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Analysis of the psychological path of merchants' use of central bank digital currency: evidence from digital RMB

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Central Bank Digital Currency (CBDC) is emerging to disrupt existing payment monopolies and enhance digital-real economies integration, yet adoption barriers persist. This study investigates merchants' willingness to adopt digital RMB(e-CNY) using the Technology-Organization-Environment (TOE) framework integrated with network effects. This study constructs a comprehensive model of e-CNY adoption, examining three key dimensions: technological adaptation, organizational support and environmental push, Structural Equation Modeling (SEM) and fuzzy set Qualitative Comparative Analysis (fsQCA) are applied to explore the complex interactions between these factors and merchants' usage behavior. The findings reveal that high-frequency usage of e-CNY by merchants requires the synergistic interaction of technological, organizational and environmental factors, None of the individual factors—such as perceived comparative advantage, perceived ease of use, compatibility, management support, organizational resource and capability, policy support, or network effects—are necessary condition on their own. Three distinct paths to high-frequency e-CNY usage are identified: technology-enviroment driven, all-factor synergy and technology-driven, while a single path, the environmentally-deficient type, explains low-frequency usage. Based on these findings, the study proposes targeted policy recommendations to promot e-CNY adoption: enhance system compatibility, improve policy Incentives, develop network effects, and establish a feedback loop between policy–technology–behavior.

KEYWORDS

configurational analysis, digital RMB(e-CNY), TOE framework, usage behavior, usage intention

Introduction

The rapid development of digital technologies has sparked a paradigm shift in global financial systems, prompting central banks worldwide to explore the issuance of central bank digital currencies (CBDCs) as a countermeasure to the growing dominance of private digital payment platforms and cryptocurrencies (Prodan et al., 2024; Faro et al., 2022). Among these initiatives, China's digital currency (e-CNY) project stands out as one of the most advanced and comprehensive retail CBDC pilots to date (Cheng, 2023). Launched by the People's Bank of China (PBOC) in 2020, the e-CNY has been deployed across over 26 pilot cities, involving millions of users and hundreds of thousands of merchants (Dowd, 2024). Unlike many other CBDC projects that remain in the conceptual or experimental stages, the e-CNY is already in active use in real-world transactions across various domains,

including retail, transportation, government services, and cross-border payments (Zhang, 2025; Lee et al., 2023). This large-scale deployment offers a unique opportunity to examine the factors influencing the adoption of a sovereign digital currency—particularly from the merchant's perspective, as they play a critical role in the payment ecosystem.

Existing literature on digital currency adoption has largely concentrated on individual consumers, drawing heavily from behavioral theories such as the Technology Acceptance Model (TAM) (Silva, 2015; An et al., 2024; Sun and Li, 2024) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003; Wu et al., 2022; Bhatnagr et al., 2025). These studies have identified key determinants such as perceived usefulness, perceived ease of use, trust, social influence, and facilitating conditions as significant predictors of user intentions (Silva, 2015; An et al., 2024; Sun and Li, 2024; Venkatesh et al., 2003; Wu et al., 2022; Bhatnagr et al., 2025). While these consumer-centric models provide valuable insights, they often overlook the distinct decision-making processes within merchants, particularly small merchants that face unique operational, financial, and strategic constraints (Sharma et al., 2024; Miklian and Hoelscher, 2022). Merchants do not merely "use" a payment method; they must integrate it into their business operations, manage transaction costs, evaluate competitive positioning, and respond to customer demand and peer behaviors (Patil et al., 2024; Agatz et al., 2024). As such, their adoption decisions are more appropriately analyzed through organizational innovation frameworks rather than individual behavioral models. A merchant is more likely to adopt e-CNY not because their relatives use it, but because their customers demand it or, crucially, because their competitors and peers in the same industry or marketplace have already adopted it. This form of influence—peer-based network effects—reflects the two-sided market structure of digital payment platforms (Huang et al., 2024; Dann et al., 2019), where the value of participation increases with the number of complementary users on both sides (Panico and Cennamo, 2022).

Despite the theoretical recognition of network effects in platform economics, empirical studies on digital currency adoption have largely treated them as an implicit or aggregated phenomenon (e.g., "number of users"), rather than as a perceived organizational pressure that can be measured and modeled within adoption frameworks. More importantly, existing applications of UTAUT in digital finance research rarely distinguish between personal social influence and industry-level network effects, thereby conflating fundamentally different mechanisms of social pressure (Zhong and Zheng, 2025). This conflation limits the explanatory power of these models in organizational contexts, where strategic mimicry, competitive parity, and supply chain interoperability are key drivers of technological diffusion (Silva, 2015).

To address this limitation, this study reconceptualizes network effects as a distinct environmental construct within the Technology-Organization-Environment (TOE) framework. The TOE framework has been successfully applied in studies of technological innovations such as e-commerce platforms (Zhong and Zheng, 2025; Mensah and Xu, 2025), cloud computing (Skafi et al., 2022; Aligarh et al., 2023; Hadwer et al., 2021), and green technologies (Sun et al., 2025; Mehmood et al., 2025), underscoring its robustness and adaptability. However, its application to central bank digital currencies-particularly in the context of merchant adoption-remains limited. In this study, network effects are operationalized through merchants' perceptions of peer adoption intensity and competitive necessity. Drawing on theories of inter-organizational imitation and institutional isomorphism, we posit that merchants do not evaluate the adoption of e-CNY in isolation, but through a comparative assessment of their competitive environment. For instance, a small vendor in a busy commercial district may adopt e-CNY not merely out of social conformity, but to avoid losing customers to competitors who already support the digital currency.

Empirically, this study employs a mixed-method approach combining Structural Equation Modeling (SEM) and fuzzy set Qualitative Comparative Analysis (fsQCA). SEM is used to test structural relationships among technological, organizational, and environmental factors, including network effects, on merchants' adoption intentions. fsQCA complements this by identifying configurations of conditions that lead to adoption, thereby revealing equifinality—the presence of multiple pathways to the same outcome. These methods provide a comprehensive and nuanced understanding of the drivers of e-CNY adoption among merchants.

This study makes three significant contributions to the TOE framework. First, it shifts the analytical focus from consumers to merchants, thereby enriching the digital currency adoption literature by introducing an organizational perspective. Second, it deepens theoretical understanding by integrating network effects into the TOE framework, providing a more comprehensive explanation of adoption behavior in networked payment ecosystems. Third, it provides actionable insights for policymakers and financial regulators seeking to boost merchant participation in the e-CNY system through targeted incentives, interoperability standards, and awareness campaigns.

Literature review and research hypotheses

Theoretical foundation

The Technology-Organization-Environment (TOE) framework, developed by Tornatzky and Fleischer (1990), is a well-established model for understanding the adoption of technological innovations within organizations. The TOE framework posits that a group's decision to adopt a new technology is influenced by three interrelated contexts: technological factors, organizational factors, and environmental factors.

Technological Context: This dimension includes the characteristics of the technology itself, such as perceived comparative advantage, compatibility, and complexity. Technologies that are perceived as offering a comparative advantage, being compatible with existing systems, and easy to use are more likely to be adopted (Saura et al., 2022).

Organizational Context: This refers to internal organizational factors, such as the size of the firm, the availability of resources, and management support. Merchants with more resources and strong leadership support are better positioned to adopt and integrate new technologies (Landa et al., 2023).

Environmental Context: The environmental context involves external factors such as regulatory pressure, market competition, and the influence of peer organizations. These external pressures can significantly influence the merchant's decision to adopt new technologies, especially when industry peers or regulatory bodies are pushing for adoption.

The TOE framework provides a comprehensive lens for understanding merchants' technology adoption, allowing for a nuanced analysis of the factors at play in the adoption of new technologies like digital currencies.

Research hypotheses

In the context of digital currencies, perceived comparative advantage has been consistently identified as a critical factor influencing adoption. Studies on digital payment systems and new financial technologies suggest that when e-CNY is perceived to offer more benefits, such as greater transaction efficiency, reduced costs, or enhanced security, merchants are more likely to adopt it (Wang, 2024). This aligns with the broader literature on technology adoption, which emphasizes the importance of comparative advantage as a driving force behind the decision to adopt innovations.

This leads to the following hypothesis:

H1: Perceived comparative advantage has a positive impact on the usage intention of e-CNY.

Perceived ease of use refers to the degree to which an individual believes that using a particular technology will be free from effort (Silva, 2015). This construct is a core component of both the Technology Acceptance Model (TAM) and UTAUT. In the context of digital payment systems, ease of use has been shown to significantly impact users' intentions to adopt new technologies (Venkatesh et al., 2003; Hussain et al., 2025). Merchants, particularly those without advanced technological expertise, are likely to be more willing to adopt e-CNY if it is perceived as easy to integrate into their existing operations with minimal effort or training (Ma et al., 2022).

This leads to the following hypothesis:

H2a: Perceived ease of use has a positive effect on usage intention of e-CNY.

