore, the moderating variable of entrepreneurship, encompassing individual traits of managers and entrepreneurs, necessitates the inclusion of their years of experience and highest education as additional control variables. Specifically, the highest education refers to the most advanced level of educational certification attained in the respondents' completed educational journeys.

Common method bias and reliability and validity tests

Homologous deviation test

Data derived from a single source in questionnaire research may result in common method bias (Podsakoff *et al.*, 2003). To mitigate potential covariance issues arising from respondents

completing all question items, Harman's single-factor test was used (Harman, 1976). Unrotated factor analysis of the questionnaire items revealed that the cumulative explained variance of the seven factors with eigenvalues exceeding 1 was 80.253%, and the variance accounted for by the first principal component was a mere 15.284%, suggesting the absence of significant homoscedasticity bias in this study.

Reliability and validity test

Reliability and validity of the data were assessed using SPSS 24.0 and AMOS 24.0 software. The results, as illustrated in Table 3, indicated that Cronbach's alpha coefficients and combined reliability (CR) values for the latent variables in the theoretical model all exceeded 0.9, demonstrating good internal consistency and reliability of the scales. Regarding validity, the analysis in Table 3 shows that the convergent validity of each latent variable was evaluated using confirmatory factor analysis. The standardized factor loadings (λ) of all items exceeded 0.8, and the average variance extracted (AVE) values surpassed 0.7, indicating strong convergent validity of the questionnaire (Aiken, 1991; Bagozzi *et al.*, 1991). Furthermore, the AVEs for each variable exceeded their respective correlation coefficients with other variables, signifying high discriminant validity of the research scale (Fornell and Larker, 1981). As evident in Table 4, the seven-factor hypothesized model exhibited a significantly better fit. Specifically: $\chi^2/df = 1.112$, below 3; NFI = 0.922, RFI = 0.916, IFI = 0.992, TLI = 0.991, CFI = 0.991, all exceeding 0.9; SRMR = 0.032, below 0.05; RMSEA = 0.02, under the critical threshold of 0.08. The model demonstrates clear discriminability among the included variables: market opportunity windows, technological opportunity windows, higher-order capabilities, conventional capabilities, strategic cognition, entrepreneurial spirit and enterprise digital transformation. Therefore, the reliability of the scales used meets the requirements.

Empirical analysis and results

This study used hierarchical regression analysis to test each hypothesis, systematically introducing control variables, main effects and interaction effects into each model sequentially (Gelman and Hill, 2006).

Descriptive statistics and correlation

The descriptive statistics and correlation analysis presented in Table A1 reveal that the correlation coefficients among market opportunities, technological opportunities, higher-order capabilities, conventional capabilities, strategic cognition, digital transformation of enterprises and entrepreneurship are all ≤ 0.477, with significant associations, thereby offering preliminary support for the regression study. Moreover, the fact that the variance inflation factor values of all variables are significantly below the critical threshold of 10 suggests the absence of any serious multicollinearity issues within the regression model. This finding is in line with the research expectations and offers preliminary data support for the hypothesis testing in this study.

Main effect analysis and mediation effect analysis

Main effect test. Hierarchical regression analysis was used to test the hypotheses, controlling for pertinent variables including firm age, employee size, annual operating revenue, ownership nature, industry type and the education and work experience of managers, as delineated in Tables 5 and 6. Table 5 presents the regression results for strategic cognition, whereas Table 6 displays the regression outcomes for the digital

Table 3. Results of reliability and validity analysis

Variables	Title item	Factor loading	AVE	CR	Cronbach's α
Market opportunities	1. The market demand is constantly expanding, and there are many potential market opportunities	0.866	0.733	0.943	0.943
	2. Market demand is not fully met, and new market segments continue to emerge	0.838			
	3. Consumers are generally willing to try new products and services	0.847			
	4. Consumers have low switching costs among different brands and product categories	0.875			
	5. Incumbent enterprises invest a lot of resources to cultivate their current core competitiveness	0.862			
	6. Most companies in the industry follow past habits and are reluctant to change much	0.850			
Technology opportunities	1. Short industry technology life cycle, easy to capture new technology opportunities	0.891	0.766	0.952	0.951
	2. Emerging technologies continue to emerge, making it easy to achieve technological leapfrog development	0.841			
	3. The industry is widely related to technology and can obtain more cross-border innovation opportunities	0.879			
	4. The technology has a wide application field, from which greater innovation benefits can be obtained	0.886			
	5. The technology market is relatively mature, and it is easy for enterprises to obtain the required technology	0.887			
	6. High degree of technology modularity, low barriers to product research and development	0.867			
Higher-order capabilities	1. Enterprises can timely respond to environmental changes and strategic adjustments	0.855	0.714	0.937	0.937
	2. The enterprise system and organizational structure are flexible, allowing the transcend of the existing power structure	0.849			
	3. Enterprises can obtain required resources from suppliers/customers/competitors/partners	0.843			
	4. Enterprises can realize shared allocation and utilization of resources within the enterprise	0.803			
	5. The enterprise can continuously improve working methods or business processes to improve work efficiency	0.863			
	6. Enterprises can use new technologies to effectively improve independent research and development capabilities and continuously introduce new products	0.854			
Ordinary capabilities	1. The company has an innovative culture widely recognized by employees	0.891	0.753	0.948	0.948
	2. The company has a sound knowledge-sharing system	0.868			
	3. The company implements cross-department staff rotation or creates cross-department project teams	0.885			
	4. the company holds meetings across departments or introduces systems to accumulate, exchange or share information among departments	0.862			
	5. The company can continuously carry out organizational innovation and process innovation	0.837			

