Entrepreneurial Opportunity Formation and Development in Digital Ecosystems: A Social Capital Theory Perspective

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Abstract

The digital entrepreneurship wave is in the ascendant, yet the formation and evolution patterns of digital entrepreneurial opportunities triggered by changes in opportunity attributes remain unrevealed. This study employs the digital ecosystem as its research context to analyze how social capital accumulated by entrepreneurs through leveraging digital ecosystem affordances influences entrepreneurial opportunity formation and development. It explains opportunity evolution patterns from both desirability and content dimensions, while examining the moderating roles of entrepreneurs' cognitive monitoring and new venture digitalization level on this pathway. This research extends social capital theory's application in digital entrepreneurship, deepens entrepreneurial opportunity research within digital ecosystems, guides entrepreneurs in utilizing digital platforms for "disruptive creation," enhances opportunity identification quality and efficiency, and fosters entrepreneurial ecosystem development.

Full Text

The Formation and Development of Entrepreneurial Opportunities in Digital Ecosystems: A Social Capital Theory-Based Inquiry

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Abstract: The wave of digital entrepreneurship is still on the rise, yet the formation and evolution patterns of digital entrepreneurial opportunities resulting from changes in opportunity attributes remain unclear. This study examines the digital ecosystem as a research context to analyze how social capital

accumulated by entrepreneurs through the affordances of digital ecosystems influences the formation and development of entrepreneurial opportunities. It explains the evolution patterns of entrepreneurial opportunities from both the desirability dimension and content dimension of opportunities, while examining the moderating effects of entrepreneurs' cognitive monitoring and new ventures' degree of digitalization on this path. This research extends the application of social capital theory in the context of digital entrepreneurship, deepens the study of entrepreneurial opportunities within digital ecosystems, and helps guide entrepreneurs to leverage digital platforms for "destructive creation," thereby improving the quality and efficiency of opportunity identification and promoting the construction of entrepreneurial ecosystems.

Keywords: digital ecosystem, social capital, entrepreneurial opportunity, opportunity set, opportunity belief

1. Introduction

In the era of the digital economy, new organizational forms such as bilateral and multilateral platforms, online communities, and ecosystems have continuously emerged, challenging the core propositions and assumptions of mainstream innovation strategy theories [5]. For entrepreneurship research, this new context challenges the "individual-opportunity nexus" research paradigm. Uncovering the novel characteristics of digital entrepreneurial opportunities and revealing the formation patterns of entrepreneurial opportunities can not only guide digital entrepreneurs to broaden their opportunity space and improve the quality and efficiency of opportunity identification, but also optimize ecosystem resource allocation and feed back into digital ecosystem construction, thereby continuously improving the entrepreneurial environment and promoting high-quality innovation and entrepreneurship development. Currently, entrepreneurship research from an ecosystem perspective has primarily focused on industrial clusters and factor agglomeration at the macro or meso level [10][11], with less attention paid to micro-level entrepreneurial activities of entrepreneurs within ecosystems [42], particularly overlooking the series of decision-making challenges and paradoxes faced by small and medium-sized enterprise entrepreneurs as platform complementors [45]. In other words, the micro-mechanisms of entrepreneurial activities in digital ecosystems need to be further unpacked.

Entrepreneurial opportunity is a core issue in entrepreneurship research and an important vehicle for explaining the micro-mechanisms of entrepreneurial activities. Since Shane and Venkataraman proposed the "individual-opportunity nexus" research paradigm, entrepreneurship research has concentrated on how the matching between heterogeneous entrepreneurial opportunities and entrepreneur characteristics affects the entrepreneurial process. As digital entrepreneurship advances, the three affordances supported by digital technology —decoupling, disintermediation, and generality—have changed both the distribution of opportunities and the entrepreneurial activities that effectively exploit them [12][2]. Whereas traditional entrepreneurship research focused on how

individual entrepreneurs obtain entrepreneurial performance by providing a single product/service, in digital ecosystems, it is also necessary to consider how products/services connect with platforms, complementary components, and consumers in digital networks [52]. This environmental change is particularly sensitive for resource-constrained SMEs [37][46]. As opportunity distribution changes, how participants in new cooperative networks innovate their resource search, acquisition, and integration plays a crucial role in opportunity identification and development [5]. In other words, how small and medium-sized entrepreneurial enterprises utilize ecosystem resources to form and expand entrepreneurial opportunities in an interconnected network environment will become a new foothold for dissecting the "individual-opportunity nexus" in digital entrepreneurship.