Beyond the initial adoption decision, perceived ease of use also influences continued usage. Studies have demonstrated that individuals are more likely to engage with technologies that they find easy to use, as it reduces the cognitive and operational burden (Venkatesh et al., 2003). For merchants, the willingness to use e-CNY regularly may depend on how seamless the experience is, including how easily they can integrate it into their daily transactions and operations. As digital payment systems become more user-friendly, merchants' usage behavior tends to increase.

This leads to the following hypothesis:

H2b: Perceived ease of use has a positive effect on usage behavior of e-CNY.

In the case of digital currencies, compatibility with merchants' current payment infrastructure and their business models is crucial for adoption. Studies have shown that when a new technology is compatible with existing systems, it reduces the perceived risk and effort of adoption (Tanveer et al., 2021). For merchants, adopting e-CNY becomes more attractive when it complements their current point-of-sale systems and business practices (Ninson, 2024).

This leads to the following hypothesis:

H3a: Compatibility has a positive effect on usage intention of e-CNY.

Merchants who find the payment system compatible with their existing infrastructure are more likely to adopt it and use it regularly (Putrevu and Mertzanis, 2024). Previous research has suggested that ease of integration and minimal disruption to business operations enhance the likelihood of usage (Cui et al., 2023). Thus, the compatibility of e-CNY with existing systems directly influences its use by merchants.

This leads to the following hypothesis:

H3b: Compatibility has a positive effect on usage behavior e-CNY.

Management support is a critical organizational factor in technology adoption. Previous studies have found that when top management supports the adoption of new technologies, it significantly enhances the likelihood of successful implementation (Hsu et al., 2019; Haber and Carmeli, 2023). In the case of e-CNY, if business owners or key decision-makers provide strong backing for its adoption, this will positively influence the willingness of merchants to integrate the system into their operations.

This leads to the following hypothesis:

H4: Management support positively influences usage intention of e-CNY.

Organizational resources and capabilities are key drivers in the adoption of new technologies. Larger firms or those with more technological and financial resources are better equipped to absorb the costs and risks associated with adopting new technologies (Omrani et al., 2022). For merchants, the availability of organizational resources such as financial capital, technical expertise, and IT infrastructure often determines their ability to integrate and adopt digital currencies (Hsu et al.; Haber and Carmeli, 2023). Merchants with more robust resources are more likely to view the adoption of e-CNY as feasible and beneficial.

This leads to the following hypothesis:

H5: Organizational resources and capabilities positively influence usage intention of e-CNY.

Policy initiatives, such as incentives, subsidies, and mandates, can significantly influence merchants' decisions to adopt new technologies like e-CNY. Previous studies have highlighted the importance of government involvement in facilitating the adoption of digital payment systems, particularly in countries where CBDC adoption is strongly supported by national regulators (Ozili, 2023).

This leads to the following hypothesis:

H6: Policy push has a positive impact on usage intention of e-CNY.

Network effects, particularly in two-sided markets like payment systems, play a pivotal role in adoption (Kumar et al., 2021). For merchants, the utility of accepting e-CNY increases as more consumers and other businesses adopt it. When a critical mass of

users and merchants adopt e-CNY, its value increases for all participants, creating a positive feedback loop that accelerates further adoption. This has been widely recognized in platform economics, where the value of participation grows as more participants join the ecosystem (Panico and Cennamo, 2022).

This leads to the following hypothesis:

H7: Network effects have a positive impact on usage intention of e-CNY.

Usage intention has been consistently identified as a strong predictor of actual technology usage behavior. Merchants who are willing to accept the technology are more likely to integrate it into their payment systems and engage with it in day-to-day business operations (Sun et al., 2022). This relationship has been demonstrated in studies of payment systems and digital technologies (Venkatesh et al., 2003).

This leads to the following hypothesis:

H8: Usage intention of e-CNY has a positive effect on e-CNY usage behavior.

Previous research has demonstrated that organizational characteristics significantly influence the translation of intentions into actions (Polyportis and Pahos, 2025), particularly in the context of technology adoption. For example, individual vendors, such as street stalls or family-run shops, may exhibit high willingness to adopt e-CNY due to perceived government support or customer demand. Larger merchants typically have greater managerial capacity, financial resources, and technical infrastructure, all of which facilitate the implementation and sustained use of new technologies (Guo et al., 2022; Oyedijo et al., 2024). For instance, a large supermarket with dedicated IT staff and integrated point-of-sale systems is well-equipped to seamlessly incorporate e-CNY acceptance, ensuring that high willingness leads to consistent usage. Therefore, the strength of the relationship between Usage intention and actual usage behavior is expected to vary significantly based on organizational characteristics.

This study proposes the following hypothesis:

H9: Merchant type moderates the relationship between Usage intention and usage behavior of e-CNY.

H10: Merchant size moderates the relationship between Usage intention and usage behavior of e-CNY.

The concept of usage intention has been widely recognized in the literature as a significant mediator between various antecedents and actual usage behavior of new technologies (Silva, 2015; Venkatesh et al., 2003). Importantly, the willingness to accept a technology not only reflects an individual's or organization's initial attitude towards adoption, but it also directly impacts the actual usage behavior (Venkatesh et al., 2003). In the context of e-CNY adoption by merchants, usage intention plays a critical role in bridging the gap between the external factors—such as the perceived benefits of the technology (e.g., comparative advantage, ease of use, compatibility) and the organizational and environmental support (e.g., management support, resources, policy push, network effects)—and the actual behavior of using the technology. This mediation effect has been well established in the broader literature on technology adoption, where the willingness to adopt a technology serves as a precursor to its eventual usage (Silva, 2015; Venkatesh et al., 2003).

Therefore, the following hypotheses are put forward:

H11: Usage intention of e-CNY mediates between perceived comparative advantage and usage Behavior of e-CNY

H12: Usage intention of e-CNY mediates perceived ease of use and usage behavior of e-CNY

H13: Usage intention of e-CNY mediates compatibility and usage behavior of e-CNY

H14: Usage intention of e-CNY mangement support and usage behavior of e-CNY.

H15: Usage intention of e-CNY mediates between organizers' capabilities and resources and usage behavior of e-CNY.

H16: Usage intention of e-CNY mediates between policy push and usage behavior of e-CNY.

H17: Usage intention of e-CNY mediates the network effect and usage behavior of e-CNY.

Based on the above hypotheses, Figure 1 displays the research model of our study.

Methodology

Measure

Since the research subjects are merchants, there is no given sampling framework. To achieve the research objective, this study applies the convenient sampling technique. The research data was collected through a self-conducted questionnaire survey on China's largest online questionnaire website. The method was to use the validated items from existing studies, which were measured based on the Likert scale (ranging from (1) strongly disagree to (5) strongly agree). All the references are listed in Table 1.

Data collection

Our data collection followed a strict protocol to ensure ethical standards and data quality. The process began with informed consent obtained from all participants. The data for this study were sourced from "Questionnaire Star," the largest online survey platform in China. The questionnaire initially included a preliminary screening question: "Are you familiar with the digital yuan?" Only merchant respondents who answered "yes" were permitted to proceed with the survey. To ensure the high quality and validity of the collected data, stringent multi-stage screening criteria were implemented during sample collection. First, response duration was analyzed using backend platform data, and questionnaires completed in less than 2 minutes were excluded to eliminate careless or inattentive responses. Second, by examining IP addresses recorded by the Questionnaire Star system, respondents