(*continued*)

Table 3.

Variables	Title item	Factor loading	AVE	CR	Cronbach's α
	6. The company's top management team can reasonably delegate power and assign responsibility to capable subordinates	0.863			
Strategic cognition	1. The company emphasizes that customers, resources, environment and other factors must be considered at the same time	0.917	0.819	0.965	0.964
	2. The company emphasizes analyzing competition and formulating strategies from the overall perspective	0.910			
	3. The company must look at the overall situation and find a balance among the many contradictions	0.922			
	4. The company believes that it is more important to capture the details than to analyze the whole	0.899			
	5. The company emphasizes that special breakthroughs are more conducive to improving competitiveness than the overall improvement	0.891			
	6. Complex management problems can only be solved by gradually decomposing and analyzing the company one by one	0.891			
Digital transformation	1. Digital technology provides support for achieving the strategic goals of our enterprise	0.888	0.809	0.974	0.974
	2. Digital technology drives our enterprises to readjust their strategic goals	0.900			
	3. Our enterprise actively uses digital technology to create new business opportunities	0.906			
	4. Our enterprise uses digital technology to improve existing business activities	0.909			
	5. Our business uses digital technology to distribute products	0.887			
	6. Our company tries to use digital technology to develop new products based on existing products	0.891			
	7. Our company tries to use digital technology to create new products that are less relevant to existing products	0.897			
	8. Our enterprise can match the new operation activities after the implementation of digitalization with the existing organizational structure, or set up a new organizational structure to support the new operation activities	0.911			
	9. Our enterprise has the organizational ability to execute digital transformation or try to improve organizational ability to meet the development needs of digital transformation	0.906			
Entrepreneurship	1. I'm always thinking of new ways to grow my business	0.821	0.702	0.934	0.948
	2. I am able to apply ideas, questions and observations to different contexts	0.862			
	3. I'm willing to take high risks for high returns	0.835			
	4. I accept uncertainty as an integral part of business	0.866			
	5. My career is a core part of my life, and I often give up my rest time for work	0.834			
	6. In the face of challenging work, I am always full of passion and eager to try	0.806			

Source: This table is created by the authors

transformation of enterprises. In Model 8 (Table 6), it is demonstrated that market opportunities significantly positively influence digital transformation ($\beta = 0.419, p < 0.001$), thereby confirming *H1a* proposed in this study; Model 10 reveals that technological opportunities significantly positively affect digital transformation ($\beta = 0.464$, $p < 0.001$), thus verifying *H1b* proposed in this study; according to Model 12, higher-order capabilities have a significantly positive effect on the digital transformation of enterprises ($\beta = 0.473$, $p < 0.001$), confirming the proposed *H2b*; Model 14 indicates that conventional capabilities significantly positively contribute to the digital transformation of enterprises ($\beta = 0.457$, $p < 0.001$), thereby validating the proposed *H2a*.

Mediation effect test. Analysis of Models 2–5 in Table 5 indicates that market opportunities, technological opportunities, higher-order capabilities and conventional capabilities each significantly positively influence strategic cognition ($\beta = 0.242$, 0.269, 0.234, 0.357, respectively, all $p < 0.001$). In Model 7 (Table 6), it is evident that strategic cognition has a significant and positive impact on the digital transformation of enterprises ($\beta = 0.454$, $p < 0.001$). A comparison of Models 8 and 9 reveals that when including both market opportunities and strategic cognition in the regression analysis,

Model	χ^2/Df	RMSEA	SRMR	NFI	RFI	IFI	TLI	CFI
Seven-factor model	1.112	0.020	0.032	0.922	0.916	0.992	0.991	0.991
Six-factor model	2.756	0.081	0.130	0.805	0.792	0.866	0.857	0.865
Five-factor model	3.975	0.106	0.156	0.717	0.700	0.772	0.757	0.771
Four-factor model	5.131	0.124	0.142	0.633	0.613	0.682	0.663	0.680
Three-factor model	6.338	0.141	0.145	0.545	0.522	0.587	0.564	0.586
Two-factor model	7.885	0.161	0.159	0.433	0.405	0.466	0.438	0.464
Single-factor model	8.670	0.169	0.167	0.376	0.346	0.405	0.374	0.403

