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Digital capabilities and metaverse entrepreneurial performance: Role of entrepreneurial orientation

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ABSTRACT

This study examines the influence of digital capabilities in sculpting entrepreneurial orientation (EO) and enhancing metaverse entrepreneurial performance (MEP). Grounded in the theoretical frameworks of the resource-based view (RBV) and dynamic capability theory (DCT), this research explains the mechanisms through which three facets of digital capabilities (infrastructure, business spanning, and proactive stance) cultivate an ecosystem conducive to entrepreneurial expansion and efficacy within the metaverse. Based on a data set of 403 metaverse entrepreneurs, a multifaceted analytical approach is applied. Partial least squares structural equation modeling (PLS-SEM) is used to assess latent variable relationships. Importance-performance map analysis (IPMA) is used to evaluate the performance and importance of various constructs. Fuzzy-set qualitative comparative analysis (fsQCA) is used to identify complex causal relationships. Collectively, these techniques enable the examination of the interplay among digital capabilities, EO, and MEP. The empirical findings show the positive impact of digital capabilities on EO and MEP, with EO mediating this relationship. These results underscore the need for metaverse entrepreneurs to improve their digital capabilities and EO to achieve enhanced performance within this dynamic entrepreneurial ecosystem.

Introduction

The metaverse—with its confluence of emerging technologies, hardware interfaces, application tools, and business scenarios—has rapidly emerged as a platform for innovation and knowledge creation (Ledesma-Chaves et al., 2024; Piñeiro-Chousa et al., 2020). This digital ecosystem is not only a new frontier for entrepreneurial ventures but also a catalyst for novel forms of innovation and knowledge enhancement. The interplay between knowledge and innovation within the metaverse is symbiotic: Knowledge acts as a springboard for innovation, which, in turn, enriches the body of knowledge. Forecasts suggest a substantial uptake in metaverse engagement, with Gartner predicting that by 2026, a quarter of the world's population will immerse themselves in the metaverse for at least one hour daily (Gartner, 2022), indicating the burgeoning potential for innovative business models and knowledge dissemination (Deloitte, 2022). The Chinese market exemplifies this surge in interest, with metaverse-related investments growing to 13.6 billion yuan, marking a 147 % increase in total investment and a 333 % rise in investment activities over the previous year (Sina et al., 2023). The metaverse's multifaceted nature presents numerous opportunities for entrepreneurial entities to innovate across varied areas, ranging from foundational technologies to consumer-facing hardware and business solutions (Schäfer et al., 2023). However, achieving sustainable innovation within this nascent domain is fraught with challenges demanding further academic investigation (Gupta et al., 2024). Despite the burgeoning interest in the metaverse as a frontier for digital entrepreneurship (Büchel & Spinler, 2024; Calandra et al., 2024; Gil-Cordero et al., 2024; Gupta et al., 2024; Weking et al., 2023), research explicitly examining how firms can leverage digital capabilities to enhance their entrepreneurial performance within this unique environment is scant. A comprehensive understanding of the components of digital capabilities and their impact on metaverse entrepreneurial performance (MEP) is lacking, which presents a significant research gap. Addressing this gap is imperative for academics and practitioners seeking to navigate and thrive in the intricate landscape of metaverse entrepreneurship. Understanding how digital capabilities can be harnessed to foster knowledge creation and innovation within the metaverse is essential for developing effective strategies and achieving a competitive advantage in this digital ecosystem.

The pursuit of entrepreneurial opportunities within the metaverse is

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fraught with uncertainties, yet digital capabilities may be key to achieving commercial success in this digital realm (Mancuso et al., 2024). As the metaverse evolves at an unprecedented pace, digital capabilities have emerged critical in metaverse entrepreneurship, particularly for entrepreneurs seeking to establish a foothold in this space (Chen et al., 2023; Gil-Cordero et al., 2024; Hsieh & Wu, 2019). Enhancing these capabilities is not merely a strategic move but a necessity for improving the MEP (Zahra et al., 2023). From the perspective of the resource-based view (RBV), a firm's competitive advantage depends on its possession of rare, valuable, inimitable, and non-substitutable resources (Barney, 1991). In the metaverse environment's context, digital capabilities represent strategic resources that profoundly influence a firm's MEP (Dabbous et al., 2023). Digital capabilities are multifaceted and encompass infrastructure, business spanning, and proactive stance (Al Dhaheri et al., 2024). However, current research lacks a clear understanding of how these capabilities are composed within the metaverse and the mechanism through which they exert their influence (Sussan & Acs, 2017). While some studies have focused on individual elements of digital capabilities, such as infrastructure, business spanning, or proactive stance, research integrating these elements into a comprehensive framework applicable to the metaverse is scarce (Kamble et al., 2023). This knowledge gap limits our understanding of the full spectrum and complexity of digital capabilities. Furthermore, research on how digital capabilities affect MEP is lacking, with few studies examining the direct relationship between the two or considering potential mediating factors (Gashi et al., 2024). Entrepreneurial orientation (EO) has been suggested as a potential mediator in the relationship between digital capabilities and MEP (Sahi et al., 2024); however, this mediating effect has not been thoroughly investigated.

Within the burgeoning metaverse landscape, dynamic capability theory (DCT) posits that firms must continuously innovate and adapt to the dynamic external environment to achieve and sustain a competitive edge (Teece, 2007). For entities engaged in metaverse entrepreneurship, it is necessary to develop robust digital capabilities and dynamically adjust and optimize resource allocation through EO to attain superior MEP (Yu et al., 2024). However, current research in this area is nascent, and the interplay between digital capabilities, EO, and MEP remains insufficiently explored (Brettel et al., 2015). This research gap limits the comprehensive understanding of how these elements interrelate and collectively contribute to MEP.

The theoretical underpinnings of digital capabilities within the metaverse environment necessitate a deeper investigation beyond the general frameworks provided by the RBV and DCT (Barney, 1991; Teece, 2007). Although these theories elucidate digital capabilities' importance, they have not fully explored specific elements and their interplay within the metaverse's context. The metaverse's unique characteristics may result in a distinct configuration of digital capabilities, such as infrastructure, business spanning, and proactive stance (Kamble et al., 2023), which could significantly influence MEP (Yao et al., 2021).

In the realm of metaverse entrepreneurship, digital capabilities are pivotal for entrepreneurs to capitalize on their resources and enhance their performance. Digital capabilities' influence on MEP involves a complex interplay that can be better understood by examining EO's mediating role. This study addresses the following research questions:

RQ1: What elements constitute digital capabilities in metaverse entrepreneurship?

RQ2: How do digital capabilities influence MEP?

RQ3: What role does EO play in the relationship between digital capabilities and MEP?

The intersection of knowledge and innovation is a focal point of inquiry in the field of metaverse entrepreneurship. This study—grounded in the RBV and DCT—explores how digital capabilities develop EO and performance within metaverse firms. This study makes several seminal contributions to the scholarly discourse on innovation and knowledge.

First, we construct a comprehensive framework that delineates the constituents of digital capabilities within the metaverse context, thereby bridging the current research gap. Second, we empirically scrutinize the direct linkage between digital capabilities and MEP, augmenting the existing knowledge base on the propelling effects of digital assets on innovative achievements. Third, we highlight EO's mediating role, offering novel perspectives on the pathways through which digital capabilities catalyze innovation and knowledge genesis in the metaverse. Finally, our methodological approach combines partial least squares structural equation modeling (PLS-SEM), importance-performance map analysis (IPMA), and fuzzy-set qualitative comparative analysis (fsQCA), thus offering a sophisticated comprehension of the intricate dynamics between digital capabilities, EO, and performance in this novel context. This methodological innovation paves the way for investigating emerging phenomena at the confluence of innovation and knowledge.

This paper is structured as follows: This introductory section is followed by a review of extant literature and the development of hypotheses. Subsequently, we elaborate on this study's methodology, present the PLS-SEM and fsQCA results, and conclude with a detailed discussion of this study's theoretical and practical implications and limitations, as well as prospective avenues for future research. This study explores the mechanisms whereby innovation fosters knowledge creation within the metaverse entrepreneurial landscape.

Literature review and hypothesis

MEP

With the emergence and application of the metaverse concept, an increasing number of studies have begun exploring the diverse facets of metaverse entrepreneurship (Ledesma-Chaves et al., 2024). Notably, MEP is a complex, multidimensional construct that gauges the efficacy of entrepreneurial initiatives within the metaverse (Donbesuur et al., 2020; Ledesma-Chaves et al., 2024; Santos-Vijande et al., 2022; Wang et al., 2024). The metaverse's unique attributes enable the use of numerous research materials and vantage points for assessing entrepreneurial performance (Mari et al., 2024). Within this innovative virtual realm, assessing entrepreneurial performance is pivotal to a company's sustainable growth and competitive edge (Dabbous et al., 2023); thus, examining MEP is significant in managerial discourse (Gupta et al., 2024).