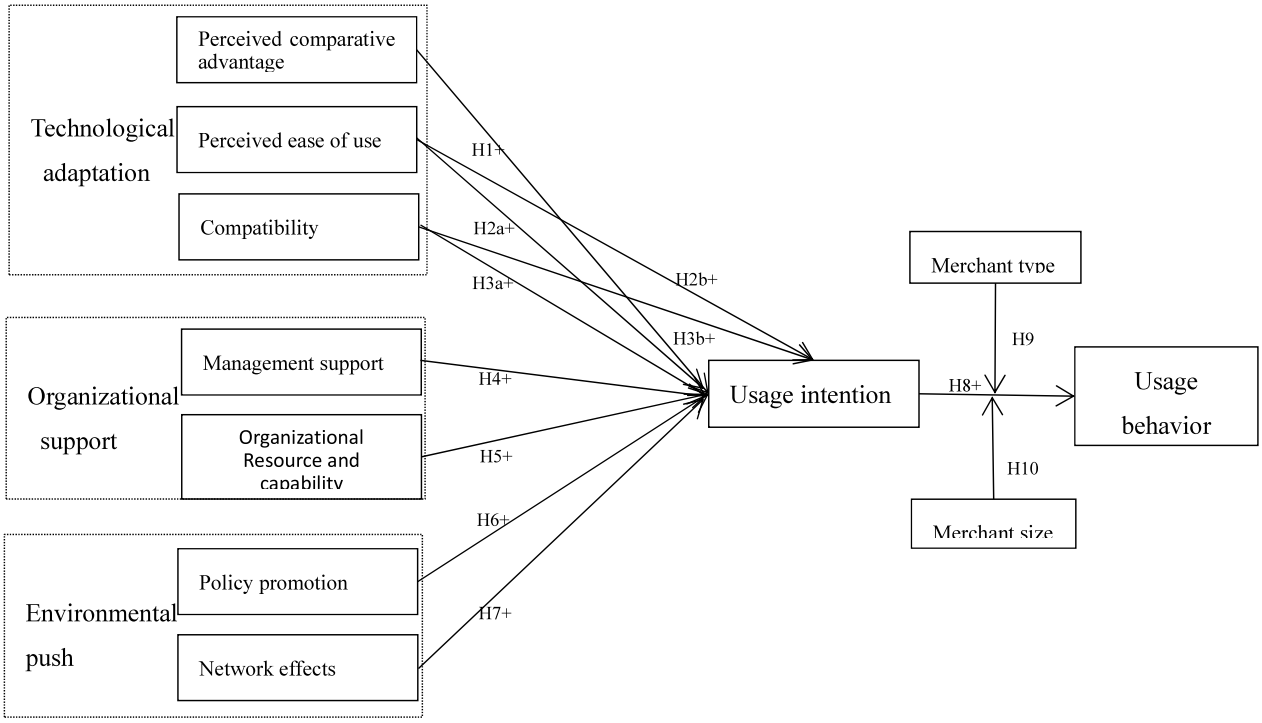

FIGURE 1
Theoretical model of influencing factor.

from non-pilot regions for the digital yuan were filtered out, ensuring that all samples originated from policy-covered areas where the digital currency is operational.

Based on the multi-stage screening procedures described above, a total of 699 valid questionnaires were retained for final analysis. To characterize the sample profile, demographic and business information was collected from the participating merchants, including gender, age, educational attainment, store type, and business scale. The detailed distribution of these characteristics is presented in Table 2.

SEM-based analysis and testing of influencing factors

Reliability analysis

Measurement models are primarily evaluated based on their reliability and validity. Academics usually use the internal consistency coefficient (Cronbach's alpha) and Composite Reliability (CR) of latent variables to assess reliability. When the CR and Cronbach's alpha values of latent variables reach 0.7 or higher, it indicates that the model has high reliability (Segars, 1997). From Table 3, it can be seen that the CR values of all the latent variables are greater than or equal to 0.723, and the Cronbach's alpha values are all greater than or equal to 0.722, indicating that the measurement model has good reliability. Moreover we tested the model by treating all the constructs as exogenous and creating a dummy random variable as an endogenous construct. As shown in Table 4, the maximum internal VIF value is 2.251, which is less than 3.3, indicating the absence of common method bias (CMB) (Kock, 2015).

The Average Variance Extracted (AVE) values for all latent variables in this study are greater than or equal to 0.566, indicating that the measurement model has good convergent validity. Meanwhile, Discriminant validity is usually determined by comparing the square root of each construct's AVE with the inter-construct correlation coefficients. As shown in Table 5, all correlation coefficients are lower than the corresponding square roots of AVE values, proving that the measurement model has good discriminant validity (Segars, 1997).

To assess the discriminant validity of the measurement model, we examined the cross-loadings. As shown in Table 6, all indicators loaded higher on their respective constructs than on any other construct. This result demonstrates satisfactory discriminant validity.

Goodness-of-fit test

Using smart PLS 4, the model was estimated and tested, Model adequacy was assessed through various fit indices to determine the validity of the research hypotheses. From Table 7, the relevant indices generally meet the recommended thresholds, indicting that the model has a good overall fit. The structural model demonstrates satisfactory goodness of fit.

Hypothetical path test

The study employs the maximum likelihood method to analyze the coefficients and test the proposed research hypotheses. The results (Table 8) indicate the following:

TABLE 1 Measurement items.

Variant	Measurement item	References source
Perceived comparative advantage (PA)	We believe the e-CNY is useful for reducing our operational risks and management costs	Jabbar et al. (2023), Ma et al. (2023)
	We perceive that the e-CNY is reliable for maintaining business continuity even in unstable network conditions	
	We find that the real-time settlement feature of the e-CNY improves our capital turnover efficiency	
Perceived ease of use (PU)	The operation process of the e-CNY is simple and easy to learn	An et al. (2024)
	The daily functions (such as receiving payments and transferring funds) are convenient and efficient	
	The user interface is intuitive and clear, and can be used without complex guidance	
Compatibility (CO)	The e-CNY payment method is highly compatible with existing business models, such as cash register and financial management processes	Dou and Kuzmina (2024), Mue (2024)
	The e-CNY is well compatible with existing payment tools such as POS machines and cash register systems	
	The introduction of the e-CNY will not cause significant conflicts with customers' existing payment habits	
Management support (MS)	The management actively advocates the application of e-CNY in business and provides necessary financial and human resource support for its promotion	Li and Li (2022)
	The management takes the initiative to learn about the relevant policy functions and conveys the relevant information to the employees	
	Merchants have sufficient funds to introduce e-CNY devices (such as dedicated POS machines and scanning devices), as well as the ability to train their employees to use this technology	
Organizational resource and capacity (OR)	We have sufficient funds for the equipment needed to introduce the e-CNY (such as dedicated POS machines and scanning devices)	Li and Li (2022)
	We have the ability to train our employees to use the e-CNY (such as internal trainers and training time)	
Policy promotion (PP)	We are aware of clear government subsidies or preferential policies for merchants using the e-CNY.	Yang et al. (2022)
	We believe that the regulatory authorities have clear regulations on the use of the e-CNY, which can ensure business security	
	We feel that the government has been taking continuous publicity and guiding measures in promoting the e-CNY.	
Network effect (NE)	The more customers choose to pay with e-CNY, the more willing we are to use it	Kumar et al. (2021)
	The more similar merchants around us use the e-CNY, the stronger our willingness to use it ourselves will be	
Usage intention (UI)	Using E-CNY was considered a great option for merchants	An et al. (2024)
	Merchants' Willingness to continue (start) using E-CNY was high	
Usage behavior (UB)	Merchants always had the E-CNY as the consumer's payment instrument of choice	Ma et al. (2023)
	Priority was given to recommending consumers to use E-CNY for payment	
	It has been investing in material and human resources to maintain the E-CNY infrastructure and system	

To ensure the validity of the sample, the following measures were taken in this study: ① Simplify the design of the questions: to ensure that the respondents understood and answered them accurately. ② Setting up an attention test: to exclude invalid or untrue responses.

Firstly, regarding the factors influencing merchants' usage intention (UI) to adopt the E-CNY, the findings reveal that: (1) Perceived comparative Advantage (PA), compatibility (CO), organizational resource capacity (OR), policy promotion (PP), and network effect (NE) all have a positive correlation on merchants' usage intention of E-CNY at the 1% significance level, Among these, policy promotion plays a critical role. Merchants are more inclined to adopt e-CNY when they perceive clear advantages, seamless integration, sufficient resources, and strong policy support.

Moreover, the significance of network effects and policy promotion underscores the critical role of public payment infrastructure and a favorable policy environment in promoting the commercial application of new payment instruments—particularly within institutional contexts like China, characterized by high market concentration and strong government involvement.

Furthermore, an analysis of the factors influencing merchants' e-CNY usage behavior (UB) indicates that perceived ease of use

TABLE 2 Demographics of respondents.

Variable	Option	Number	Percentage (%)
Gender	Male	373	53.4
	Female	326	46.6
Age	18–20	52	7.4
	21–30	104	14.9
	31–40	277	39.6
	41–50	156	22.3
	50 and above	110	15.7
Education	Junior high school and below	46	6.6
	High school	121	17.3
	Junior college	186	26.6
	Undergraduate	207	29.6
	Postgraduate and above	139	19.9
Type	Sole proprietorship	35	5.0
	Partnership with others	115	16.5
	Husband and wife	168	24.0
	Hiring workers	247	35.3
	Family operation	134	19.2
Scale	1–3 people	234	33.5
	4–10 people	216	30.9
	11–20 people	136	19.5
	21 people or more	113	16.2

(PU), compatibility (CO), and usage intention (UI) all exert significant positive effects on usage. with compatibility having the strongest effect (path coefficient = 0.378). This suggests that seamless integration with existing systems drives higher usage (Bayram and Shi, 2024). However, management support (MS) does not significantly influence adoption, highlighting that internal motivation alone is insufficient without external incentives or clear short-term benefits (Ma et al., 2022; Davis FD., 1989; Venkatesh et al., 2012).

Mediation effect test

According to Table 8, hypotheses H2a and H4 are not supported, indicating that perceived ease of use and management support have no significant effect on usage intention. The mediation analysis thus focuses solely on usage intention as a mediator between the other predictors and usage behavior. Following established procedures (Baron and Kenny, 1989). Structural Equation Modeling (SEM) results in Table 9 show that the indirect effects of compatibility, organizational resource capacity, policy promotion, and network effect through usage intention are all significant, with confidence intervals excluding zero. In contrast, the indirect effect of perceived comparative advantage is non-significant. This finding implies that the promotion of the e-CNY should not rely solely on emphasizing technological superiority, but must also be accompanied by highly compatible, user-friendly product designs and perceptible ease of use.