Centering on the classic proposition in entrepreneurship research— "why some people, rather than others, can identify and develop entrepreneurial opportunities" in digital ecosystems—this study will focus on: (1) How do the contextual characteristics of digital ecosystems affect the formation and development of entrepreneurial opportunities? (2) How do entrepreneurs form opportunity beliefs in digital ecosystems? (3) How do entrepreneurial opportunities evolve and develop in digital ecosystems? To answer these questions, this study adopts social capital theory as the primary conceptual foundation, combines it with affordance theory to interpret the patterns of entrepreneurs' utilization of ecosystem resources, and employs temporal and content changes from "opportunity belief" to "opportunity set" to comprehensively depict entrepreneurial opportunities, thereby clearly illustrating the entrepreneurial process of "individual-opportunity matching" in digital ecosystems.

2.1 The Evolution and Development of Entrepreneurial Opportunity Research

Entrepreneurial opportunity serves as the cornerstone and pillar of entrepreneurship research, forming an important bridge connecting entrepreneurs' cognition and behavioral interactions [58]. Precisely because of its foundational and inclusive nature, academia has struggled to reach a consensus on the definition of "what constitutes an entrepreneurial opportunity," particularly regarding the ongoing debate between the "discovery view" and "creation view" of opportunity sources. Due to the unclear conceptualization of "opportunity," on the one hand, scholars find it difficult to compare research findings and clearly delineate the research frontier on entrepreneurial opportunities; on the other hand, this lack of conceptual clarity means scholars face significant challenges when testing current opportunity theories, further limiting the ability to substantiate theoretical debates with empirical results [56]. Throughout the "individual-opportunity nexus" research paradigm, the focus has consistently centered on the "individual" level. Although there have been discussions about the heterogeneous attributes of opportunities (such as innovativeness) or accompanying factors (such as uncertainty), the term "opportunity" itself has remained elusive.

One reason is that, at least in the initial stages of the entrepreneurial process, opportunity itself is a non-existent entity [49].

Against the backdrop of digital entrepreneurship, everything has fundamentally changed based on the characteristics of digital infrastructure and digital products themselves. Digital infrastructure, as an external driver of opportunity generation, more clearly distinguishes the opportunity realization process into prospecting, development, and exploitation stages, with each stage having controllable critical success factors [57]. Meanwhile, the layered modular architecture creates differences in digital products' degree of coupling and embodiment, which in turn affects their editability and distributability, making non-linearity and rapid iteration important features of digital entrepreneurial opportunities. Through communication channels established via digital technologies, ecosystem elements can participate in all aspects of value chain creation. Compared with single technology-oriented innovative opportunities, user value orientation and ecosystem innovation orientation present new requirements for the heterogeneous attributes of entrepreneurial opportunities. Entrepreneurial opportunities are no longer vague references in the entrepreneurial process but rather actionable entrepreneurial ideas co-created by action subjects who generate entrepreneurial beliefs under new contextual factors. Thus, digital entrepreneurial opportunities exhibit new characteristics distinct from traditional opportunities, and digital ecosystems, in particular, provide more concrete contextual elements for further grounding digital entrepreneurial opportunities, offering new opportunities for describing and measuring entrepreneurial opportunities.

2.2 The Connotation and Characteristics of Digital Ecosystems

The term "ecosystem" originates from biology and, in the abstract sense, refers to a biological community composed of living entities and physical environments. Species and environments form relationships of co-existence, mutual dependence, and co-evolution through complex interaction processes [9]. Moore was the first to introduce it into management research, defining it as "an economic community based on interactions among organizations and individuals" [40]. Digital technology has greatly enhanced people' s ability to collect, store, analyze, and share information, changing the flow of goods and knowledge, thus making more flexible and efficient organizational forms—digital ecosystems—increasingly prevalent [4]. Digital ecosystems refer to self-organizing, self-growing, and sustainable systems composed of heterogeneous digital entities and their interaction relationships, which increase system utility, promote information flow, and enhance internal and external cooperation and system innovation through member interactions [36]. Specifically, they can be manifested at different levels such as industrial ecosystems, business ecosystems, and platform ecosystems.

From an evolutionary path perspective, digital platforms themselves may evolve into ecosystems by constructing a collaborative architecture for participants to maximize strategic synergy of resources. Taking innovation platforms as an example, by building technical modules and providing complementary innovative

products or services for innovation developers, they form platform-led innovation ecosystems together with complementors [4]. Such digital platforms often have three core characteristics: intermediary effects, demand-side drivers, and digital technology empowerment [51], particularly the self-growth nature based on digital technology's layered architecture, which lays the foundation for digital ecosystem formation.