Although extant research has examined MEP, as Table 1 outlines, several significant gaps remain. The initial comprehension of the mechanisms and processes influencing MEP is lacking, with most studies focusing exclusively on direct correlations between various predictors and MEP, neglecting to account for potential mediating factors (Ritala et al., 2021). Furthermore, most empirical investigations have utilized qualitative analysis techniques, such as case studies and interviews (Calandra et al., 2024), precipitating a dearth of research employing an approach integrating PLS-SEM and fsQCA—necessary for a holistic understanding of the underlying mechanisms of MEP. Ultimately, the relationship between the development of digital capabilities and MEP has not been thoroughly explored. This study examines the nexus among digital capabilities, EO, and MEP in metaverse entrepreneurship.

Building on the foundation of prior research, this study uses a multimethod analysis framework to examine the mechanisms influencing MEP. This study assesses digital capabilities' direct impact on MEP and introduces a novel mediation model to test EO's intermediary role. By leveraging both PLS-SEM and fsQCA, this study seeks methodological complementarity, thereby enhancing its findings' robustness. Furthermore, MEP is measured from multiple vantage points. This study's design aims to deepen MEP's theoretical comprehension and offer pragmatic guidance for entrepreneurs intending to augment their MEP.

Digital capabilities in metaverse

Digital capabilities have emerged as a key source of competitive

Table 1
Literature review on metaverse entrepreneurial performance.

Author(s)	Key Findings
Büchel and Spinler (2024)	The metaverse has significantly reshaped e-commerce by creating new customer interfaces and core strategies, precipitating a pronounced shift toward digital products and the adoption of the metaverse as an additional sales channel.
Calandra et al. (2024)	The metaverse fosters innovative forms of digital entrepreneurship predicated on technological advancement, immersive design, and enhanced stakeholder participation.
Gao et al. (2024)	This systematic review of metaverse-related research underscores an urgent need for a heightened focus and comprehensive investigations of the metaverse's social and individual impacts.
Gupta et al. (2023)	This study examines emerging business models and future entrepreneurial demands and underscores the need for novel standards and policies to ensure sustainable entrepreneurship in the metaverse.
Hubbard and Aguinis (2023)	Virtual reality and the metaverse can serve as empirical research platforms in management and organizational studies, presenting innovative avenues for exploring poorly understood phenomena.
Kraus et al. (2022)	Facebook's transition toward the metaverse presents an incremental evolution of its business model rather than a revolutionary change.
Mancuso et al. (2024)	This study offers a framework for business model innovation within the metaverse, with a focus on "phygital" transformations and the potential for complete virtual immersions.
Ning et al. (2023)	Integrating various novel technologies in the metaverse presents both challenges and opportunities in network infrastructure, management technology, virtual reality object connectivity, and convergence.
Weking et al. (2023)	The metaverse provides transformative avenues for entrepreneurship, thus influencing the formation of offerings, ventures, and processes.
Yemenici (2022)	The metaverse presents substantial entrepreneurial opportunities, albeit with potentially high initial costs. Entrepreneurs venturing into the metaverse are recommended to conduct thorough feasibility studies to validate their ideas.
Zabel et al. (2023)	Non-focal firms can adapt to the metaverse through dynamic sensing capabilities, with productive opportunism, bricolage behavior, and social screening emerging as pivotal factors.

advantage for organizations (Mancuso et al., 2024). In nascent domains, such as the metaverse, digital capabilities constitute a critical asset for firm innovation (Nambisan et al., 2017). Within the metaverse, these capabilities empower firms to amalgamate data, analyze and anticipate consumer demands, develop virtual environments, and foster digital collaboration (Dubey et al., 2023). Extant research has deliberated on the constitution of digital capabilities and their integrative role within organizational frameworks. Digital capabilities, which conjoin an organization's information technology resources, competencies, and management acumen, can be instrumental in realizing strategic objectives (Al Dhaheri et al., 2024) and significantly influence key performance indicators, such as innovation capacity, competitive edge, and overall performance (Gao et al., 2023; Sousa-Zomer et al., 2020). Nevertheless, empirical research on the discrete elements of digital capabilities and their specific contributions to the metaverse remains sparse. This study aims to enhance the comprehension of digital capabilities in the metaverse, focusing on elucidating its constituent and operational mechanisms.

Drawing on the RBV, this study delineates digital capabilities as a constellation of digital resources and competencies indispensable for metaverse entrepreneurship (Barney, 1991; Chaudhuri et al., 2022; Kamble et al., 2023; Mikalef & Gupta, 2021; Santos-Vijande et al., 2022; Yao et al., 2021). Following prior research, we hypothesize that within the metaverse, digital capabilities comprise infrastructure, business spanning, and proactive stance (Gupta & George, 2016; Kamble et al., 2023). Infrastructure, the tangible substratum of digital capabilities, includes both hardware and software. Business spanning pertains to strategically assimilating digital capabilities to achieve business digitization. Proactive stance mirrors a firm's propensity to embrace, leverage, and revolutionize through cutting-edge technological advancements (Kamble et al., 2023; Yao et al., 2021). Collectively, these three dimensions determine a firm's digital capabilities and profoundly influence its entrepreneurial achievements.

Theoretical framework

This study's theoretical framework is rooted in the RBV and DCT, which offer a robust lens through which to comprehend how digital capabilities influence EO and MEP.

The RBV posits that a firm's internal resources—characterized by their rarity, non-substitutability, inimitability, and strategic value—are paramount to achieving a competitive edge (Barney, 1991; Quttainah & Ayadi, 2024). In the digital and metaverse realms, digital capabilities have emerged as a critical internal resource, endowing firms with a competitive advantage vis-à-vis metaverse entrepreneurship (Teece, 2018). This study conceptualizes digital capabilities as a higher-order formative construct encompassing first-order reflective constructs—namely, infrastructure, business spanning, and proactive stance (Kamble et al., 2023). These dimensions constitute a firm's digital capabilities, substantially impacting its entrepreneurial performance within the metaverse (Cenamor et al., 2019). This conceptualization is congruent with the RBV's foundational principles and provides theoretical scaffolding for our study.

Notably, DCT underscores the necessity for firms to identify, acquire, integrate, and reconfigure both internal and external resources to adapt to the evolving landscape and sustain a competitive edge (Capatina et al., 2024; Teece et al., 1997). Within the metaverse entrepreneurship context, firms must continuously leverage and refine their digital capabilities, thereby augmenting MEP through EO (Sahi et al., 2024). This theoretical scaffold reveals the mechanisms whereby firms can secure a competitive advantage in the metaverse through dynamic resource management and utilization (Mikalef et al., 2021). The theoretical model deepens the comprehension of innovation dynamics in virtual environments by

1) framing digital capabilities as a knowledge-based resource specific to metaverse contexts;
2) advancing a dual pathway (direct and mediated) whereby these capabilities influence entrepreneurial performance; and
3) emphasizing EO's pivotal role in translating digital knowledge into innovative outcomes.

This framework establishes the groundwork for investigating how firms can capitalize on their digital knowledge base to propel innovation and generate value within emerging virtual ecosystems (Fig. 1). Moreover, it contributes to the scholarly discourse on the interplay between technological capabilities, entrepreneurial processes, and innovation within the digital realm.