Specifically, hypotheses. H13 and H15–H17 are supported, while H11, H12, and H14 are not.

In summary, the mediating role of usage intention on merchants' e-CNY usage behavior is reflected in the following four "causal chains":

1. Compatibility → usage intention of e-CNY → e-CNY usage behavior
2. Organizational resource capacity → usage intention of e-CNY → e-CNY Usage Behavior
3. Policy promotion → usage intention of e-CNY → e-CNY usage behavior
4. Network effect → usage intention of e-CNY → e-CNY usage behavior

Moderating effect test

Drawing on prior literature (FISS et al., 2013), this paper examines merchant type and merchant size as the moderating variables in the relationship between usage intention and usage behavior, To facilitate the analysis, this paper employs the INDEX approach and evaluates the corresponding confidence intervals. The results show that the 95% confidence intervals include 0, indicating that neither merchant type nor merchant size exerts a significant moderating effect on the relationship between usage intention and usage behavior, Accordingly, hypotheses H9 and H10 are not supported.

This result indicates that, at the current stage, the influence path of usage intention on actual usage behavior is relatively consistent across merchants, regardless of their size or industry category. It suggests that, as a foundational payment infrastructure, the promotion strategy for e-CNY should focus on institutional development, technological integration, and ecosystem scenario optimization, rather than placing excessive emphasis on differences among merchant types.

Configuration path identification based on QCA

The relationship between merchants' usage intention and usage behavior regarding e-CNY is not isolated or linear, but rather shaped by the interplay of multiple interdependent factors. To make the study more in-depth and comprehensive, this paper supplements the net effect analysis from Structural Equation Modeling (SEM) with fuzzy set Qualitative Comparative Analysis (fsQCA), exploring how combinations of conditions influence merchants' acceptance and usage of e-CNY.

Variable selection and calibration

According to the SEM analysis, all independent and mediating variables exert either direct or indirect effects on

TABLE 3 Reliability and validity of the measurement model.

Variable	Item	Alpha	Factor loading	CR	AVE
Perceived Comparative Advantage	Q1-1	0.805	0.756	0.805	0.579
	Q1-2		0.765		
	Q1-3		0.760		
Perceived Ease of Use	Q2-1	0.823	0.784	0.824	0.609
	Q2-2		0.793		
	Q2-3		0.763		
Compatibility	Q3-1	0.823	0.795	0.823	0.608
	Q3-2		0.791		
	Q3-3		0.753		
Management Support	Q4-1	0.827	0.76	0.827	0.615
	Q4-2		0.772		
	Q4-3		0.820		
Organizational Resource and Capacity	Q5-1	0.722	0.771	0.741	0.591
	Q5-2		0.733		
Policy Promotion	Q6-1	0.831	0.785	0.832	0.623
	Q6-2		0.813		
	Q6-3		0.769		
Network Effect	Q7-1	0.736	0.829	0.723	0.566
	Q7-2		0.704		
Usage Intention	Q8-1	0.770	0.755	0.772	0.629
	Q8-2		0.830		
Usage Behavior	Q9-1	0.823	0.779	0.823	0.608
	Q9-2		0.801		
	Q9-3		0.759		

TABLE 4 Collinearity statistics (VIF) - inner model.

Variable	PA	PU	CO	MS	OR	PP	NE	UI	UB
PA								1.993	
PU								2.251	1.712
CO								1.746	1.638
MS								1.979	
OR								1.596	
PP								1.53	
NE								1.65	
UI									1.296
UB									

TABLE 5 Correlation matrix and discriminant validity.

Variable	PA	PU	CO	MS	OR	PP	NE	UI	UB
PA	0.761								
PU	0.381	0.78							
CO	0.269	0.373	0.78						
MS	0.304	0.345	0.345	0.784					
OR	0.331	0.388	0.296	0.284	0.752				
PP	0.341	0.358	0.349	0.329	0.332	0.789			
NE	0.365	0.364	0.393	0.313	0.353	0.345	0.769		
UI	0.29	0.337	0.32	0.312	0.289	0.362	0.332	0.793	
UB	0.33	0.335	0.29	0.352	0.3	0.336	0.34	0.303	0.78

the outcome variables, Although perceived ease of use and management support are found to have no significant direct effects, fsQCA emphasizes the joint effects of variables configurations, thus, this paper includes perceived comparative advantage, perceived ease of use, compatibility, management support, organizational resource capacity, policy promotion, network effect, and usage intention as antecedent conditions influencing the merchants' use of e-CNY,The theoretical model is illustrated in Figure 2.

Before conducting fsQCA, it is necessary to calibrate the data for each variable, Following Ragin's calibration criteria, the original values of all continuous variables are transformed using the 5%, 95%, and 50% thresholds to define full membership, full non-membership, and the crossover point, respectively (Pappas and Woodside, 2021; Xu et al., 2024).

Data calibration

Following Pappas and Woodside, 2021, all continuous variables measured on 5-point Likert scales were calibrated using the direct method. The empirical 95th, 50th, and fifth percentiles of each variable were used as the three fuzzy set anchors: full membership (0.95), crossover (0.50), and full non-membership (0.05). This percentile-based approach avoids arbitrary cutoffs and aligns the calibration with the empirical distribution of the data (Pappas and Woodside, 2021). Table 10 reports the calibration anchors for all conditions.

Single-factor necessity analysis

This study uses fsQCA to perform a necessity analysis of individual antecedent conditions based on clear sets. The criterion a necessity score above 0.9. As shown in Table 11, no single condition exhibits a consistency greater than 0.9 meets this threshold for either high-or low-frequency usage behavior, indicating that a single condition alone cannot explain either outcome, Instead, combinations of multiple conditions are required to form sufficient pathways.

Sufficiency analysis of conditional configurations

Sufficiency analysis of condition combinations (histogram analysis) is used to assess the explanatory power of the combinations of antecedent conditions. This analysis consists of two main steps: the truth table algorithm and the criterion analysis. The first step of the truth table algorithm is to create a truth table from the fuzzy data, which contains 2^k rows, representing all possible combinations of antecedent conditions that lead to a particular outcome (BI). The second step involves applying relevant thresholds to filter the truth table rows. The screening criteria are as followed: i) a minimum case frequency of 3 is established to avoid trivial groupings that are not empirically significant; ii) a consistency threshold of 0.8 is determined (with at least 75% retention) to ensure the robustness strength of the groupings. (iii) The PRI consistency of 0.75 is set to further refine the results. Based on these criteria, normalization analysis is performed, which results in the conditional configurations shown in Table 12.

High-frequency use of e-CNY by merchants

Model 1: technology-enviroment driven type

Configurations 1 and 4(PU*NE) represent a technology-environment driven model where high perceived ease of use and strong network effects serve as core conditions, supplemented by either high compatibility and strong usage intention or only high compatibility. These configurations suggests merchants are likely to actively adopt e-CNY even organizational support is absent, provided they perceive it as easy to use and compatible, with substantial network effects. Configuration 1 covers 41.5% of cases, illustrating that ease of use and system compatibility—supported by national payment integration policies—can drive adoption among SMEs, especially when aided by government incentives such as tax reductions and settlement discounts. Based on this analysis, the following propositions is proposed:

Proposition 1: The absence of organizational-level conditions can be compensated for high perceive easy of use and strong network effects, prompting adoption of e-CNY. Take small and

TABLE 6 Cross-loadings.

Variable	CO	MS	NET	OC	PEU	PP	PU	UB	UI
CO1	0.850	0.268	0.319	0.235	0.233	0.317	0.294	0.225	0.294
CO2	0.861	0.302	0.348	0.279	0.218	0.299	0.318	0.252	0.259
CO3	0.867	0.326	0.354	0.250	0.241	0.284	0.345	0.274	0.274
MS1	0.258	0.827	0.247	0.217	0.259	0.256	0.311	0.276	0.219
MS2	0.310	0.882	0.273	0.270	0.220	0.289	0.274	0.309	0.313
MS3	0.324	0.873	0.293	0.249	0.307	0.306	0.307	0.328	0.276
NET1	0.389	0.304	0.910	0.324	0.319	0.344	0.361	0.338	0.322
NET2	0.310	0.254	0.867	0.302	0.330	0.269	0.287	0.266	0.269
OC1	0.254	0.233	0.321	0.876	0.331	0.290	0.349	0.279	0.247
OC2	0.270	0.275	0.303	0.893	0.252	0.297	0.336	0.255	0.264
PEU1	0.212	0.247	0.316	0.282	0.846	0.294	0.317	0.286	0.240
PEU2	0.250	0.282	0.307	0.254	0.847	0.299	0.322	0.287	0.238
PEU3	0.222	0.237	0.304	0.298	0.851	0.274	0.331	0.267	0.263
PP1	0.278	0.290	0.293	0.294	0.294	0.863	0.295	0.290	0.314
PP2	0.325	0.282	0.304	0.300	0.293	0.868	0.288	0.301	0.299
PP3	0.302	0.286	0.306	0.267	0.297	0.863	0.345	0.280	0.330
PU1	0.306	0.303	0.331	0.322	0.343	0.312	0.876	0.294	0.321
PU2	0.326	0.286	0.298	0.318	0.338	0.298	0.858	0.276	0.270
PU3	0.329	0.292	0.316	0.359	0.301	0.314	0.844	0.293	0.276
UB1	0.281	0.323	0.293	0.290	0.287	0.288	0.300	0.868	0.292
UB2	0.222	0.320	0.324	0.255	0.301	0.259	0.274	0.865	0.252
UB3	0.245	0.268	0.267	0.228	0.261	0.319	0.290	0.844	0.236
UI1	0.267	0.270	0.289	0.258	0.236	0.299	0.315	0.283	0.896
UI2	0.311	0.303	0.314	0.263	0.289	0.356	0.296	0.266	0.908

micro merchants as an example. Although they lack internal resources, they will still actively adopt e-CNY when it is highly compatible with the existing QR code acquiring system and the platform traffic incentives are significant (network effect).