Therefore, digital ecosystems are viewed as spontaneously formed multilateral organizations of enterprises that achieve common value propositions, rather than being limited to upstream and downstream partner networks sharing the same value chain [4]. Platformization—the prevalence of multilateral platform organizations—implies a transition from individualized product/service competition to managing transaction and value creation processes mediated by platforms [23][24][25][30][47]. Platform owners provide value for users by attracting more complementors, which not only improves ecosystem functionality but also enhances the formation of economies of scale and scope of innovation [25]. Consequently, "non-generic complementarity" is the fundamental characteristic that distinguishes ecosystems from other structural arrangements [33]. To provide complementarity, participants in ecosystems must invest substantial asset-specific investments, thereby forming interdependence among actors. Meanwhile, digital ecosystems also feature openness. By providing boundary resources such as standardized interfaces, legal protection, and other value-added services, they help entrepreneurs (platform complementors) effectively conduct entrepreneurial activities and sustain innovation [45]. Furthermore, openness is reflected in platform architecture design and ecosystem management. Finally, the boundarylessness of ecosystems further promotes cooperation among actors, facilitates knowledge and information exchange between internal and external ecosystem units, attracts more actors to join the ecosystem, and promotes the formation of innovation strategies and outcomes.

A comparison between digital platforms and digital ecosystems is shown in Table 1 .

2.3 The Impact of Digital Ecosystems on Entrepreneurial Opportunities

The digital ecosystem perspective not only expands the extension of technology entrepreneurship but also updates the interaction mechanisms among ecosystem elements based on fixed domain scenarios. These contextual characteristics not only change the intrinsic attributes of entrepreneurial opportunities (new features of digital entrepreneurial opportunities) but also challenge the "individual-opportunity nexus" research paradigm.

From the "individual" perspective, the non-linear characteristics of entrepreneurial opportunity development become more pronounced under the influence of digital infrastructure as an external driver, posing higher challenges for digital entrepreneurs. Based on digital entrepreneurship application scenar-

ios, how entrepreneurs embed themselves in social interactions, utilize specific cognitive patterns and learning methods to form opportunity evaluations, and subsequently generate different behavioral responses to grasp and exploit opportunities will become an important direction for action-oriented entrepreneurship research. For instance, differences in entrepreneurs' thinking and cognitive patterns during opportunity identification reveal that the micro-mechanism enabling different entrepreneurs to see different opportunities lies in the role of structural connections [26]. The ability for perspective-taking in multi-actor interactions [48], cognitive monitoring capability to overcome "cognitive dissonance" [7], and critical reflective capability to adjust cognitive processes [17] will all become important labels for digital entrepreneurs. Essentially, this reflects that entrepreneurs in the digital entrepreneurship context are engaged in higher-order learning and iterative innovation.

From the "opportunity" perspective, due to the openness, editability, and extensibility of digital product components, entrepreneurs can adjust opportunities through lower-cost trial-and-error and accomplish opportunity co-creation through more convenient social interactions, but they are also constrained by more contextual factors. Whereas entrepreneurship research in the past focused on founder characteristics and personal networks, in the digital ecosystem context, coordinated products and related decisions are particularly important [54]. For example, a platform' s technological openness and decision rights configuration affect entrepreneurial opportunities generated through platform operations, even lowering the knowledge threshold required for entrepreneurship and reducing initial learning costs [43]. Furthermore, platform leaders' decisions regarding innovation asset leverage—whether to support the dissemination and utilization of other innovation assets such as technology, processes, and intellectual property among platform ecosystem members—will further reduce the knowledge gap in discovering and exploiting potential opportunities, influencing opportunity iteration methods and opportunity set expansion directions. Finally, the degree of platform openness, diversity, and complementarity can similarly affect the formation of strong and weak relationships among interacting actors on the platform, thereby moderating entrepreneurial behavior or its impact on entrepreneurial performance.

2.4 Literature Review

As an important contextual factor for digital entrepreneurship, digital ecosystems provide an opportunity for theorizing entrepreneurial opportunity research. Using "opportunity" as the main thread to explore the mechanisms and effects of digital entrepreneurship and advance the "individual-opportunity nexus" research paradigm, this study identifies the following critical scientific questions that need to be addressed.