Hypothesis

Building on the RBV, a firm's internal resources are pivotal for achieving and sustaining a competitive edge (Barney, 1991; Wu et al., 2022). Digital capabilities are valuable, rare, inimitable, and non-substitutable resources. With the metaverse, Digital capabilities include technological infrastructure, business integration, and a proactive approach to digital innovation (Kamble et al., 2023; Yao et al., 2021). Notably, EO is indicative of a firm's inclination to pursue new opportunities, embrace risk-taking, and foster innovation (Bouhalleb & Tapinos, 2023; Brettel et al., 2015; Putniņš & Sauka, 2020; Santos-Vijande et al., 2022; Tajeddini et al., 2023; Yu et al., 2024). Robust digital capabilities equip firms with the requisite data and analytical instruments to discern new opportunities and develop innovative products

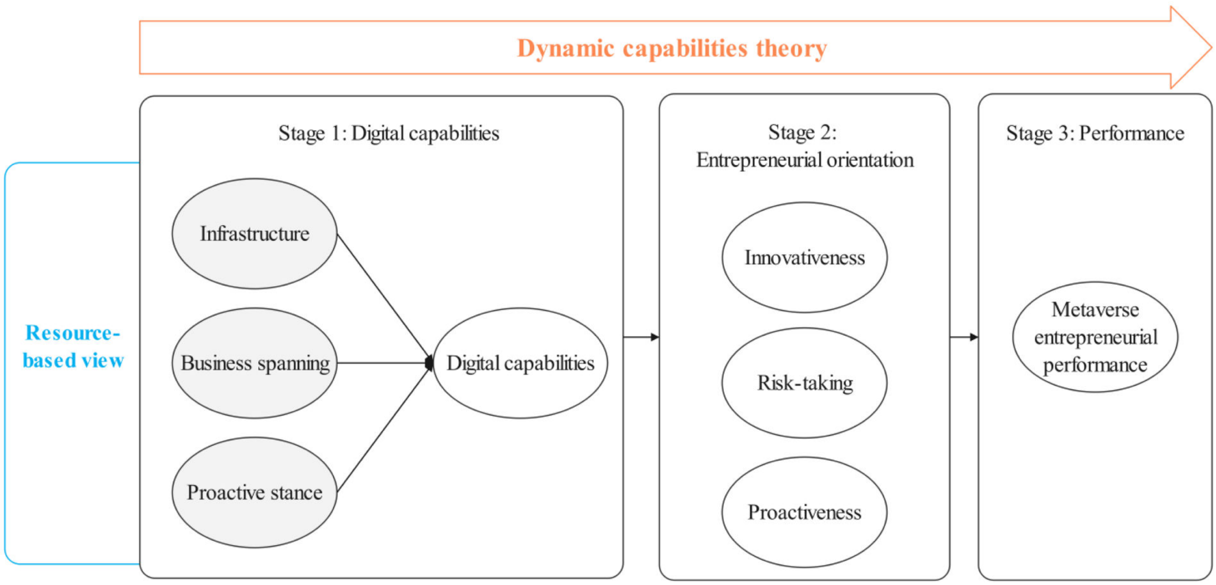

Fig. 1. Theoretical framework of metaverse entrepreneurial performance.

and services, thereby augmenting innovation (Mikalef & Gupta, 2021). Such capabilities also enhance a firm's capacity to comprehend and anticipate risks, enabling more advantageous decision-making and increased risk tolerance (Ivanov & Dolgui, 2021). Moreover, digital capabilities enable firms to swiftly adapt to market and technological changes, thereby improving their responsiveness to new opportunities (Monteiro et al., 2019). Consequently, digital capabilities are strategic resources that empower firms to better perceive and capture market opportunities and, consequently, transform them into innovative outcomes (Nambisan et al., 2017). As an internal resource, digital capabilities bolster operational efficiency and innovation (Khan & Tao, 2022). Firms endowed with robust digital capabilities are frequently more adept at navigating environmental changes and uncertainties, particularly when exhibiting high EO. Especially in the metaverse context, digital capabilities emerge as a resource, enabling firms to understand, react to, and capitalize on opportunities (Kamble et al., 2023). Thus, from the RBV perspective, digital capabilities act as foundational resources that amplify a firm's EO by enhancing its capacity, proactiveness, and risk-taking. Accordingly, we propose the following hypothesis:

H1: Digital capabilities positively influence EO.

Per DCT, firms must continuously recalibrate their resource allocations to adapt to the flux of environmental changes (Khurana et al., 2022; Teece et al., 1997). Digital capabilities represent a manifestation of dynamic capabilities empowering firms to discern and capitalize on novel opportunities and reconfigure resources in response to burgeoning market demand (Mikalef et al., 2021; Teece, 2018). Further, EO embodies a firm's dynamic capacity to harness digital capabilities for resource integration and performance enhancement (Ye et al., 2022)—consistent with DCT's contention that dynamic capabilities play a pivotal role in securing competitive advantage within turbulent environments (Teece et al., 1997). Digital capabilities are instrumental in refining a firm's operational efficiency and augmenting its innovation capacity and market responsiveness (Sultana et al., 2022). A firm equipped with robust digital capabilities is more prone to optimizing resource allocation, thereby amplifying MEP (Khurana et al., 2022). Digital capabilities are crucial for seizing and leveraging new opportunities in the metaverse to enhance MEP (Wang et al., 2024). In the metaverse, which is replete with dynamism and uncertainty, digital capabilities allow firms to exploit real-time data and digital instruments, enabling them to swiftly adapt to technological evolutions and shifting consumer preferences (Gupta et al., 2023; Srinivasan & Venkatraman, 2018). Digital capabilities further facilitate ongoing innovation pertaining to products, services, and business models attuned to the metaverse (Wang et al., 2024; Zahra et al., 2023). Automation and digitization refine operational processes, thus enhancing performance outcomes (Sultana et al., 2022). Accordingly, we propose the following hypothesis:

H2: Digital capabilities positively influence MEP.

Building upon the RBV, EO is recognized as critical for firm innovation, risk-taking, and proactive behaviors (Barney, 1991; Donbesuur et al., 2020), with numerous studies substantiating its positive impact on firm performance (Elgarhy et al., 2023; Kusa et al., 2021). EO is a multifaceted construct that encompasses innovativeness, risk-taking, and proactiveness, which are pivotal for firms to navigate effectively through uncertain and dynamic environments (Aftab et al., 2022). In the metaverse, which is marked by swift technological changes and fluid market conditions, firms with robust EO are adept at discerning and capitalizing on novel opportunities, thus enhancing performance (Gupta et al., 2024; Ledesma-Chaves et al., 2024). This perspective is supported by DCT, which posits that EO catalyzes internal competencies' evolution and reconfiguration to accommodate shifting environmental demands (Teece et al., 1997; Wang et al., 2021). Elevated EO nurtures a firm's propensity for innovation, risk-taking, and proactivity, qualities that are advantageous for identifying and seizing new opportunities, thereby amplifying entrepreneurial performance (Mari et al., 2024). Firms with pronounced EO typically exhibit a robust innovation ethos and constantly develop new products and services to augment their MEP (Dubey et al., 2020). Risk-taking firms are inclined to explore and exploit new opportunities in the metaverse, and this adventurous spirit aids in enhancing MEP (Putniņš & Sauka, 2020). Firms that are—compared to those that are not—characterized by a proactive stance are more likely to embrace challenges, outpace their competitors, and achieve superior outcomes in the metaverse (Gali et al., 2020). Furthermore, EO-endowed firms exhibit heightened adaptability, enabling them to swiftly respond to fluctuations in the metaverse environment and recalibrate their strategies to optimize their MEP (Santoro et al., 2021). Accordingly, we propose the following hypothesis:

H3: EO positively influences MEP.

From the DCT's perspective, a company's capacity to assimilate, cultivate, and reconfigure its internal and external competencies is fundamental to tackling the challenges posed by rapidly evolving environments (Dubey et al., 2020; Teece et al., 1997). Digital capabilities have emerged as dynamic assets that amplify a firm's performance and innovation capacity (Kamble et al., 2023; Mikalef & Gupta, 2021). While digital capabilities lay the technological groundwork, EO represents the strategic direction that harnesses these capabilities to attain enhanced performance (Brettel et al., 2015; Santos-Vijande et al., 2022). Companies endowed with formidable digital capabilities are better positioned to bolster EO by streamlining innovative endeavors, gauging risk, and engaging proactively with the market (Ritala et al., 2021; Yu et al., 2024). This collaborative dynamic empowers firms to refine resource allocation and recalibrate strategies efficiently, thus elevating MEP (Dubey et al., 2020; Zahra et al., 2023). Empirical studies demonstrate that EO plays a mediating role in the nexus between resources and performance outcomes by transforming capabilities into measurable achievements (Brettel et al., 2015; Sahi et al., 2024). Within the metaverse's context, this mediating role is of paramount importance as companies must harmonize their digital capabilities with entrepreneurial initiatives to navigate the intricate digital terrain adeptly (Calandra et al., 2024; Gupta et al., 2023). Accordingly, we propose the following hypothesis:

H4: EO mediates digital capabilities' impact on MEP.

Following Kamble et al.'s (2023) methodology, this study considers position and sector as control variables to augment the practical utility of the theoretical MEP model depicted in Fig. 2.

Method

This study's methodology is divided into four phases (Fig. 3).

Measures

Following Kumar et al.'s (2024) guidelines, a meticulous multi-step process was undertaken to develop our measurement tools (Table 2) and ensure their precision and reliability. The initial phase involved an exhaustive review of pertinent literature, from which we extracted several important metrics. Subsequently, building on prior studies' foundational work, these metrics were carefully tailored to align with our study's specific context and aims. Through rigorous internal discourse, we developed an initial version of our measurement scale.