Mode 2: all-factor synergy type

Configurations 2 and 3 share core conditions across technology, organization and environment dimensions, exhibiting an all-factor synergy model. Configuration 2 (PU*MS*OR*NE) indicates that merchants are more likely to actively use e-CNY when high perceived ease of use, strong compatibility, abundant organizational resource capacity and significant network effect are present as core conditions, covering 0.391 of case. Configuration 3 (PA*PU*OR*NE) represents that merchants are likely to adopt the e-CNY when high perceived ease of use, abundant organizational resource capability, active policy promotion, and strong network effect are core conditions, covering 0.366. Both paths reflect how technological readiness, resource capacity, and external incentives jointly facilitate adoption. Compatibility and policy promotion can substitute for each other when other core conditions are met.

Proposition 2: When merchant possess strong technological conditions, organizational resource capability,and network effects, the synergy of technical, resource, and market factors effectively promote e-CNY adoption. This path is applicable to chain supermarkets. Under the joint promotion of the technical deployment of the headquarters, the resource support of the branches and the local government's consumption voucher policy, it has been used at a high frequency.

Model 3: technology-driven type

Configuration 5 is characterized by core conditions in the technological dimension: perceived comparative advantage and compatibility, supplemented by perceived ease of use and policy

TABLE 7 Indicators of model fit.

Indicator	Estimated model	Null model
Error Variance	235.008	6762.677
Number of Model Parameters	83.000	24.000
Number of Observations	699.000	n/a
Degrees of Freedom	216.000	276.000
P-value	0.000	0.000
χ^2/df	1.088	24.502
RMSEA	0.012	0.187
RMSEA 90% CI Lower Bound	0.007	0.184
RMSEA 90% CI	0.017	0.191
GFI	0.971	n/a
AGFI	0.948	n/a
PGFI	0.696	n/a
SRMR	0.064	n/a
NFI	0.965	n/a
TLI	0.979	n/a
CFI	0.997	n/a
AIC	0.971	n/a
BIC	0.948	n/a

promotions. High task–technology fit, such as seamless integration with POS systems, encourages voluntary adoption even without organizational or environmental support.

Proposition 3: High perceived ease of use and system compatibility can compensate for the absence of organizational and environmental support, encouraging e-CNY adoption. A typical representative of this path is a digital service provider. Due to the advantages of e-CNY in API integration and settlement efficiency (high comparative advantage and compatibility), it voluntarily connects even without specific policy incentives.

Low-frequency use of e-CNY

As shown Table 10, Only one configuration that leads to low-frequency usage of e-CNY: Configuration 6 (~PP). The absence of policy promotion is the core condition, while perceived ease of use serves as a supplementary condition This configuration has an original coverage of 0.652 and explains over 85% of relevant cases, underscoring the critical role of policy incentives. Without external support, merchants are less motivated to adopt e-CNY despite perceiving it as easy to use, resulting in low-frequency adoption (Krishna et al., 2025).

Proposition 4: In the absence of external environmental support and with neutral managerial stance, merchant may perceive e-CNY as easy to use but adopt it frequently due to insufficient motivation.

Cross-configuration comparison

① Environmental conditions play a central role in merchants' decisions to adopt e-CNY. Across all five configurations related to high-frequency use of high-frequency use, environmental conditions appear either as core or supplementary factors. Conversely, the sole configuration leading to low-frequency use (Configuration 6) is characterized by the absence of environmental support as a core condition.

② A divergence may exist between usage intention and usage behavior. This inconsistency has been documented in various research domains, including individual product consumption (Pal and Vanijja, 2020). Organic food (Yu et al., 2024; Qiu et al., 2022) and environmental sustainability practices (Wu et al., 2023). For example, SJ Tung et al. (Yu et al., 2024) systematically reviewed the behavioral differences of "inconsistency between words and actions" in the consumption of green products and proposed that factors such as cognitive disharmony, habits, price sensitivity, and poor usability are the main causes. Their findings highlight subjective norms as a key determinant contributing to this divergence. Most studies examining such discrepancies follow a two-stage approach: first identifying the existence of the intention–behavior gap, and then analyzing the underlying mechanisms driving the inconsistency. By comparing Configurations 3, 4, and 5, this paper reveals that whether usage intention is missing as a supplementary or core condition, other factors across the TOE dimensions can compensate for this absence, still resulting merchants to use e-CNY with high frequency.

Robustness check

Follow the method of Petteri 2023 et al. (2023), a robustness test is conducted by adjusting the consistency threshold from 0.80 to 0.85, raising the PRI threshold from 0.75 to 0.80, and setting the frequency threshold to 1. The two driving modes of "All-Factor Synergy Type" and "Technology-Driven Type." remain stable, Although "technology-driven" path disappears, but it is still a subset of the original configuration result; The configuration for low-frequency e-CNY usage remains identical to the results presented in Table 12, with a total of 1 configuration path output. The overall consistency and coverage exceed 0.9 and 0.5 respectively, indicating that the findings are robust.

To identify which antecedent conditions are structurally critical to the solution, we conducted a comprehensive leave-one-out sensitivity analysis. This test iteratively removes each of the eight antecedent conditions (PA, PU, CO, MS, OR, PP, NE, UI) and re-runs the fsQCA analysis to assess how solution consistency and coverage degrade. Table 13 presents the complete results.

The leave-one-out analysis reveals that: 1. Network effects are the dominant structural factor but not strictly necessary, confirming two-sided market dynamics as central to CBDC adoption. 2. No single condition is sufficient or necessary on its own, validating the configurational approach over linear models. 3. Multiple equifinal pathways exist, allowing diverse merchant types to adopt e-CNY through different combinations of technological, organizational, and environmental conditions. 4. Usage intention functions as a mediator rather than a structural driver, resolving the intention-behavior gap through configurational logic.

TABLE 8 Hypothetical path test results.

Hypothesized relationship	Pathway	Path coefficient	S.E.	t-value	p-value	Significance	Hypothesis testing results
H1	PA→UI	0.127	0.057	2.228	0.020	significant	Supported
H2a	PU→UI	0.071	0.056	1.268	0.223	Not significant	Not supported
H2b	PU→UB	0.251	0.056	4.482	0.000	significant	Supported
H3a	CO→UI	0.015	0.007	2.029	0.087	significant	Supported
H3b	CO→UB	0.231	0.059	3.915	0.000	significant	Supported
H4	MS→UI	0.091	0.06	1.517	0.131	Not significant	Not supported
H5	OR→UI	0.199	0.053	3.755	0.000	significant	Supported
H6	PP→UI	0.129	0.05	2.580	0.015	significant	Supported
H7	NE→UI	0.168	0.057	2.947	0.008	significant	Supported
H8	UI→UB	0.217	0.054	4.019	0.000	significant	Supported

TABLE 9 Mediation effect test of usage intention.