Source: This table is created by the authors

Table 4. Results of the validated factor analysis fitted metrics

Variables	Model 1	Model 2	SC Model 3	Model 4	Model 5
EstYear	−0.127 (0.113)	−0.098 (0.111)	−0.118 (0.109)	−0.119 (0.110)	−0.088 (0.106)
EmpSize	−0.033 (0.145)	−0.024 (0.141)	−0.043 (0.140)	−0.061 (0.142)	−0.063 (0.136)
Reve	0.028 (0.097)	0.041 (0.094)	0.055 (0.094)	0.045 (0.094)	0.092 (0.091)
Natu	0.039 (0.151)	−0.006 (0.149)	0.010 (0.146)	0.032 (0.147)	0.021 (0.141)
Indus	0.007 (0.104)	0.008 (0.101)	−0.001 (0.100)	0.000 (0.101)	0.009 (0.097)
Edu	−0.083 (0.118)	−0.076 (0.115)	−0.055 (0.115)	−0.041 (0.117)	−0.058 (0.111)
WYear	0.032 (0.134)	0.052 (0.131)	0.018 (0.130)	0.037 (0.131)	0.016 (0.126)
MO		0.242 (0.076)***			
TO			0.269 (0.067)***		
HC				0.234 (0.078)***	
OC					0.357 (0.069)***
R^2	0.024	0.081	0.095	0.077	0.147
ΔR^2	0.024	0.056	0.070	0.053	0.123
Adjust R^2	−0.002	0.052	0.067	0.049	0.121
F value	0.927	2.836**	3.379**	2.708**	5.582***

Notes: *, **, *** mean $p < 0.05$; $p < 0.01$ and $p < 0.001$, respectively. The regression coefficients in the table are all the standardized regression coefficients, and the standard errors are in parentheses
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Table 5. Main and mediating effects tests

Table 6.
Main effect and mediating effect tests

	DT					
Variables	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
EstYear	0.000 (0.116)	0.058 (0.105)	0.049 (0.107)	0.086 (0.098)	0.015 (0.103)	0.057 (0.096)
EmpSize	0.053 (0.149)	0.067 (0.133)	0.067 (0.136)	0.076 (0.125)	0.034 (0.133)	0.050 (0.123)
Reve	−0.083 (0.100)	−0.096 (0.089)	−0.060 (0.091)	−0.075 (0.083)	−0.035 (0.089)	−0.055 (0.082)
Natu	0.125 (0.155)	0.107 (0.139)	0.046 (0.143)	0.048 (0.132)	0.074 (0.139)	0.070 (0.128)
Indus	−0.008 (0.107)	−0.011 (0.095)	−0.006 (0.097)	−0.009 (0.089)	−0.022 (0.095)	−0.022 (0.088)
Edu	−0.092 (0.122)	−0.055 (0.109)	−0.080 (0.111)	−0.052 (0.102)	−0.045 (0.109)	−0.025 (0.101)
WYear	0.004 (0.138)	−0.010 (0.124)	0.040 (0.127)	0.020 (0.116)	−0.020 (0.123)	−0.026 (0.114)
MO			0.419 (0.073)***	0.328 (0.069)***		
TO					0.464 (0.063)***	0.369 (0.061)***
EWO						
HC						
OC						
IWO						
EWO × IWO						
SC		0.454 (0.057)***		0.376 (0.055)***		0.355 (0.054)***
R^2	0.023	0.223	0.191	0.321	0.232	0.346
ΔR^2	0.023	0.201	0.169	0.130	0.210	0.114
Adjust R^2	−0.004	0.199	0.166	0.297	0.208	0.323
F	0.859	9.316***	7.664***	13.556***	9.786***	15.180***

Notes: *, **, *** mean $p < 0.05$; $p < 0.01$ and $p < 0.001$, respectively. The regression coefficients in the table are all the standardized regression coefficients, and the standard errors are in parentheses
Source: This table is created by the Authors

(*continued*)

Table 6.