We convened a panel of five experts, each with substantial research and practical experience in the realms of digital entrepreneurship and the metaverse, which provided a robust theoretical and practical framework for our scale. Through a detailed discussion, we scrutinized and refined potential issues during the item selection phase. After three iterative rounds of comprehensive deliberation, we arrived at the second iteration of our measurement.

Following Wang et al. (2024), we engaged 19 student entrepreneurs with substantial exposure to diverse metaverse entrepreneurship domains in the pre-testing phase. The pre-test outcomes revealed a high degree of internal consistency (Cronbach's alpha > 0.7) in our measurement scale, signifying its reliability (Tavakol & Dennick, 2011). We meticulously collated and analyzed the student entrepreneurs' feedback, which informed further enhancements to our scale.

For our questionnaire's third version, we implemented a stringent back-translation protocol to guarantee semantic equivalence and cultural appropriateness across linguistic contexts (Tajeddini et al., 2023). We recruited two translators who were native speakers of both English and the study language, with considerable translation expertise and academic credentials. We employed a dual-independent back--translation approach, wherein the two translators independently translated and back-translated the questionnaires.

Employing our scale, we quantified the study constructs—digital capabilities, EO, and MEP. As suggested by Martín-Navarro et al. (2023), we used a 7-point Likert scale (1 = "strongly disagree" and 7 = "strongly agree"), which adeptly captures respondents' sentiments or perceptions toward various constructs, thus yielding granular data.

Samples

As metaverse entrepreneurship is an emerging domain wherein individuals well-versed in digital realms are often pioneers and innovators, we deliberately focused on student entrepreneurs. Despite being students, these participants were deeply involved in actual metaverse ventures, offering valuable insights into the expression of digital capabilities and EO in this innovative context. This methodology is consistent with recent studies on technology entrepreneurship that have effectively utilized student samples (Blankesteijn, 2024; Kulkov et al., 2023). We employed snowball sampling to access a cohort of entrepreneurs with substantial experience in metaverse entrepreneurship (Biernacki & Waldorf, 1981). We contacted the University Student Entrepreneurship Association in Eastern China to secure a list of students engaged in metaverse entrepreneurship. During data collection, we strategically selected non-random snowball sampling to engage a specific group with profound knowledge of our study's focus, thereby ensuring data quality and robust theoretical insights. Moreover, snowball sampling helped identify individuals with specific information or experience, such as those having successfully established businesses in

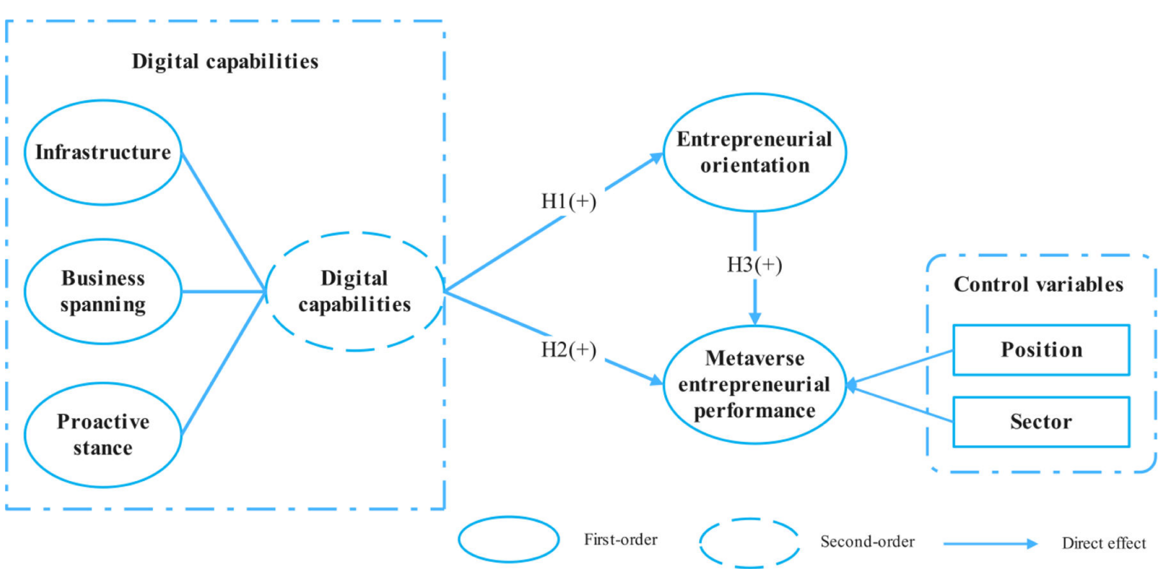

Fig. 2. Theoretical model of metaverse entrepreneurial performance.

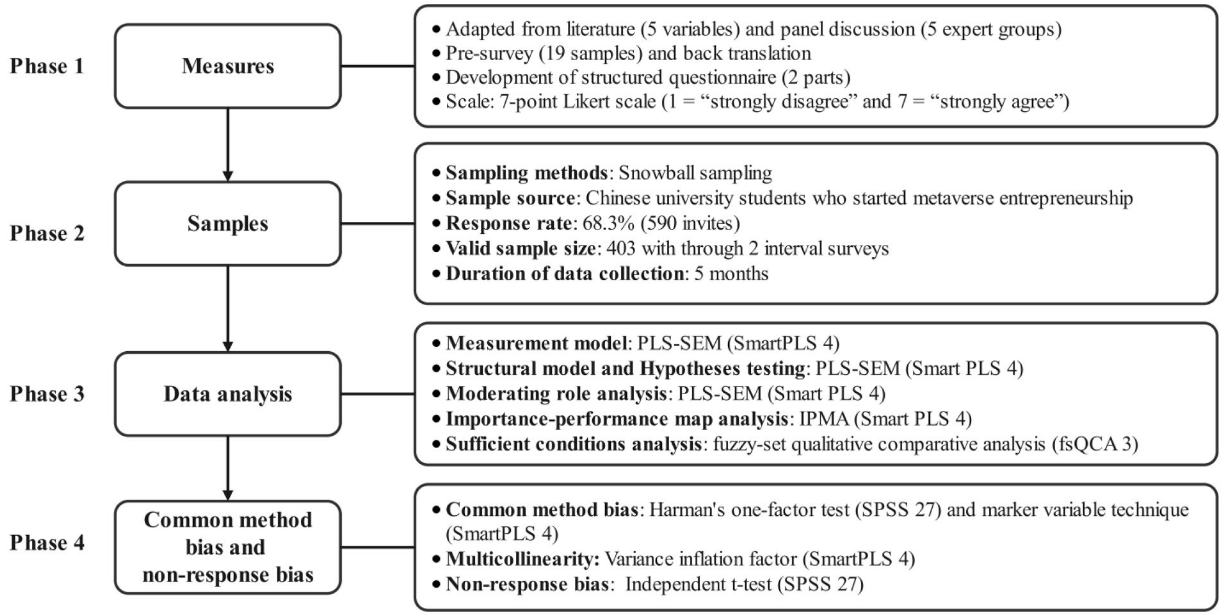

Fig. 3. Method flowchart of metaverse entrepreneurial performance.

the metaverse.

Our study's central constructs—specifically, digital capabilities, EO, and MEP—are conceptualized as subjective and perceptual, rendering them amenable to survey collection methods (Bouhalleb & Tapinos, 2023). Considering our study participants' geographical dispersion across various cities in China, the survey methodology was economical and efficient, enabling us to collect a significant data set despite geographic constraints. Consequently, we opted for a survey as the primary data collection method.

We used the online platform Questionnaire Star (wjx.cn) to create electronic questionnaires, which were distributed via WeChat and email (Wang & Esperança, 2023). The questionnaire was divided into two sections. The first section inquired about the respondent firms' characteristics and solicited information about aspects, such as position and sector. The second section focused on the five constructs in the research model. We strategically designed the first survey question as a filter. Respondents who selected "Unfamiliar with the topic of metaverse entrepreneurship" were directed to the end of the survey immediately, ensuring that only relevant respondents continued, thereby maintaining this study's methodological quality. To mitigate a single survey administration's limitations, we administered the survey across two phases (Martín-Navarro et al., 2023).

In the interest of the respondents' privacy, we did not collect any personal information. At the outset, we clearly communicated to the participants that the data collected would be used exclusively for research purposes and would be treated with the utmost confidentiality (Santos-Vijande et al., 2022). Participants were informed of their right to withdraw from the survey at any time.