Independent variable	Path	Bootstrap 95% CI			Bias-corrected CI includes zero	Mediation effect
		Lower	Upper	P-value		
Perceived Comparative Advantage	H11:PA→UI→UB	−0.040	0.126	0.093	Yes	No
Compatibility	H13:CO→UI→UB	0.025	0.209	0.000	No	Yes
Organizational Resource Capacity	H15:OR→UI→UB	0.068	0.433	0.010	No	Yes
Policy promotion	H16:PP→UI→UB	0.092	0.224	0.001	No	Yes
Network effect	H17:NE→UI→UB	0.073	0.472	0.044	No	Yes

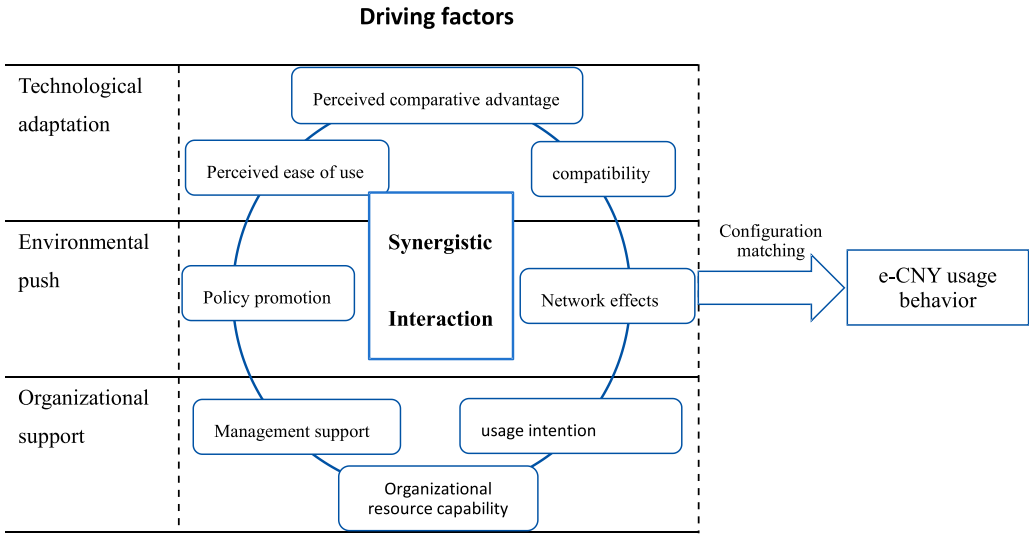

FIGURE 2
Theoretical model of the Configuration path anaysis.

TABLE 10 Variable calibration statistics.

Condition	Full membership (0.95)	Crossover (0.50)	Full non-membership (0.05)
Usage Behavior (UB)	4.85	3.15	1.65
Perceived Advantage (PA)	4.80	3.20	1.60
Perceived Usefulness (PU)	4.75	3.10	1.55
Compatibility (CO)	4.60	3.00	1.50
Management support (MS)	4.70	3.05	1.45
Organizational resource capability (OR)	4.65	3.00	1.40
Policy promotion (PP)	4.55	3.05	1.50
Network Effect (NE)	4.85	3.25	1.65
Usage Intention (UI)	4.75	3.10	1.45

TABLE 11 One-way necessity analysis.

Antecedent variable	High-frequency use behaviors		Low-frequency use behavior	
	Consistency	Coverage	Consistency	Coverage
PA	0.884	0.885	0.254	0.260
~PA	0.262	0.255	0.888	0.887
PU	0.786	0.764	0.359	0.357
~PU	0.339	0.340	0.763	0.785
CO	0.682	0.681	0.391	0.400
~CO	0.399	0.391	0.688	0.689
MS	0.761	0.751	0.353	0.357
~MS	0.348	0.344	0.754	0.764
OR	0.453	0.451	0.636	0.642
~OR	0.641	0.634	0.456	0.458
PP	0.726	0.708	0.408	0.403
~PP	0.389	0.393	0.705	0.723
NE	0.770	0.749	0.362	0.357
~NE	0.339	0.344	0.745	0.766
UI	0.653	0.605	0.511	0.479
~UI	0.439	0.469	0.580	0.629

The symbol "~" indicates the negation of a condition; consistency refers to the degree to which the antecedent condition is a superset of the outcome, and coverage represents the empirical relevance of a consistent superset.

Conclusion and policy recommendations

Research conclusions

Guided by the Technology-Organization-Environment (TOE) framework, this study employs a mixed-method approach integrating Structural Equation Modeling (SEM) and fuzzy set Qualitative Comparative Analysis (fsQCA) to investigate the drivers of merchants' e-CNY adoption. Based on 699 valid responses, the findings offer three key conclusions:

First, SEM results confirm that technological factors (perceived comparative advantage, compatibility), organizational readiness (resource capacity), and environmental influences (policy promotion, network effects) significantly enhance merchants' usage intention, which in turn strongly predicts actual usage behavior.

Second, the fsQCA reveals five distinct configuration pathways to high-frequency usage, demonstrating equifinality—different

TABLE 12 Configuration Results for Merchants Using e-CNY.

Antecedents	High-frequency use of the e-CNY					Low frequency use of e-CNY
	Configuration 1	Configuration 2	Configuration 3	Configuration 4	Configuration 5	Configuration 6
PA		●	●		★	●
PU	★	★	★	★	●	●
CO	●	★		●	★	
MS	⊗	●	⊗		⊗	
OR		★	★			
PP		⊗	★		●	☆
NE	★	★	★	★		⊗
UI	●		☆	⊗	⊗	⊗
Consistency	0.910	0.947	0.944	0.983	0.904	0.865
Original Coverage	0.415	0.391	0.366	0.289	0.264	0.652
Unique Coverage	0.055	0.004	0.018	0.017	0.041	0.652
Total cases (n)	172	162	152	120	110	164
Unique cases	23	2	7	7	17	164
Overlapping cases	149	160	145	113	93	0
Overall Solution Consistency	0.821					0.865
Overall Solution Coverage	0.916					0.652

★ indicates that the core condition of the configuration is present, ☆ indicates that the core condition of the configuration is absent; ● indicates that the auxiliary condition of the configuration is present, ⊗ indicates that the auxiliary condition of the configuration is absent, and ` ' indicates that the condition can be either present or absent.

TABLE 13 Leave-one-out sensitivity analysis.

Condition removed	Configs Remaining	ΔSolution consistency	ΔSolution coverage	Structural role
None (Baseline)	C1-C5	0.821	0.916	Full model
~PA	C1,C2,C4	+0.003	−8.3%	Moderate
~PU	C3, C5	−0.012	−41.2%	Critical
~CO	C1-C5	+0.008	−2.1%	Peripheral
~MS	C1,C3,C4,C5	−0.006	−4.7%	Specific (C2)
~OR	C1, C4	−0.019	−36.8%	Critical
~PP	C1,C2,C4,C5	+0.011	−5.2%	Specific (C3,C6)
~NE	C5 only	−0.034	−67.5%	Most critical
~UI	C1-C4	−0.007	−3.9%	Mediator

Positive Δ Consistency indicates slight improvement (due to removal of noisy configurations); negative values indicate solution degradation. Coverage loss indicates the proportion of outcome variance no longer explained after condition removal.

combinations of conditions can lead to the same outcome. For instance, while SEM showed management support had no significant direct effect on intention, fsQCA identified it as a core condition in specific synergistic configurations. This highlights the complementarity of the two methods: SEM pinpoints net effects of individual factors, whereas fsQCA uncovers how multiple conditions interact as necessary or sufficient causal recipes.

Third, comparative analysis with international CBDC initiatives reveals distinctive features of e-CNY adoption. While European digital euro pilots emphasize privacy and regulatory compliance, and India's digital rupee focuses on financial inclusion, the Chinese model demonstrates a unique reliance on platform compatibility and government-led ecosystem incentives as key drivers—a finding that extends the TOE framework's application in highly digitalized payment contexts.

Contributions

This study offers four key contributions:

Theoretical Integration and Extension: By integrating the TOE framework with adoption behavior theory, we identify and validate eight critical antecedents of e-CNY adoption. More importantly, we reveal causal asymmetry and configurational complexity—advancing beyond conventional linear models and offering a nuanced theoretical lens for digital currency adoption research.

Contextualization of Network Effects: Incorporating network effects as a dynamic environmental factor captures the self-reinforcing nature of currency adoption, offering a more realistic model of how digital payments diffuse in platform-based economies.

Methodological Advancement: The SEM-fsQCA mixed-method approach exemplifies how variance-based and set-theoretic methods can be jointly applied to technology adoption studies, enabling researchers to disentangle complex causal patterns.

Empirical and Practical Insights: We provide empirical evidence of the intention–behavior divergence in CBDC adoption, showing that supportive contextual conditions can compensate for weak intention—a finding with strategic importance for policymakers and platform designers.

General discussion: Our findings are contextualized within China's unique institutional environment, characterized by its highly digitized payment ecosystem and government-led promotion policies. This specific focus constitutes a core contribution rather than a limitation, as it provides a crucial benchmark for understanding CBDC adoption dynamics. The results caution against the direct transferability of our conclusions to other CBDC contexts with differing financial or regulatory landscapes. Thus, this study serves as a foundational case study, highlighting the critical role of contextual factors and offering a framework for their assessment in future global CBDC implementations.

Policy implications

To enhance the practical relevance of our findings, we propose a set of prioritized policy recommendations structured around implementation feasibility and expected impact. This framework directly reflects the empirical drivers identified in the SEM and fsQCA results—particularly the importance of network effects, perceived usefulness, and organizational readiness in shaping merchants' adoption and usage behaviors.

In the short term (0–6 months), policymakers should focus on quick-win measures that are low-cost and high-impact. These include simplifying merchant onboarding procedures, offering targeted activation incentives, and rapidly expanding e-CNY demonstration zones in high-frequency retail and service scenarios. Such interventions can immediately strengthen perceived usefulness and network externalities, thereby increasing initial merchant activation.