	DT					
Variables	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17
EstYear	0.015 (0.103)	0.059 (0.095)	0.049 (0.105)	0.079 (0.098)	0.074 (0.086)	0.060 (0.086)
EmpSize	−0.005 (0.133)	0.017 (0.122)	0.013 (0.134)	0.034 (0.126)	−0.001 (0.111)	−0.005 (0.110)
Reve	−0.048 (0.088)	−0.064 (0.081)	0.000 (0.090)	−0.031 (0.085)	0.024 (0.074)	0.005 (0.074)
Natu	0.110 (0.138)	0.099 (0.126)	0.101 (0.139)	0.094 (0.130)	0.025 (0.116)	0.029 (0.115)
Indus	−0.021 (0.095)	−0.021 (0.087)	−0.006 (0.095)	−0.009 (0.090)	−0.020 (0.079)	−0.021 (0.078)
Edu	−0.007 (0.110)	0.007 (0.101)	−0.060 (0.109)	−0.041 (0.103)	0.004 (0.091)	0.013 (0.091)
WYear	0.015 (0.123)	0.002 (0.113)	−0.017 (0.124)	−0.022 (0.116)	0.005 (0.102)	0.009 (0.101)
MO						
TO						
EWO					0.415 (0.079)***	0.449 (0.083)***
HC	0.473 (0.073)***	0.388 (0.069)***				
OC			0.457 (0.068)***	0.338 (0.068)***		
IWO					0.403 (0.078)***	0.446 (0.083)***
EWO × IWO						0.122 (0.061)*
SC		0.364 (0.053)***		0.335 (0.057)***		
R^2	0.238	0.36	0.224	0.319	0.474	0.483
ΔR^2	0.216	0.122	0.201	0.096	0.451	0.009
Adjust R^2	0.215	0.338	0.200	0.296	0.455	0.463
F	10.122***	16.158***	9.333***	13.451***	25.785***	24.012***

the direct effect of market opportunities on enterprise digital transformation is reduced ($\beta = 0.328$, $p < 0.001$), yet remains significant. This suggests that strategic cognition partially mediates the relationship between market opportunities and enterprise digital transformation. Similarly, comparing Models 10 and 11, the inclusion of both technological opportunities and strategic cognition in the regression analysis leads to a diminished direct effect of technological opportunities on enterprise digital transformation ($\beta = 0.369$, $p < 0.001$), yet the effect remains significant, indicating a partial mediating role of strategic cognition between technological opportunities and enterprise digital transformation. In conclusion, strategic cognition is found to play a partial mediating role in how external windows of opportunity influence the digital transformation process of enterprises, thereby verifying *H4*.

Upon comparing Models 12 and 13, wherein both higher-order capabilities and strategic cognition are included in the regression analysis, it is observed that the direct effect of higher-order capabilities on enterprise digital transformation is diminished ($\beta = 0.388$, $p < 0.001$), yet remains significantly influential. This finding suggests that strategic cognition serves as a partial mediator between higher-order capabilities and the digital transformation of enterprises. Similarly, a comparison of Models 14 and 15, which incorporate both conventional capabilities and strategic cognition in the regression analysis, shows a reduced direct impact of conventional capabilities on enterprise digital transformation ($\beta = 0.338$, $p < 0.001$), yet the influence remains significant. This indicates that strategic cognition also partially mediates the relationship between conventional capabilities and the digital transformation of enterprises. In conclusion, strategic cognition is identified as a partial mediator in the internal windows of opportunity affecting the enterprise digital transformation process, thereby verifying *H5*. Models 16 and 17 examine the impact of the interaction between external and internal windows of opportunity on the digital transformation of enterprises. The findings reveal that the interaction term's coefficient is 0.122 ($p < 0.05$), indicating a positive relationship between the combined effect of external and internal windows of opportunity and enterprise digital transformation, thereby supporting *H3*.

Moderating effect test

As indicated by the results of the regression analysis presented in Table 7, Models 18–26 progressively incorporate control variables, independent variables (market opportunities, technological opportunities, higher-order capabilities, conventional capabilities), moderating variables and interaction terms in the regression models related to strategic cognition. In Model 20, the interaction between market opportunities and entrepreneurship is found to be significant ($\beta = 0.137$, $p < 0.05$); Model 22 demonstrates that the interaction between technological opportunities and entrepreneurship is significant ($\beta = 0.160$, $p < 0.05$), indicating a substantial moderating effect of entrepreneurship on the influence of external windows of opportunity on strategic cognition. Consequently, *H6* is verified. In Model 24, the interaction between higher-order capabilities and entrepreneurship is significant ($\beta = 0.124$, $p < 0.05$); Model 26 reveals that the interaction between conventional capabilities and entrepreneurship is significant ($\beta = 0.151$, $p < 0.05$), signifying the significant moderating effect of entrepreneurship on the influence of internal windows of opportunity on strategic cognition. Figure 2 illustrates the variances in the slopes representing the effects of market opportunities, technological opportunities, higher-order capabilities and conventional capabilities on strategic cognition at various levels of entrepreneurship. At higher levels of entrepreneurship, the slope of the fitted line representing the impact of market opportunities on strategic cognition is steeper than at lower levels, indicating a stronger positive effect of