Data collection spanned five months from April 1 to September 1, 2023. Overall, we gathered 403 valid questionnaires (Table 3), exceeding the minimum sample size requirement of 92, as calculated using G*Power 3.1 (Kamble et al., 2023), thus fulfilling this study's sample size requirements. Table 3 presents an exhaustive overview of our sample demographic. The sample comprised 403 respondents, with a balanced distribution across various positions in metaverse entrepreneurship. Notably, 35 % of the respondents were founders, and an additional 35.2 % held key positions—such as chief technology officer, chief product officer, chief marketing officer, chief operating officer, and chief financial officer. This distribution ensured that our sample reflected the insights of individuals with direct decision-making authority and significant involvement in metaverse ventures. The sector distribution indicated that 74.2 % of the ventures were B2C, while 25.8 % were B2B, mirroring the prevailing landscape of metaverse entrepreneurship, which is predominantly consumer-facing. The gender distribution, with 59.8 % men and 40.2 % women respondents, suggested a relatively equitable representation—crucial for capturing the diversity of perspectives in this growing field.

Data analysis

Our study employed a multi-method analysis framework that integrated PLS-SEM, IPMA, and fsQCA. The PLS-SEM analysis—conducted using SmartPLS 4.0 software, which is particularly suitable for exploratory research—facilitates the concurrent estimation of measurement and structural models, perfectly aligning with our objectives (Ledesma-Chaves et al., 2024). We assessed the measurement model to ensure all constructs' convergent and discriminant validity (Hair et al., 2022). Subsequently, we estimated the structural model and rigorously tested our research hypotheses using bootstrap variance analysis for mediation effects (Wang et al., 2024).

The IPMA was employed because it provides actionable insights into management practices by mapping each predictor variable's importance and performance level (Hair et al., 2022; Wang & Zhang, 2024). Furthermore, we conducted fsQCA using fsQCA 3.0, a methodology that identifies the necessary and sufficient conditions that precipitate various outcomes, thus elucidating the intricate tapestry of causal relationships (Ragin, 2009; Wang & Esperança, 2023). These methodologies are complementary, offering both variable-centered (PLS-SEM) and configuration-centered (fsQCA) analytical perspectives (Wang et al., 2024). While PLS-SEM helped evaluate our hypothesized relationships, fsQCA revealed the complex factor combinations that contributed to elevated MEP. Additionally, IPMA bridged these approaches by converting statistical outcomes into pragmatic managerial implications. This multifaceted methodological approach bolstered our findings' robustness and provided a comprehensive understanding of the phenomenon under scrutiny. This enabled us to transcend a singular methodological approach's limitations and, thereby, test our hypotheses while simultaneously unearthing deep, nuanced relationships that might otherwise remain obscure.

Table 2
Measures.

Measures	Loadings	VIF
Entrepreneurial Orientation (EO; adapted from Bouhalleb & Tapinos, 2023; Brettel et al., 2015; Santos-Vijande et al., 2022)		
Alpha: 0.929, CRA: 0.929, CRC: 0.941, AVE: 0.638, Mean: 4.505, SD: 1.505		
EO1. Our team actively introduces improvements and innovations in our organization.	0.782	2.081
EO2. Our organization is creative in its operation methods.	0.778	2.076
EO3. Our organization explores new ways of working.	0.873	3.329
EO4. The term "risk taker" is considered a positive attribute in our organization.	0.787	2.188
EO5. We encourage people in our organization to take calculated risks with new ideas.	0.797	2.235
EO6. Our organization emphasizes exploration and experimentation to identify opportunities.	0.784	2.120
EO7. We strive to take the initiative and seize opportunities.	0.798	2.234
EO8. We excel at identifying market opportunities.	0.786	2.136
EO9. We initiate actions to which other organizations respond.	0.799	2.273
Infrastructure (INF; adapted from Kamble et al., 2023; Yao et al., 2021)		
Alpha: 0.825, CRA: 0.828, CRC: 0.884, AVE: 0.656, Mean: 3.835, SD: 1.506		
INF1. Our team has access to fundamental infrastructure services, such as cloud computing and data storage.	0.815	1.795
INF2. Our team can procure high-performance hardware infrastructure at reasonable prices.	0.836	2.031
INF3. Our team has access to efficient data transmission and network infrastructure services.	0.751	1.521
INF4. Our team can procure reliable and secure data management infrastructure.	0.835	1.869
Business spanning (BS; adapted from Kamble et al., 2023; Yao et al., 2021)		
Alpha: 0.860, CRA: 0.861, CRC: 0.905, AVE: 0.704, Mean: 4.565, SD: 1.565		
BS1. Our organization actively bridges the gap between our digital capabilities and business strategies.	0.818	1.945
BS2. We consistently integrate our metaverse initiatives into our business strategic planning.	0.854	2.246
BS3. Our metaverse plans are flexible and adjust according to changes in business requirements.	0.836	1.999
BS4. Our team can understand the value of metaverse investments.	0.848	2.245
Proactive stance (PS; adapted from Kamble et al., 2023; Yao et al., 2021)		
Alpha: 0.866, CRA: 0.866, CRC: 0.909, AVE: 0.713, Mean: 4.771, SD: 1.578		
PS1. We actively seek out and experiment with new metaverse tools and techniques.	0.861	2.352
PS2. Our organization encourages and supports the exploration of new metaverse applications.	0.830	1.986
PS3. We continuously seek innovative ways to improve our metaverse usage's effectiveness.	0.839	2.079
PS4. We stay current with the latest metaverse innovations and incorporate them into our operations.	0.847	2.055
Metaverse entrepreneurial performance (MEP; adapted from Santos-Vijande et al., 2022; Wang et al., 2024)		
Alpha: 0.778, CRA: 0.786, CRC: 0.870, AVE: 0.691, Mean: 4.542, SD: 1.742		
MEP1. We have observed consistent growth in our sales since the implementation of our metaverse strategies.	0.849	1.563
MEP2. Our metaverse ventures have increased our market share.	0.817	1.607
MEP3. Our profitability has increased owing to our metaverse projects.	0.828	1.659

Constructs and measurement items	Path coefficient	P value
Digital capabilities (DC; adapted from Kamble et al., 2023; Yao et al., 2021)		
Infrastructure	0.478	**
Business spanning	0.350	*
Proactive stance	0.378	*

Note: Cronbach's alpha is represented as "Alpha." Composite reliability (rho_a) is denoted as "CRA." Composite reliability (rho_c) is signified as "CRC." Average variance extracted is abbreviated as "AVE." $p < 0.05$*, $p < 0.01$**, $p < 0.001$*** (two-tailed).

Common method and non-response biases

Common method bias (CMB), a potential pitfall during data collection and analysis, can undermine the dependability of research outcomes (Podsakoff et al., 2003). To mitigate CMB, we implemented a multifaceted approach. Before the survey's development, extensive expert deliberations were conducted to meticulously define the metrics and elucidate their interrelationships and, thereby, ensure a scientifically robust questionnaire design. Moreover, a pre-survey was conducted to refine and adjust the questionnaire based on participant feedback, further minimizing the likelihood of CMB. Throughout the survey, the respondents were assured that their information would be utilized solely for research purposes and treated with stringent confidentiality.

Table 3
Sample characteristics ($N = 403$).

Characteristics	Category	N	%
Position	Founders	141	35.0
	CEO/General Manager	80	19.9
	Chief of technology, product, marketing, operations, and finance	142	35.2
	Others	40	9.9
Sector	B2B	104	25.8
	B2C	299	74.2
Gender	Men	241	59.8
	Women	162	40.2

After data collection, we performed Harman's one-factor test, a diagnostic assessment for CMB. The test revealed that the first factor accounted for 41.9 % of the variance, which is below the 50 % threshold, suggesting that CMB was not a predominant concern in our study. Additionally, we employed the marker variable technique to control for CMB, selecting a construct unrelated to our study's focal variables—specifically, perceived ease of use (PEU)—based on prior recommendations. The PEU measure—derived from the existing literature (Wang et al., 2023a)—has a Cronbach's alpha value of 0.791, composite reliability (rho_a) of 0.761, composite reliability (rho_c) of 0.849, average variance extracted (AVE) of 0.657, mean of 4.315, and SD of 1.602. The analysis of PEU against the other model variables demonstrated no significant correlations, reinforcing the conclusion that CMB did not significantly affect our research findings.

Multicollinearity, which can destabilize regression models and skew parameter estimates (Hair et al., 2022), was assessed by calculating the variance inflation factor values. As Table 2 indicates, the highest VIF value was 3.329—significantly below the benchmark threshold of 10, indicating that multicollinearity was not a critical issue in our model.

Furthermore, we examined the potential for non-response bias (NRB). The sample was bifurcated according to the data collection sequence. Employing SPSS 27, we conducted independent *t*-tests to discern any discrepancies in position, gender, and sector between the two subsets (Wang & Esperança, 2023). These findings revealed no significant NRB in our sample ($p > 0.05$).