In the medium term (6–18 months), policy efforts should address organizational and technical constraints by promoting cross-platform interoperability, upgrading POS infrastructure to support advanced e-CNY functions, and providing structured digital literacy training for merchants. These initiatives enhance organizational readiness and reduce operational frictions, thereby supporting more stable and sustained e-CNY adoption.

In the long term (18 + months), systemic and institutional reforms are needed to embed e-CNY into the broader digital payment ecosystem. Key priorities include establishing a unified payment governance framework, expanding programmable e-CNY value-added services, and building a data-driven policy feedback mechanism that enables dynamic adjustment of incentives and regulatory measures. These strategic investments strengthen network externalities and ensure long-term merchant retention and usage growth.

Limitations and future research directions

Despite its contributions, this study has several limitations that should be acknowledged. The most significant limitation stems from our data source. As the data were collected via a pre-designed questionnaire that did not capture information on respondents' industry sector, local policy intensity, or other contextual factors, we were unable to include several key control variables. This data constraint also prevented us from employing more robust econometric techniques, such as instrumental variables or lagged variable models, to fully address potential endogeneity concerns like reverse causality.

Therefore, we explicitly acknowledge that our findings should be interpreted with caution regarding alternative explanations and causal claims. This limitation, however, presents a clear pathway for future research. Subsequent studies could design surveys to specifically incorporate these missing variables and collect longitudinal data. Such efforts would enable the use of rigorous methods to establish causality and further test the generalizability of our model. By outlining these avenues, we hope our work serves as a foundational step toward a more comprehensive understanding of digital currency adoption dynamics.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the School of Information, Central University of Finance and Economics. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

XZ: Visualization, Methodology, Data curation, Investigation, Software, Formal Analysis, Conceptualization, Writing – original draft. JZ: Funding acquisition, Writing – review and editing, Visualization, Supervision, Conceptualization, Validation.

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Conflict of interest

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References

Agatz, N., Cho, S. H., Sun, H., and Wang, H. (2024). Transportation-enabled services: concept, framework, and research opportunities. *Serv. Sci.* 16 (1), 1–21. doi:10.1287/serv.2024.0116

Aligarh, F., Sutopo, B., and Widarjo, W. (2023). The antecedents of cloud computing adoption and its consequences for MSMEs' performance: a model based on the technology-organization-environment (TOE) framework. *Cogent Bus. and Manag.* 10 (2), 2220190. doi:10.1080/23311975.2023.2220190

An, L., Wang, Y., Yan, Y., and Ma, C. (2024). The role of emotional factors in the acceptance of digital currency: an extended study of a technology acceptance model. *Finance Res. Lett.* 62, 105090. doi:10.1016/j.frl.2024.105090

Baron, R. M., and Kenny, D. A. (1989). The moderator-mediator variable distinction in social psychological research:Conceptual, strategic, and statistical considerations. *Of Personality Soc. Psychol.* 51 (6), 1173–1182. doi:10.1037/0022-3514.51.6.1173

Bayram, I. S., and Shi, X. (2024). Bidirectional charging hubs in the electric vehicle retail landscape: opportunities and challenges for the UK case. *IEEE Open J. Veh. Technol.* 5, 1470–1495. doi:10.1109/OJVT.2024.3474426

Bhatnagr, P., Rajesh, A., and Misra, R. (2025). The impact of Fintech innovations on digital currency adoption: a blockchain-based study in India. *Int. J. Account. and Inf. Manag.* 33 (2), 313–333. doi:10.1108/IJAIM-11-2023-0275

Cheng, P. (2023). Decoding the rise of central bank digital Currency in China: designs, problems, and prospects. *J. Bank. Regul.* 24 (2), 156–170. doi:10.1057/S41261-022-00193-5

Cui, L., Wu, H., Wu, L., Kumar, A., and Tan, K. H. (2023). Investigating the relationship between digital technologies, supply chain integration and firm resilience in the context of COVID-19. *Ann. Operations Res.* 327 (2), 825–853. doi:10.1007/s10479-022-04735-y

Dann, D., Teubner, T., and Weinhardt, C. (2019). Poster child and Guinea pig – insights from a structured literature review on Airbnb. *Int. J. Contemp. Hosp. Manag.* 31 (1), 427–473. doi:10.1108/IJCHM-03-2018-0186

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly.* 13, 319–340. doi:10.2307/249008

Dou, X., and Kuzmina, S. (2024). Digital transformation of Rmb business in China. 1-4 (88), 160–163. doi:10.24412/2500-1000-2024-1-4-160-163

Dowd, K. (2024). So far, Central Bank Digital currencies have failed. *Econ. Affairs* 44 (1), 71–94. doi:10.1111/ecaf.12621

Faro, B., Abedin, B., and Cetindamar, D. (2022). Hybrid organizational forms in public sector's digital transformation: a technology enactment approach. *J. Enterp. Inf. Manag.* 35 (6), 1742–1763. doi:10.1108/JEIM-03-2021-0126

Fiss, P. C., Sharapov, D., and Cronqvist, L. (2013). Opposites attract? Opportunities and challenges for integrating large-n QCA and econometric analysis. *Political Res. Q.* 66 (1), 191–198. doi:10.1177/1065912912468269e

Guo, X., Lu, G., Villena, V. H., Vogel, D., and Heim, G. R. (2022). Supply chain transformation and technology management challenges in develo regions: inductive theory building from rural Chinese nanostores. *J. Operations Manag.* 68 (5), 454–486. doi:10.1002/joom.1198

Haber, L., and Carmeli, A. (2023). Leading the challenges of implementing new technologies in organizations. *Technol. Soc.* 74, 102300. doi:10.1016/j.techsoc.2023.102300

Hadwer, Al, Tavana, M., Gillis, D., and Rezania, D. (2021). A systematic review of organizational factors impacting cloud-based technology adoption using technology-organization-environment framework. *Internet Things* 15, 100407. doi:10.1016/j.iot.2021.100407

Hsu, H. Y., Liu, F. H., Tsou, H. T., and Chen, L. J. (2019). Openness of technology adoption, top management support and service innovation: a social innovation perspective. *J. Bus. and Industrial Mark.* 34 (3), 575–590. doi:10.1108/JBIM-03-2017-0068

Huang, L., Tan, J., Xie, G., and Tian, Y. (2024). The driving pathways for the construction of rural e-commerce entrepreneurial ecosystem based on the TOE

framework. *Humanit. Social Sciences Communications* 11 (1), 1–4. doi:10.1057/s41599-024-04072-4

Hussain, A., Zhiqiang, M., Li, M., Jameel, A., Kanwel, S., Ahmad, S., et al. (2025). The mediating effects of perceived usefulness and perceived ease of use on nurses' intentions to adopt advanced technology. *BMC Nursing* 24 (1), 33. doi:10.1186/s12912-024-02648-8

Jabbar, A., Geebren, A., Hussain, Z., Dani, S., and Ul-Durar, S. (2023). Investigating individual privacy within CBDC: a privacy calculus perspective. *Res. Int. Bus. Finance* 64, 101826. doi:10.1016/j.ribaf.2022.101826

Kock, N. (2015). Common method bias in PLS-SEM: a full collinearity assessment approach. *Int. J. E-Collaboration (ijec)* 11 (11), 1–10. doi:10.4018/ijec.2015100101

Krishna, A., Kambewa, D., Tchuwa, F., Kasonga, F., and Higdon, P. (2025). What do communities feel about community-driven development? Learning from investigations in rural Malawi. *World Dev. Perspect.* 38, 100692. doi:10.1016/j.wdp.2025.100692

Kumar, V., Nim, N., and Agarwal, A. (2021). Platform-based mobile payments adoption in emerging and developed countries: role of country-level heterogeneity and network effects. *J. Int. Bus. Stud.* 52 (8), 1529–1558. doi:10.1057/s41267-020-00346-6

Landa, E., Zhu, C., Sesabo, J., and Machumu, H. (2023). Leader support and the integration of innovative teaching–learning technologies: the mediating role of technological level of knowledge. *Educ. Inf. Technol.* 28 (12), 15523–15541. doi:10.1007/s10639-023-11776-8

Lee, D. K. C., Shih, C. M., and Zheng, J. (2023). Asian CBDCs on the rise: an in-depth analysis of developments and implications. *Quantitative Finance Econ.* 7 (4), 665–696. doi:10.3934/QFE.2023032

Li, J., and Li, B. (2022). Digital inclusive finance and urban innovation: evidence from China. *Rev. Dev. Econ.* 26 (2), 1010–1034. doi:10.1111/rode.12846

Ma, C., Jin, Z., Mei, Z., Zhou, F., She, X., Huang, J., et al. (2022). Internet of things background: an empirical study on the payment intention of central bank digital currency design. *Mob. Inf. Syst.* 2022, 4–12. doi:10.1155/2022/4846372

Ma, C., Wu, J., Sun, H., Zhou, X., and Sun, X. (2023). Enhancing user experience in digital payments: a hybrid approach using SEM and neural networks. *Finance Res. Lett.* 58, 104376. doi:10.1016/j.frl.2023.104376