Table 7. Moderating effect test

Variables	Model 18	Model 19	Model 20	Model 21	SC Model 22	Model 23	Model 24	Model 25	Model 26
EstYear	−0.127 (0.113)	−0.092 (0.109)	−0.096 (0.109)	−0.113 (0.109)	−0.127 (0.108)*	−0.111 (0.109)	−0.126 (0.109)	−0.084 (0.106)	−0.082 (0.105)
EmpSize	−0.033 (0.145)	−0.025 (0.140)	−0.015 (0.139)	−0.041 (0.139)	−0.047 (0.138)	−0.058 (0.140)	−0.059 (0.140)	−0.061 (0.135)	−0.057 (0.134)
Reve	0.028 (0.097)	0.018 (0.094)	0.007 (0.093)	0.037 (0.094)	0.031 (0.093)	0.022 (0.094)	0.030 (0.094)	0.071 (0.092)	0.063 (0.091)
Natu	0.039 (0.151)	−0.004 (0.147)	−0.022 (0.147)	0.012 (0.146)	−0.010 (0.145)	0.031 (0.146)	0.025 (0.145)	0.020 (0.141)	0.011 (0.139)
Indus	0.007 (0.104)	0.014 (0.100)	0.017 (0.099)	0.004 (0.100)	0.001 (0.099)	0.007 (0.100)	0.001 (0.100)	0.013 (0.097)	0.031 (0.096)
Edu	−0.083 (0.118)	−0.092 (0.114)	−0.086 (0.114)	−0.070 (0.115)	−0.057 (0.115)	−0.060 (0.117)	−0.069 (0.116)	−0.071 (0.111)	−0.055 (0.111)
WYear	0.032 (0.134)	0.039 (0.130)	0.027 (0.130)	0.012 (0.130)	−0.003 (0.129)	0.025 (0.130)	0.016 (0.130)	0.008 (0.126)	−0.009 (0.125)
MO		0.220 (0.075)***	0.232 (0.075)***						
TO				0.233*** (0.071)	0.265*** (0.071)				
HC						0.209*** (0.078)	0.208*** (0.077)		
OC								0.333*** (0.070)	0.355*** (0.070)
En		0.156* (0.078)	0.173** (0.078)	0.108 (0.082)	0.148* (0.084)	0.151* (0.079)	0.156* (0.079)	0.119* (0.077)	0.147* (0.077)
MO × En			0.137* (0.083)						
TO × En					0.160* (0.083)				
HC × En							0.124 (0.087)*		
OC × En									0.151* (0.071)
R^2	0.024	0.103	0.121	0.105	0.125	0.098	0.113	0.16	0.181
ΔR^2	0.024	0.079	0.018	0.08	0.021	0.074	0.015	0.136	0.02
Adjust R^2	−0.002	0.072	0.087	0.073	0.091	0.067	0.079	0.131	0.149
F	0.927	3.301***	3.537***	3.346***	3.684***	3.130**	3.286***	5.467***	5.664***

Notes: *, **, *** mean $p < 0.05$; $p < 0.01$ and $p < 0.001$, respectively. The regression coefficients in the table are all the standardized regression coefficients, and the standard errors are in parentheses

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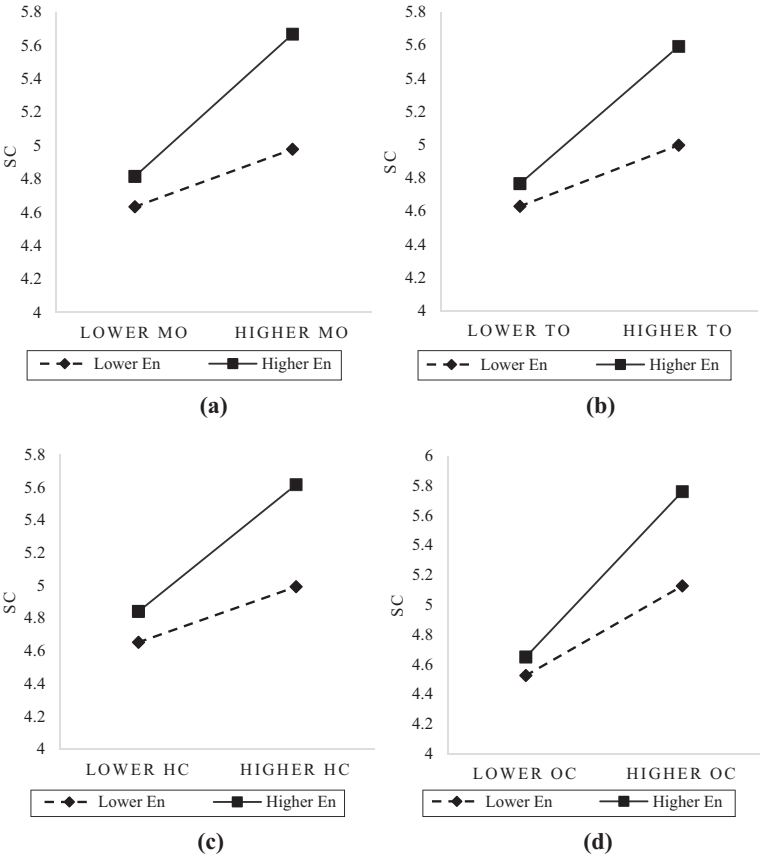

Figure 2.
Moderating effect of entrepreneurship

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market opportunities on strategic cognition. Similarly, technological opportunities, higher-order capabilities and conventional capabilities exert stronger positive effects on strategic cognition at higher levels of entrepreneurship. Thus, *H7* is verified.