PLS-SEM results

Measurement model

The measurement model was meticulously assessed using PLS-SEM. Convergent validity was determined by examining all item loadings, following Hair et al.'s (2021) recommendation that item loadings must exceed 0.7 to ensure a robust association with their respective latent variables. As Table 2 reveals, all item loadings exceeded the threshold of 0.7, indicating adequate convergent validity. Both Cronbach's alpha and composite reliability are key indicators of internal consistency, with values exceeding 0.7 suggesting high consistency among the measures of latent variables (Hair et al., 2022). In our study, the Cronbach's alpha and composite reliability values for all latent variables surpassed 0.7, thus fulfilling the criterion for internal consistency.

Discriminant validity was ascertained using the Fornell-Larcker criterion and heterotrait-monotrait ratio of correlations (HTMT). The Fornell-Larcker criterion stipulates that the square root of the AVE for a latent variable should exceed its correlations with other latent variables (Fornell & Larcker, 1981). Table 4 presents the findings, revealing that

Table 4
Discriminant validity.

Fornell-Larcker criterion and heterotrait-monotrait ratio					
Variable	BS	EO	INF	MEP	PS
BS	0.839	0.318	0.651	0.288	0.616
EO	0.286	0.799	0.325	0.691	0.311
INF	0.551	0.285	0.810	0.338	0.596
MEP	0.237	0.592	0.271	0.831	0.287
PS	0.531	0.280	0.505	0.237	0.844
Cross loadings					
Items	BS	EO	INF	MEP	PS
BS1	0.818	0.220	0.442	0.198	0.449
BS2	0.854	0.264	0.507	0.223	0.428
BS3	0.836	0.246	0.467	0.206	0.425
BS4	0.848	0.227	0.432	0.168	0.483
EO1	0.286	0.782	0.239	0.475	0.281
EO2	0.183	0.778	0.185	0.488	0.178
EO3	0.241	0.873	0.229	0.468	0.205
EO4	0.186	0.787	0.186	0.467	0.158
EO5	0.199	0.797	0.229	0.465	0.255
EO6	0.273	0.784	0.265	0.468	0.267
EO7	0.252	0.798	0.258	0.491	0.207
EO8	0.224	0.786	0.258	0.466	0.234
EO9	0.199	0.799	0.193	0.468	0.217
INF1	0.459	0.212	0.815	0.234	0.418
INF2	0.487	0.229	0.836	0.200	0.431
INF3	0.359	0.227	0.751	0.211	0.370
INF4	0.474	0.255	0.835	0.232	0.414
MEP1	0.210	0.559	0.232	0.849	0.217
MEP2	0.188	0.442	0.244	0.817	0.181
MEP3	0.191	0.465	0.199	0.828	0.190
PS1	0.482	0.239	0.446	0.187	0.861
PS2	0.408	0.251	0.406	0.210	0.830
PS3	0.443	0.222	0.406	0.186	0.839
PS4	0.459	0.233	0.445	0.217	0.847

Note: EO = Entrepreneurial orientation; INF = Infrastructure; BS = Business spanning; PS = Proactive stance; MEP = Metaverse entrepreneurial performance; DC = Digital capabilities.

the square roots of the AVEs for all latent variables were greater than their correlations with other variables, thereby satisfying the Fornell-Larcker criterion and establishing discriminant validity. Moreover, we calculated the HTMT values among all the latent variables, as suggested by Henseler et al. (2015). Notably, HTMT values below the threshold of 0.85 indicate discriminant validity. Table 4 presents that all HTMT values were below 0.85, further substantiating the discriminant validity. A cross-loading analysis was also performed. Table 4 suggests that each item's loading on its designated variable was more substantial than that on the other variables, providing additional evidence of solid discriminant validity (Hair et al., 2022).

Structural model

The structural model assessment was conducted using the SmartPLS 4.0 software—employing a bootstrap sampling procedure with 5000 iterations—to test the relationships and hypotheses in our research model, following Hair et al.'s (2021) guidelines. The results, as Fig. 4 depicts, indicate that digital capabilities significantly positively impact both EO ($\beta = 0.345$, $p < 0.001$) and MEP ($\beta = 0.116$, $p < 0.05$), thereby substantiating H1 and H2. Additionally, EO significantly positively influences MEP ($\beta = 0.554$, $p < 0.001$), which supports H3.

To evaluate the model's quality, we examined its explanatory power and predictive relevance. The R-squared (R^2) values indicate the extent to which the model accounts for the variance in the endogenous variables. The R^2 for EO was 0.121 and that for MEP was 0.37, suggesting that while the model explains a moderate amount of the variance for EO, it accounts for a substantial portion of the variance in MEP. The Q-square (Q^2) values, which indicate predictive relevance, were calculated and found to be above zero for both EO ($Q^2 = 0.074$) and MEP ($Q^2 = 0.24$), implying that the model possesses a satisfactory level of explanatory and predictive power (Hair et al., 2022).

Additionally, the model's goodness-of-fit was determined using the standardized root mean square residual (SRMR) as an index of fit. Our model's SRMR value was 0.08—within the acceptable range for an acceptable fit (Hair et al., 2022).

Mediation

We utilized a bootstrap-based PLS-SEM approach to examine the mediating effect in accordance with Hair et al.'s (2021) analytical recommendations. Table 5 reveals that digital capabilities exerted a significant indirect impact on MEP through EO (β=0.191, $p < 0.001$). This indirect effect accounted for 62.21 % of the total effect of digital capabilities on MEP. According to the criteria established by Hair et al. (2021), partial mediation is indicated when the variance accounted for (VAF) falls within the range of 20 %–80 %. The VAF in our study was within this range, thereby fulfilling the criteria for partial mediation. Consequently, our results substantiate H4, which posits that EO is a

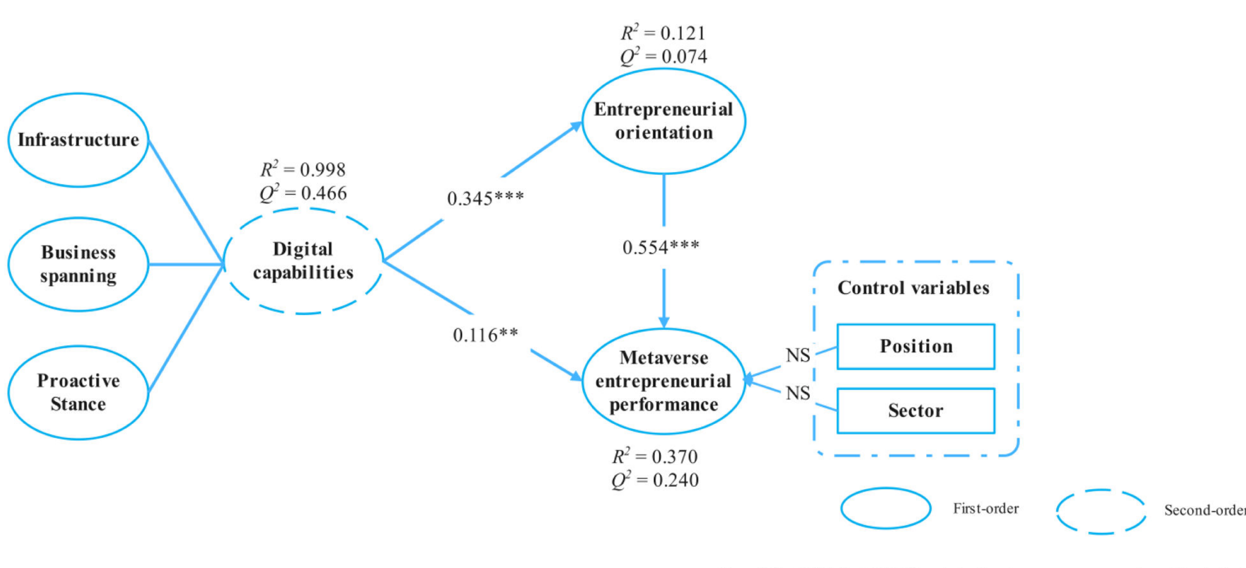

Fig. 4. Structural model results of metaverse entrepreneurial performance.

Table 5
Mediation of entrepreneurial orientation.

Path		B	VAF	Type
DC → EO → MEP	Direct effect	0.116*	62.21 %	Partial mediation
	Indirect effect	0.191***		
	Total effect	0.307***		

Note: Variance accounted for (VAF): 20 % ≤ VAF ≤ 80 % Partial mediation. ***$p < 0.001$ **$p < 0.01$ *$p < 0.05$, NS: not significant.

partial mediator in the relationship between digital capabilities and MEP.