First, describing and measuring entrepreneurial opportunities in digital ecosystems. Digital ecosystems provide more concrete contextual elements for further grounding digital entrepreneurial opportunities. How do entrepreneurial oppor-

tunities in digital ecosystems differ from traditional entrepreneurial opportunities? How should they be measured? This requires us to integrate changes in contextual elements into entrepreneurial opportunity research based on analyzing the characteristics of digital entrepreneurial opportunities, adopt a dynamic opportunity perspective to comprehensively depict the key stages and micro-mechanisms of opportunity generation processes, and construct a process model of entrepreneurial opportunities in digital ecosystems.

Second, the impact of contextual element changes on entrepreneurial behavior and patterns. Traditional entrepreneurship research focuses on how individual entrepreneurs obtain entrepreneurial performance by providing a single product/service. In digital ecosystems, entrepreneurs' network capabilities and social capital in utilizing ecosystem resources within interdependent environments become critical to entrepreneurial success or failure. How can social capital theory or social network theory be applied to this new context to guide entrepreneurial activity patterns? This requires us to break existing assumptions, adopt a more structured or holistic perspective, conduct sophisticated research designs, and expand the application space of existing theories.

Third, "individual-opportunity matching" in digital ecosystems. The "individual-opportunity nexus" research paradigm constitutes the foundation of entrepreneurial opportunity research and represents the essential manifestation of using the "opportunity"theme to explain digital entrepreneurship mechanisms. The uniqueness of digital entrepreneurship does not lie in the characteristics of digital tools and infrastructure themselves, but in how entrepreneurs align their goals and capabilities with these characteristics [44]. Furthermore, how do the affordances of digital ecosystems affect the entrepreneurial process of the "individual-opportunity nexus" ? Solving these problems requires us to contextualize digital ecosystems and combine them with opportunity research itself to develop research designs.

3. Research Framework

Accompanied by the empowerment of digital technologies, multi-level digital architectures enable participants to conduct activities at different architectural levels, transforming innovation cooperation in ecosystems from sequential linear supply chain models to multi-layered networked ecosystem models [6]. Particularly with the popularization of digital platforms, an increasing number of entrepreneurs need to select specific platforms to obtain resource support and must re-understand the entrepreneurial process in environments with complementary products and modular components. To reflect this characteristic in the entrepreneurial context, this study employs Social Capital Theory as the foundation to explain the patterns of entrepreneurs' utilization of digital ecological resources, combined with Affordance Theory, to construct a theoretical framework of "Digital Ecosystem Characteristics–Social Capital–Entrepreneurial Opportunity" (as shown in Figure 1 [Figure 1: see original paper]).

Davidsson [19] points out that the reason for the unclear conceptualization of "opportunity" lies in the confusion between the content dimension of opportunity and the subjective preference (desirability) dimension. This study uses changes in "opportunity belief" and "opportunity set" to dissect this dilemma, describing and measuring entrepreneurial opportunities in the digital ecosystem context from both the desirability dimension and content dimension. From a dynamic opportunity perspective, it interprets the complex, non-linear formation mechanisms of entrepreneurial opportunities in digital ecosystems. Specifically, it includes three main aspects: (1) explaining the impact of digital ecosystem contextual characteristics on entrepreneurial opportunities from social capital theory; (2) examining how entrepreneurs form opportunity beliefs in digital ecosystems from the desirability dimension; and (3) examining the iteration and evolution patterns of entrepreneurial opportunities in digital ecosystems from the content dimension.

3.1 Research Module 1: The Impact of Digital Ecosystem Contextual Characteristics on Entrepreneurial Opportunities

For traditional entrepreneurial opportunities, the focus is on entrepreneurs' individual experience or entrepreneurial teams' deep exploration of a particular market opportunity [3]. Based on the three affordances of digital technology —decoupling, disintermediation, and generality—digital entrepreneurial opportunities exhibit new characteristics of iterativity, interactivity, extensibility, and ecology. The process from opportunity generation, implementation, expansion, to re-implementation is much faster, and entrepreneurial opportunities have been greatly expanded in both intensity and richness, even enabling cross-boundary innovation possibilities. Simultaneously, the entrepreneurial process is no longer determined by individual entrepreneurs but becomes the result of multi-party co-creation. Therefore, new ventures in digital ecosystems often possess stronger advantages in opportunity and resource aggregation [54], and the key elements in opportunity formation and development processes will consequently change. Drawing on affordance theory, affordance refers to the action possibilities brought about by digital technology, jointly determined by the characteristics of the technology itself and the user' s intentions. The openness, interdependence, and cooperation of digital ecosystems provide possibilities for entrepreneurs to effectively utilize ecosystem resources and identify and develop entrepreneurial opportunities, requiring individual-level action to actualize. To handle complex, dynamic relationships in the cooperation process, it becomes particularly important for new ventures to be adept at utilizing relational capabilities or network capability. Social capital theory posits that social capital is "the sum of actual and potential resources that individuals or social units obtain from network relationships" [41], which can be further refined into structural, relational, and cognitive dimensions. The structural dimension refers to the connection patterns among social network members, described through network configuration and position, distance between resources, structural hierarchy, and diversity or heterogeneity of ties, with network structure types affecting