Robustness test

To evaluate the robustness of the hypothesis testing results, the variable of enterprise digital transformation was replaced with that of digital strategic orientation. The specific results are detailed in Table 8. The results demonstrate that, with digital strategic orientation as the dependent variable, the signs of the regression coefficients for the independent and mediating variables in each model remain consistent with those observed in the main effects test (Table 6), and all regression coefficients are statistically significant. These findings align with those reported in the previous section of the paper. Consequently, the robustness of the model's regression results in this study is affirmed.

Table 8. Robustness test results (digital strategy orientation as dependent variable)

Variables	DSO								
	Model 27	Model 28	Model 29	Model 30	Model 31	Model 32	Model 33	Model 34	Model 35
EstYear	−0.086 (0.102)	−0.055 (0.100)	−0.032 (0.097)	−0.077 (0.099)	−0.050 (0.097)	−0.076 (0.098)	−0.049 (0.096)	−0.050 (0.097)	−0.033 (0.096)
EmpSize	0.058 (0.131)	0.067 (0.127)	0.073 (0.123)	0.048 (0.127)	0.058 (0.123)	0.022 (0.126)	0.036 (0.123)	0.029 (0.124)	0.042 (0.122)
Reve	−0.070 (0.087)	−0.056 (0.085)	−0.066 (0.082)	−0.043 (0.085)	−0.056 (0.083)	−0.048 (0.084)	−0.058 (0.082)	−0.010 (0.083)	−0.028 (0.082)
Natu	0.081 (0.136)	0.032 (0.134)	0.033 (0.130)	0.051 (0.132)	0.049 (0.129)	0.072 (0.131)	0.064 (0.127)	0.063 (0.129)	0.059 (0.127)
Indus	0.093 (0.094)	0.095 (0.091)	0.093 (0.088)	0.085 (0.091)	0.086 (0.088)	0.085 (0.090)	0.085 (0.087)	0.095 (0.089)	0.093 (0.087)
Edu	−0.039 (0.107)	−0.032 (0.104)	−0.014 (0.101)	−0.012 (0.104)	0.001 (0.101)	0.014 (0.104)	0.024 (0.101)	−0.016 (0.101)	−0.005 (0.100)
WYear	0.070 (0.122)	0.092 (0.118)	0.080 (0.115)	0.056 (0.117)	0.052 (0.115)	0.077 (0.116)	0.069 (0.113)	0.055 (0.115)	0.052 (0.113)
MO		0.261*** (0.068)	0.204*** (0.068)						
TO				0.268*** (0.061)	0.205*** (0.061)				
HC						0.299*** (0.069)	0.245*** (0.069)		
OC								0.335*** (0.063)	0.266*** (0.066)
SC			0.238*** (0.054)		0.232*** (0.055)		0.230*** (0.054)		0.193** (0.056)
R^2	0.03	0.096	0.148	0.1	0.149	0.117	0.165	0.138	0.17
ΔR^2	0.03	0.066	0.052	0.07	0.049	0.086	0.049	0.108	0.032
Adjust R^2	0.004	0.068	0.118	0.072	0.119	0.089	0.136	0.112	0.141
F	1.160	3.434***	4.982***	3.598***	5.004***	4.273***	5.681***	5.199***	5.876***

Notes: *, **, *** mean $p < 0.05$; $p < 0.01$ and $p < 0.001$, respectively. The regression coefficients in the table are all the standardized regression coefficients, and the standard errors are in parentheses

Source: This table is created by the authors

Conclusion and discussion

Main research conclusions

With the rapid development of the digital economy, seizing the opportunities emerging from environmental changes and exerting internal capabilities according to the actual situation of enterprises to realize digital transformation is an important issue currently facing enterprises. Based on theoretical analysis and hypotheses, this paper empirically examines the impact of internal and external windows of opportunity on the digital transformation of enterprises, as well as the role of strategic cognition and entrepreneurship, using a questionnaire research method. The research findings are presented as follows:

First, a significant positive correlation exists between external windows of opportunity and enterprise digital transformation. Specifically, external windows of opportunity, including market and technology factors, provide sufficient market space and access to low-cost technological resources for enterprises, laying an essential foundation for the advancement of digital transformation (Lee and Malerba, 2017). Moreover, emerging technological paradigms place enterprises and incumbents on comparable technological footing, thereby reducing the barriers to entry for digital transformation. Simultaneously, the substantial market capacity driven by new market demands offers enterprises a buffer for continuous trial-and-error improvements in their digital transformation efforts, facilitating their developmental progress.