PLS_Predict

To assess our model's predictive capability, we employed the PLS prediction approach proposed by Hair et al. (2021). The results, as Table 6 presents, indicate that the predictive error for most measures, when calculated using the PLS-SEM prediction technique, was lower than that obtained through linear regression, suggesting that our PLS model offers greater predictive accuracy than traditional linear regression models.

Importance-performance map analysis

We employed SmartPLS 4.0 software to conduct IPMA for MEP, as Fig. 5 illustrates, following Hair et al.'s (2021) methodology. The analysis revealed that EO exerted the most significant influence on MEP, with an importance score of 0.554. Additionally, EO exhibited a relatively high performance level, denoted by a score of 58.146. These findings underscore that EO is a critical component of our research model and a pivotal factor impacting MEP (Brettel et al., 2015; Hughes et al., 2021).

Table 6
PLS_prediction of metaverse entrepreneurial performance.

Items	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE	((PLS-SEM)-LM)_RMSE	((PLS-SEM)-LM)_MAE
BS1	1.952	1.651	1.958	1.643	−0.006	0.008
BS2	1.904	1.554	1.915	1.559	−0.011	−0.005
BS3	1.773	1.503	1.789	1.506	−0.016	−0.003
BS4	1.878	1.571	1.882	1.558	−0.004	0.013
BS1	1.952	1.652	1.958	1.643	−0.006	0.009
BS2	1.902	1.553	1.915	1.559	−0.013	−0.006
BS3	1.771	1.499	1.789	1.506	−0.018	−0.007
BS4	1.870	1.564	1.882	1.558	−0.012	0.006
INF1	1.849	1.560	1.867	1.558	−0.018	0.002
INF2	1.893	1.605	1.920	1.622	−0.027	−0.017
INF3	1.927	1.656	1.947	1.678	−0.020	−0.022
INF4	1.813	1.538	1.837	1.553	−0.024	−0.015
PS1	1.769	1.441	1.784	1.470	−0.015	−0.029
PS2	1.778	1.438	1.799	1.458	−0.021	−0.020
PS3	1.877	1.568	1.900	1.596	−0.023	−0.028
PS4	2.078	1.790	2.105	1.810	−0.027	−0.020
EO1	1.840	1.542	1.845	1.553	−0.005	−0.011
EO2	1.738	1.398	1.728	1.411	0.010	−0.013
EO3	2.030	1.744	2.024	1.723	0.006	0.021
EO4	1.816	1.496	1.822	1.514	−0.006	−0.018
EO5	1.923	1.618	1.929	1.624	−0.006	−0.006
EO6	2.058	1.776	2.061	1.770	−0.003	0.006
EO7	1.918	1.653	1.923	1.640	−0.005	0.013
EO8	1.793	1.490	1.767	1.488	0.026	0.002
EO9	1.912	1.607	1.876	1.564	0.036	0.043
INF1	1.848	1.559	1.867	1.558	−0.019	0.001
INF2	1.893	1.606	1.920	1.622	−0.027	−0.016
INF3	1.928	1.659	1.947	1.678	−0.019	−0.019
INF4	1.814	1.539	1.837	1.553	−0.023	−0.014
MEP1	2.065	1.757	2.065	1.768	0.000	−0.011
MEP2	2.132	1.827	2.133	1.821	−0.001	0.006
MEP3	2.144	1.824	2.135	1.830	0.009	−0.006
PS1	1.768	1.441	1.784	1.470	−0.016	−0.029
PS2	1.780	1.438	1.799	1.458	−0.019	−0.020
PS3	1.878	1.569	1.900	1.596	−0.022	−0.027
PS4	2.079	1.790	2.105	1.810	−0.026	−0.020

fsQCA results

We used the fsQCA method to further substantiate the findings of our PLS-SEM analysis. This approach is adept at identifying necessary and sufficient conditions that contribute to high MEP, as articulated by Ragin (2009). Initially, we calibrated the causal conditions and outcome variable. The process involved transforming variables from Likert-scale values to fuzzy-set membership scores, which indicate the degree of affiliation with specific sets. These scores range from 0.05 (full non-membership) to 0.95 (full membership), using 0.5 as the crossover point. In the necessity analysis phase, we found no variable with a consistency value exceeding 0.9, indicating that no single variable could entirely account for the outcome variable. Subsequently, we constructed a truth table presenting all possible combinations of causal conditions and selected configurations for a detailed analysis based on frequency and consistency values. For this study, we established a minimum frequency threshold of 10 cases, a raw consistency threshold of 0.80, and a PRI (Presens) consistency of 0.6.

Table 7 reveals two configurations that are instrumental in achieving high MEP, each exhibiting high consistency (>0.85) and a coverage of 0.554. These findings indicate strong empirical relevance. This comprehensive approach offers a novel perspective that complements our hypothesis testing and reveals more profound relationships. The fsQCA identified the following configurations that resulted in high MEP:

Configuration 1: High infrastructure, high proactive stance, and high EO combine to result in high MEP.

Configuration 2: High infrastructure, high business spanning, and high EO combine to result in high MEP.

These findings underscore that various combinations of digital capabilities components and EO result in superior performance, reflecting the principle of equifinality. This suggests that metaverse entrepreneurs can attain high MEP through diverse pathways contingent on their specific strengths in digital capabilities and EO. The fsQCA results highlight the critical role of infrastructure across both configurations, emphasizing its significance as a foundational element for MEP. The analysis further indicates that firms can achieve high MEP either through a proactive technology stance or strong business integration of digital capabilities, insofar as they sustain strong infrastructure and EO. Such nuanced insights are not typically revealed by traditional variable-based methods such as PLS-SEM alone. Consequently, the fsQCA analysis enriches our understanding of the intricate interplay between digital capabilities and EO in influencing MEP, thus enhancing our theoretical contributions and offering actionable implications for entrepreneurs to adjust their strategies accordingly.

Discussion

Discussion of key findings

This study's four hypotheses were all substantiated through our PLS-SEM analysis, yielding valuable insights into the prospective trajectory of digital entrepreneurship within the metaverse. First, we established that digital capabilities significantly enhance EO (H1: $\beta = 0.345$, $p < 0.001$). This suggests that, as firms fortify their digital infrastructure, align their digital strategies with business objectives, and adopt a proactive stance toward new technologies, they cultivate a stronger entrepreneurial mindset. This mindset is characterized by innovation, proactiveness, and risk-taking—pivotal for navigating the metaverse's complexities (Schäfer et al., 2023). This finding suggests that future digital entrepreneurs must prioritize developing comprehensive digital capabilities to foster an entrepreneurial culture adept at thriving in this

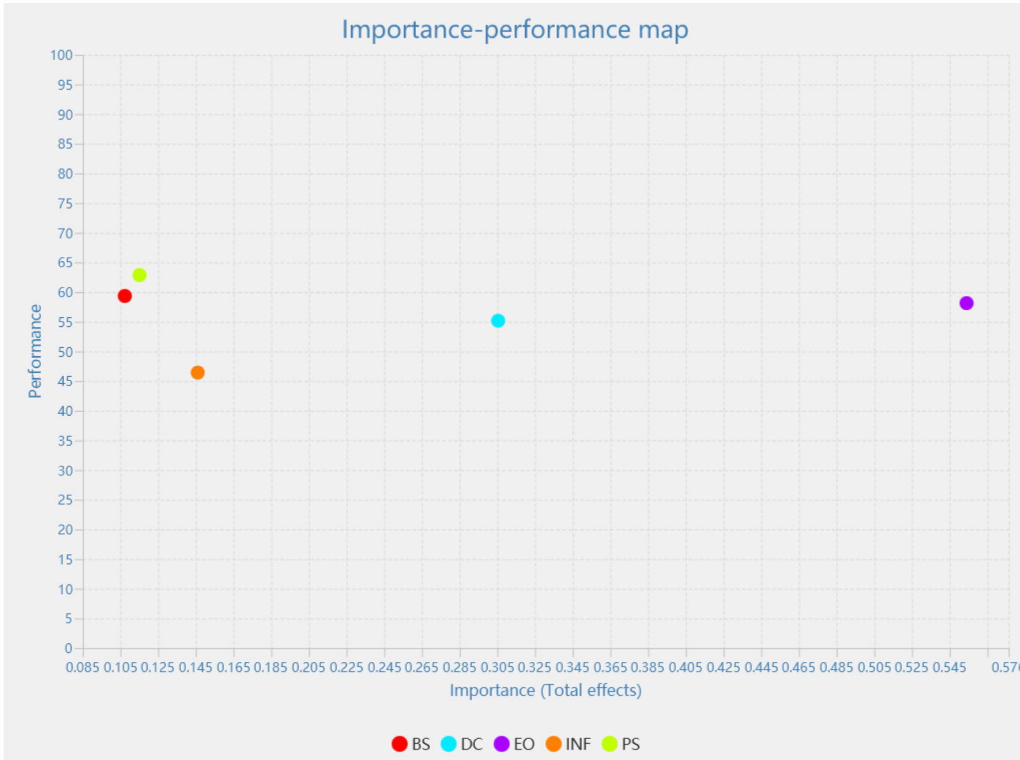

Fig. 5. IPMA of metaverse entrepreneurial performance.