Mehmood, K., Kautish, P., Rashid, M., Leong, M. K., and Honglei, H. (2025). Harvesting green futures: charting the TOE-Based roadmap to innovation and sustainability in manufacturing SMEs. *Corp. Soc. Responsib. Environ. Manag.*, csr.70203. doi:10.1002/csr.70203

Mensah, J. K., and Xu, Y. (2025). Adoption of E-commerce technologies among SMEs in Ghana under the influence of integrated UTAUT and TOE frameworks. *Inf. Dev.*, 02666669251325479. doi:10.1177/02666669251325479

Miklian, J., and Hoelscher, K. (2022). SMEs and exogenous shocks: a conceptual literature review and forward research agenda. *Int. Small Bus. J.* 40 (2), 178–204. doi:10.1177/02662426211050796

Mue, I. (2024). "An analysis on strategic objectives of the issuance of the digital renminbi," in *2024 2nd international conference on Cyber resilience (ICCR)* (IEEE), 1–4. doi:10.1109/ICCR61006.2024.10533156

Ninson, S. S. (2024). *Assessing the efficacy of blockchain digital point-of-sale (Pos) with credit reward systems for small and medium Scale enterprises (SMEs).* Accra, Ghana: Ashesi University. Available online at: https://hdl.handle.net/20.500.11988/1261.

Omrani, N., Rejeb, N., Maalaoui, A., Dabić, M., and Kraus, S. (2022). Drivers of digital transformation in SMEs. *IEEE Transactions Engineering Management* 71, 5030–5043. doi:10.1109/TEM.2022.3215727

Oyedijo, A., Kusi-Sarpong, S., Mubarik, M. S., Khan, S. A., and Utulu, K. (2024). Multi-tier sustainable supply chain management: a case study of a global food retailer. *Supply Chain Manag. Int. J.* 29 (1), 68–97. doi:10.1108/SCM-05-2022-0205

Ozili, P. K. (2023). CBDC, Fintech and cryptocurrency for financial inclusion and financial stability. Digital Policy. *Regul. Gov.* 25 (1), 40–57. doi:10.1108/DPRG-04-2022-0033

Pal, D., and Vanijja, V. (2020). Perceived usability evaluation of Microsoft Teams as an online learning platform during COVID-19 using system usability scale and technology acceptance model in India. *Child. Youth Services Review* 119, 105535. doi:10.1016/j.childyouth.2020.105535

Panico, C., and Cennamo, C. (2022). User preferences and strategic interactions in platform ecosystems. *Strategic Management Journal* 43 (3), 507–529. doi:10.1002/smj.3149

Pappas, I. O., and Woodside, A. G. (2021). Fuzzy-set qualitative comparative analysis (fsQCA): guidelines for research practice in information systems and marketing. *Int. Journal Information Management* 58, 102310. doi:10.1016/j.ijinfomgt.2021.102310

Patil, K., Garg, V., Gabaldon, J., Patil, H., Niranjan, S., and Hawkins, T. (2024). Firm performance in digitally integrated supply chains: a combined perspective of transaction cost economics and relational exchange theory. *J. Enterp. Inf. Manag.* 37 (2), 381–413. doi:10.1108/JEIM-09-2022-0335

Petteri, L., George, G., and Alexy, O. (2023). When do novel business models lead to high performance? A configurational approach to value drivers, competitive strategy, and firm environment. *Acad. Manag. J.* 66 (1), 164–194. doi:10.5465/amj.2020.0969

Polyportis, A., and Pahos, N. (2025). Understanding students' adoption of the ChatGPT chatbot in higher education: the role of anthropomorphism, trust, design novelty and institutional policy. *Behav. and Inf. Technol.* 44 (2), 315–336. doi:10.1080/0144929X.2024.23173645

Prodan, S., Konhäusner, P., Dabija, D. C., Lazaroiu, G., and Marincean, L. (2024). The rise in popularity of central bank digital currencies. A systematic review. *Heliyon* 10 (9), e30561. doi:10.1016/j.dss.2013.08.008

Putrevu, J., and Mertzanis, C. (2024). The adoption of digital payments in emerging economies: challenges and policy responses. Digital policy. *Regul. Gov.* 26 (5), 476–500. doi:10.1108/DPRG-06-2023-0077

Qiu, X., Jin, J., He, R., and Mao, J. (2022). The deviation between the willingness and behavior of farmers to adopt electricity-saving tricycles and its influencing factors in Dazu District of China. *Energy Policy* 167, 113069. doi:10.1016/j.enpol.2022.113069

Saura, J. R., Skare, M., and Riberio-Navarrete, S. (2022). How does technology enable competitive advantage? Reviewing state of the art and outlining future directions. *J. Compet.* 14 (4), 172. doi:10.7441/joc.2022.04.10

Segars, A. H. (1997). Assessing the unidimensionality of measurement: a paradigm and illustration within the context of information systems research. *Omega* 25 (1), 107–121. doi:10.1016/S0305-0483(96)00051-5

Sharma, G. D., Kraus, S., Talan, A., Srivastava, M., and Theodoraki, C. (2024). Navigating the storm: the SME way of tackling the pandemic crisis. *Small Bus. Econ.* 63 (1), 221–241. doi:10.1007/s11187-023-00810-1

Silva, P. (2015). Davis' technology acceptance model (TAM)(1989). *Information seeking behavior and technology adoption: Theories and trends*, 205–219. doi:10.4018/978-1-4666-8156-9.ch013

Skafi, M., Yunis, M. M., and Zekri, A. (2022). Factors influencing SMEs' adoption of cloud computing services in Lebanon: an empirical analysis using TOE and contextual theory. *Ieee Access8* 8, 79169–79181. doi:10.1109/ACCESS.2020.2987331

Sun, M. S., and Li, Z. (2024). User perception and acceptance of central bank digital currency in developed and Develo countries: an empirical Study using technology acceptance model. *UCJC Bus. Soc. Rev. Former. Known As Universia Bus. Rev.* 21 (80). doi:10.3232/UBR.2024.V21.N1.11

Sun, Y., Xue, W., Bandyopadhyay, S., and Cheng, D. (2022). WeChat mobile-payment-based smart retail customer experience: an integrated framework. *Inf. Technol. Manag.* 23 (2), 77–94. doi:10.1007/s10799-021-00346-4

Sun, Y., Chen, J., Kong, C., Zheng, X., and Zhang, X. (2025). What factors influence the motivation of logistics enterprises to adopt green technology? An empirical study based on the TOE model. *Br. Food J.* 127, 1–25. doi:10.1108/BFJ-01-2025-0061

Tanveer, A., Zeng, S., Irfan, M., and Peng, R. (2021). Do perceived risk, perception of self-efficacy, and openness to technology matter for solar PV adoption? An application of the extended theory of planned behavior. *Energies* 14 (16), 5008. doi:10.3390/en14165008

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly* 27, 425–478. doi:10.2307/30036540

Venkatesh, V., Thong, J. Y. L., and Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Quarterly* 36, 157–178. doi:10.2307/41410412

Wang, J. (2024). Digital RMB promoting financial digital transformation in the banking sector. *Financial Engineering Risk Management* 7 (1). doi:10.23977/ferm.2024.070112

Wu, B., An, X., Wang, C., and Shin, H. Y. (2022). Extending UTAUT with national identity and fairness to understand user adoption of DCEP in China. *Sci. Rep.* 12 (1), 6856. doi:10.1038/s41598-022-10927-0

Wu, T., Jia, W., and Wang, Q. (2023). Deviation between willingness and actual behavior regarding community participation in protected areas: a case study in Shengjin lake national nature reserve in China Front. reserve in. *China Front. Environ. Sci.* 11, 1062147. doi:10.3389/fenvs.2023.1062147

Xu, X., Tahir, S. H., Khan, K. B., Sajid, M. A., and Safdar, M. A. (2024). Beyond regression: unpacking research of human complex systems with qualitative comparative analysis. *Heliyon* 10 (10), e31457. doi:10.1016/j.heliyon.2024.e31457

Yang, M., Chen, H., Long, R., and Yang, J. (2022). The impact of different regulation policies on promoting green consumption behavior based on social network modeling. *Sustain. Prod. Consum.* 32, 468–478. doi:10.1016/j.spc.2022.05.007

Yu, X., Yang, Y., and Li, S. (2024). Users' continuance intention towards an AI painting application: an extended expectation confirmation model. *Plos One* 19 (5), e0301821. doi:10.1371/journal.pone.0301821

Zhang, J. (2025). Impact of Digital Yuan (e-CNY) promotion on traditional banking: challenges and response strategies. *Law Econ.* 4 (1), 24–37. doi:10.56397/LE.2025.01.04

Zhong, W., and Zheng, Y. (2025). Do political connections stifle firm innovation? Natural experimental evidence from China's anti-corruption campaigns. *Strategic Manag. J.* 46 (5), 1183–1216. doi:10.1002/smj.3690