Second, a significant positive correlation has been identified between the internal window of opportunity and enterprise digital transformation. Specifically, superior conventional and advanced capabilities within the enterprise enhance its perceptual capabilities, facilitating the identification of key digital transformation information. This leads to the timely recognition of both evident and latent external opportunities, prompting the enterprise to reallocate resources, modify business processes, reorient its development strategy and align its strategic innovation direction with its innovative actions and processes. This alignment is crucial to ensuring the seamless execution of the enterprise's digital transformation activities (Wang and Ahmed, 2007).

Thirdly, strategic cognition serves as a mediating factor between external and internal windows of opportunity and the digital transformation of enterprises. Specifically, the strategic cognition pattern developed through past business activities establishes a selection mechanism for digital transformation strategies, directing the enterprise toward varied approaches. When a window of opportunity presents itself, superior strategic cognition enables the assimilation and integration of internal and external resources, steers adaptive enhancement, iterative progress and structural refinement, thereby advancing the enterprise's digital transformation process (Eggers and Kaplan, 2013).

Finally, entrepreneurship exerts a positive moderating effect on the relationship between internal and external windows of opportunity and strategic cognition. Specifically, a stronger entrepreneurial, risk-taking and career-focused ethos among business leaders enhances the perception of external opportunities and emphasizes the significance of bolstering internal enterprise capabilities. This orientation aids in departing from established practices, facilitating the integration of digital resources and fostering departmental synergy, thereby establishing a crucial foundation for developing strategic cognition in the enterprise's internal digital transformation (Hodgkinson and Healey, 2011).

Theoretical contributions

The main theoretical contributions of this paper are as follows:

- Elucidating the relationship between internal and external windows of opportunity and enterprise digital transformation offers fresh theoretical insights. Digital

transformation, as an emerging phenomenon in the field of enterprise innovation and development, is attracting extensive attention from both industry and academia (Nambisan *et al.*, 2019). Notably, most existing studies focus on discussing the concept of digital transformation and its characteristics (Ciriello *et al.*, 2018; Nambisan *et al.*, 2017), highlighting a theoretical gap in exploring the intrinsic antecedents of digital transformation in enterprises (Ciampi *et al.*, 2021). This paper integrates the window of opportunity theory, distinguishing external factors such as technology and market (Lee and Malerba, 2017), as well as internal factors such as firms' conventional and higher-order capabilities (Helfat and Winter, 2011), to examine how these windows facilitate firms' digital transformation. This approach thereby bridges the gap in previous research on the intrinsic antecedents of digital transformation and responds to the scholarly call for a multifactorial combinatorial approach to investigating the factors influencing organizational digital transformation (Ciampi *et al.*, 2021; Siachou *et al.*, 2021).

- The integration of strategic cognitive theory elucidates the intricate process mechanisms of digital transformation in firms, leveraging both external contextual opportunities and internal capabilities. Although previous studies have affirmed the facilitating role of windows of opportunity for innovation development (Matarazzo *et al.*, 2021; Verhoef *et al.*, 2021), the deeper logical relationship between windows of opportunity and firms' digital transformation still needs to be explored in depth (Lee and Malerba, 2017). This paper establishes that strategic cognition plays a partially mediating role between internal and external windows of opportunity and digital transformation, through both theoretical analysis and empirical testing. It uncovers how enterprises can discern technological and market windows of opportunity, synergize internal and external resources and facilitate the effective development and execution of digital transformation strategies through strategic cognition development (Love *et al.*, 2014). This work demystifies the "black box" relationship between windows of opportunity and the digital transformation process. The obtained conclusions further supplement the insufficiency of intrinsic antecedent factors affecting digital transformation and provide a new thinking framework for subsequent empirical research related to digital transformation. In addition, the findings further expand the research perspective of strategic cognition theory and provide a new context for subsequent research (Adner *et al.*, 2019).
- Incorporating entrepreneurship into the path mechanism of digital transformation broadens the scope of research on antecedent variables in digital transformation. While studies have concentrated on the role of external stakeholders (investors, suppliers, consumers, media, etc.) in driving digital transformation (Dellaert, 2018; Jacobides, 2019; Kouvelis *et al.*, 2019), they often overlook the fact that as a corporate strategy, firms' digital transformation is more influenced by internal managerial and entrepreneurial factors (Hambrick and Mason, 1984). Consequently, this paper integrates the personal characteristics of entrepreneurship into the theoretical model of the digital transformation process, empirically examining how entrepreneurship impacts the development of corporate strategic cognition in response to arising windows of opportunity. These findings enhance the exploration of the intrinsic antecedents of enterprise digital transformation (Li *et al.*, 2018), broaden the boundary conditions of the "Window of opportunity – Strategic cognition – Digital transformation" theoretical model and offer a novel perspective for the study of entrepreneurship theory.