Table 7
Configurations of high-level metaverse entrepreneurial performance.

	Configurations	
	1	2
Business spanning		◉
Proactive stance	◉	
Infrastructure	◉	◉
Entrepreneurial orientation	◉	◉
Raw coverage	0.496	0.507
Unique coverage	0.047	0.058
Consistency	0.864	0.868
Solution coverage	0.554	
Solution consistency	0.857	

Note: The symbols "◉" denote core conditions. Conversely, instances of empty cells indicate a situation deemed "irrelevant" or "unconcerned.".

emerging virtual ecosystem.

Second, our results demonstrated that digital capabilities directly and positively influence MEP (H2: $\beta = 0.116$, $p < 0.05$). This finding underscores the indispensable role of digital resources and competencies in achieving superior performance in the metaverse (Gupta et al., 2023; Teece, 2018). As the metaverse continues to evolve, firms with advanced digital capabilities are poised to leverage technological advancements to innovate, optimize operations, and enhance customer experience, thereby gaining a competitive edge.

Third, we found that EO significantly positively influences MEP (H3: $\beta = 0.554$, $p < 0.001$). This finding highlights the importance of nurturing an entrepreneurial mindset for success in the metaverse (Sahi et al., 2024). Firms that employ innovation, proactivity, and risk-taking are better equipped to identify and seize novel opportunities in this dynamic virtual domain.

Our study elucidates that EO serves as a partial mediator in the nexus between digital capabilities and MEP (H4: β=0.191, $p < 0.001$). This finding underscores the crucial mechanism whereby digital proficiency metamorphoses into quantifiable performance outcomes from an entrepreneurial perspective. Thus, while digital capabilities furnish the requisite instruments and assets, EO adeptly harnesses these capabilities to propel performance. For the growing realm of digital entrepreneurship in the metaverse, this suggests that digital competencies must be concurrently cultivated and an entrepreneurial ethos to attain superior performance must be nurtured (Gashi et al., 2024).

Our findings have profound implications for the trajectory of digital entrepreneurship in the metaverse. As the metaverse proliferates and permeates diverse facets of commerce and society, digital entrepreneurs must adapt by augmenting their digital capabilities and EO (Bouhalleb & Tapinos, 2023). The confluence of these elements is paramount in surmounting the unprecedented challenges and opportunities engendered by the metaverse. Enterprises that invest in digital infrastructure, proactively adopt new technologies, and foster an entrepreneurial mindset are more likely to innovate, swiftly adapt to market fluctuations, and secure a sustained competitive advantage in the metaverse.

Moreover, our study suggests that the metaverse offers a distinctive milieu wherein digital capabilities and EO interact with heightened dynamism compared to traditional settings. The partial mediation effect indicates that possessing digital capabilities alone is insufficient. Firms must concurrently cultivate entrepreneurial acumen to exploit these capabilities effectively. This accentuates the imperative for future research and practice to concentrate on amalgamating digital strategies with entrepreneurial processes to fully capitalize on the metaverse's potential.

In summary, our investigation delineates a strategic roadmap for digital entrepreneurs aspiring to thrive in the metaverse. By prioritizing the enhancement of digital capabilities and cultivation of EO, firms can augment their performance and secure a competitive edge in this emerging virtual landscape (Mari et al., 2024). As the metaverse continues to transform, these findings become increasingly pertinent, orienting scholars and practitioners to comprehend and leverage the synergy between technological innovation and entrepreneurial endeavors.

Theoretical implications

Our study introduces a novel lens through which to dissect the constellation of digital capabilities and their consequential impact on MEP, thereby making a substantial contribution to theoretical advancement. Prior studies have delved into the correlation between digital capabilities and corporate performance (Bharadwaj, 2000; Teece, 2018), yet these studies frequently concentrate on direct linkages, sidelining the exploration of potential mediating variables. Our study bridges this gap by elucidating the role of EO as a conceivable mediator (Ledesma-Chaves et al., 2024) that facilitates the influence of digital capabilities on MEP (Mancuso et al., 2024).

By integrating the RBV and DCT, our study delineates an innovative theoretical framework for elucidating digital capabilities' influence on EO and MEP. These paradigms bolster our understanding of the mechanisms whereby digital capabilities engender EO and, in turn, MEP. Our findings reveal that digital capabilities can augment a firm's EO, thereby enhancing its MEP. This finding provides fresh empirical evidence for the application of the RBV and DCT in the metaverse entrepreneurial milieu and paves the way for the further evolution of these theoretical frameworks.

Employing a multifaceted methodological approach, including PLS-SEM, IPMA, and fsQCA, we revealed pivotal MEP catalysts. Methodological pluralism provides both theoretical and empirical substantiation of the efficacy of metaverse entrepreneurship. This polyvalent analytical lens offers a holistic vantage for hypothesis testing and unearthing more profound interconnections, thereby enriching theoretical contributions and managerial praxis (Hair et al., 2022; Ragin, 2009). Our study offers rich empirical validation of the extant theory and provides actionable insights for application.

Practical implications

This study's empirical results offer salient insights for stakeholders in the metaverse ecosystem, including entrepreneurs, policymakers, and practitioners. For entrepreneurs venturing into the metaverse, the deliberate enhancement of digital capabilities and EO emerges as pivotal in bolstering MEP. Entrepreneurs must allocate resources toward infrastructure development, business spanning, and proactive stability to strengthen their digital capabilities (Chen et al., 2023; Kamble et al., 2023). Concurrently, they must encourage EO with a focus on augmenting innovation, risk-taking propensity, and proactiveness to harness digital capabilities effectively and, thus, elevate MEP (Al Dhaheri et al., 2024). Firms should cultivate a culture that encourages employee innovation, proactiveness, and risk-taking (Gil-Cordero et al., 2024).

Policymakers should focus on promoting firm-level digital capabilities and EO through strategic policy intervention. They can stimulate the development and modernization of digital infrastructure, enhance business spanning, and instill a proactive stance through financial incentives and preferential policies (Wang & Esperança, 2023). Moreover, policymakers should vigilantly monitor and adapt legal and regulatory frameworks in the metaverse to safeguard digital assets, stimulate innovation, and nurture equitable competition (Wang et al., 2023b).

Practitioners can harness the findings of this study as a potent strategy for augmenting the efficacy of metaverse entrepreneurship. Further, MEPs can be substantially improved by focusing on enhancing digital capabilities and EO. A profound comprehension of the interplay between digital capabilities, EO, and MEP enables practitioners to devise more nuanced strategies and action plans tailored to metaverse entrepreneurial contexts (Gupta et al., 2023).

Conclusions, limitations, and further research

This study enriches our comprehension of the interplay between knowledge and innovation in the growing domain of metaverse entrepreneurship. By scrutinizing the interrelations among digital capabilities, EO, and MEP, we introduce novel insights into how digital knowledge assets catalyze innovation within virtual ecosystems. The PLS-SEM analysis revealed that digital capabilities substantially augment a firm's EO, which, in turn, partially mediates the influence of digital capabilities on MEP. These findings have significant implications for both theoretical discourse and practical application. From a theoretical standpoint, our investigation underscores the utility and relevance of the RBV and DCT within the metaverse entrepreneurial context, presenting a novel theoretical lens for the nexus among digital capabilities, EO, and MEP. Our results provide innovative insights for metaverse entrepreneurs, policymakers, and practitioners, indicating that firms can enhance MEP by bolstering their digital capabilities and EO.

While this study makes notable contributions, it has limitations that future research could address. First, the sample was predominantly from China, necessitating further examination of our findings' generalizability. Future studies could include a multinational sample. Second, although we employed perceptual data, the use of more objective performance metrics could be advantageous. Third, subsequent research could examine the moderating effects or reveal novel mediating mechanisms. Although our engagement with student entrepreneurs offers valuable insights into metaverse entrepreneurship, future studies could extend these findings to include a more diverse array of entrepreneurs to augment generalizability. Fourth, future research could consider adopting innovative analytical methodologies, such as text mining or deep learning. Finally, exploring the disputes among various metaverse firm types could yield profound insights. We are confident that future research will reveal additional intriguing findings.

Data availability

The datasets used or analysed during the current study are available from the author on reasonable request.

Ethics approval

Not applicable.

CRediT authorship contribution statement

Shaofeng Wang: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Hao Zhang:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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