Managerial implications

Practical inspirations from the research process:

- Enterprises must seize the full spectrum of digital transformation opportunities to expedite their own digital transformation processes. In the digital era, swift shifts in technology paradigms and market demands present numerous windows of opportunity for enterprise development, reducing the technological barriers and market pressures associated with innovative progress. Consequently, enterprises should comprehensively exploit these opportunities, actively constructing the necessary strategic decision-making, production research and development and marketing management frameworks to facilitate digital transformation and ensure its successful implementation.
- During digital transformation, enterprises need to intensify their monitoring of the external environment and proactively adapt their strategies to dynamically align with these external conditions. They should construct and refine the internal knowledge network, facilitating efficient internal exchanges of market and technological information, and implement ongoing learning and technical training to enhance the internal organization's capacity for learning, assimilating and applying knowledge, thereby fortifying the enterprise's competitive strength. This approach further solidifies the enterprise's competitive edge.
- During the digital transformation process, enterprises need to focus on enhancing their management's strategic cognition through ongoing training and industry exchanges, thereby deepening managers' comprehension of the value of the digital transformation strategy. Simultaneously, by establishing institutional norms and unified standards for data collection, storage and analysis, they can facilitate the collaborative execution of the digital transformation strategy across different departments within the enterprise.
- During the digital transformation process, the presence of risk-taking, innovative and pioneering spirit in leaders is crucial to augmenting the organization's perceptiveness and responsiveness, thereby facilitating the enterprise's digital transformation in an uncertain environment. Consequently, within enterprise management, special emphasis should be placed on cultivating and stimulating the entrepreneurial spirit, as well as its dissemination within the organization, and actively fostering an environment to adapt to external changes. This approach aims to create a "working together" synergy, maximizing the impact of the entrepreneurial spirit and ensuring its extensive and profound integration into the collective psyche of the organization's members.

Limitations and future research

Initially, this study focuses on enterprises undergoing digital transformation, considering the age of these enterprises as a control variable, yet it does not segment the research based on varied age groups. Future research could segment enterprises based on age, for instance, separately analyzing start-ups within six years of inception and mature enterprises older than eight years. Second, using the windows of opportunity theory, this paper primarily examines the intermediate mechanisms through which external situational and internal capability opportunities impact digital transformation. However, numerous antecedent factors influencing digital transformation remain, and future studies may delve into additional intermediary factors from diverse theoretical standpoints. Thirdly, this study uses cross-sectional data, limiting its ability to assert causal relationships between variables

or to capture the dynamic interplay between internal and external windows of opportunity, strategic cognition and digital transformation. Future studies could use longitudinal tracking methods to intricately investigate the interactions between external situational opportunities, internal organizational capabilities and digital transformation, using multiple tools and methods for more precise variable measurement and analysis.

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Further reading

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Appendix

	Mean	S.D.	ESTYear	EmpSize	Rave	Natu	Iduus	Edu	Wyear	MO	TO	HC	OC	SC	DT	En
ESTYear	1.800	0.794	1.000													
EmpSize	1.370	0.790	0.290**	1.000												
Rave	1.990	1.105	0.193**	0.573**	1.000											
Natu	2.250	0.681	0.243**	0.513**	0.443**	1.000										
Iduus	2.250	0.839	−0.073	0.088	−0.053	0.077	1.000									
Edu	2.760	0.745	0.010	0.237**	0.155*	0.166**	0.105	1.000								
Wyear	2.120	0.642	0.068	0.068	0.082	0.138*	−0.090	−0.074	1.000							
MO	5.221	1.111	−0.097	−0.015	−0.024	0.102	0.022	−0.009	−0.070	1.000						
TO	5.054	1.238	−0.014	0.010	−0.051	0.069	0.034	−0.091	0.064	0.186**	1.000					
HC	5.382	1.083	−0.009	0.044	−0.029	0.021	0.030	−0.152*	−0.008	0.186**	0.257**	1.000				
OC	5.465	1.172	−0.101	−0.035	−0.135*	−0.015	0.013	−0.073	0.042	0.310**	0.297**	0.337**	1.000			
SC	5.043	1.381	−0.120*	−0.050	−0.009	−0.005	0.003	−0.082	0.034	0.247**	0.274**	0.238**	0.361**	1.000		
DT	4.807	1.423	0.030	0.047	−0.011	0.100	0.000	−0.073	0.026	0.417**	0.473**	0.477**	0.454**	0.448**	1.000	
En	5.459	1.071	−0.020	0.091	0.155*	0.083	−0.039	0.110	0.082	0.131*	0.311**	0.142*	0.175**	0.179**	0.427**	1.000

Notes: *, ** and *** indicate significance at the statistical levels of 5, 1 and 1%, respectively
Source: This table is created by the authors

Table A1.
Descriptive statistics of variables and correlation coefficient matrix