members' resource access and exchange capabilities. The relational dimension manifests as recognition of various relationships, norms, and concepts in entrepreneurial activities, providing a solid foundation for transfer and exchange, preventing opportunistic behavior, incentivizing cooperation, and maintaining close and frequent interactions. The cognitive dimension represents shared values, interests, paradigms, and interpretations among network members, often analyzed through shared narratives, codes, and languages. Unlike traditional entrepreneurship research that focuses on entrepreneurs' personal social networks, the emergence of new social networks and data flow characteristics within networks has changed the formation patterns of social capital, thereby altering and expanding the structure and dimensions of social capital [5].

In digital ecosystems, users and agents constitute the core elements of the ecosystem [51]. To attract more participating actors and create network effects, platform owners need to maintain openness, influencing connections among platform (ecosystem) participants through technological openness (providing architectural interface specifications) and organizational openness (governance structure) to promote mutual cooperation [45]. Breaking the vertical knowledge exchange between users and producers, proactive horizontal knowledge spillover becomes an important characteristic of ecosystem structure [12]. Therefore, for entrepreneurs in digital ecosystems, the accumulation of structural capital means the degree to which new ventures utilize modular resources, acquire complementary assets, and satisfy consumer demand by providing adaptable complementary products. Similarly, under conditions of user privacy protection and digital technology empowerment, greater user participation and user value creation space require new ventures to maintain close and frequent interactions with users and effectively cooperate with other ecosystem actors to develop user value, which helps them proactively maintain intra-community relationships and achieve multilateral relationship coordination. Consequently, the openness, interdependence, and cooperation of digital ecosystems further influence the formation of relational capital. Finally, ecosystem outputs signify not only economic results; from a cultural-cognitive perspective, the formation of shared concepts and meanings plays an important role in promoting sustainable ecosystem development [55]. Shared goals at the ecosystem level are reflected in the establishment of member management models and collective decision-making mechanisms, with digital technology affordances accelerating this process [12]. Open, interdependent, and closely cooperative ecosystems facilitate knowledge sharing, information dissemination, and common understanding among participants. To maintain sustainable ecosystem development, participants need to adjust their behaviors, conducting entrepreneurial activities under the constraints of digital ecological technical norms and governance norms, which will promote the formation of shared values, interests, paradigms, and interpretations among ecosystem members. Therefore, the openness, interdependence, and cooperation of digital ecosystems lay the foundation for entrepreneurial opportunity formation and development, with the key lying in the social capital that entrepreneurs accumulate and form by utilizing digital

ecosystem resources. Thus, we propose Proposition 1.

Proposition 1: In digital ecosystems, social capital accumulated by entrepreneurs through utilizing ecosystem resources influences the formation and development of entrepreneurial opportunities.

3.2 Research Module 2: The Formation Mechanism of Opportunity Beliefs in Digital Ecosystems

In the context of digital entrepreneurship, the "individual-opportunity nexus" research paradigm is endowed with more refined boundary conditions. Based on a thorough analysis of how ecosystem contextual characteristics affect entrepreneurial opportunities, this section examines the influence of social capital on entrepreneurs' opportunity belief formation from the desirability dimension, addressing the research question of "why some people, rather than others, can identify and exploit digital entrepreneurial opportunities" during the startup phase. The research question is further refined into:

(1) The Relationship Between Social Capital and Opportunity Beliefs in Digital Ecosystems

Why can some people, rather than others, identify and exploit entrepreneurial opportunities under the same circumstances? Entrepreneurs' judgment of opportunity value is a future-based subjective interpretation [13]. "Opportunity belief" is considered "the personal perception of the extent to which an entrepreneurial idea can represent an opportunity" [26], which can help entrepreneurs overcome doubt, reduce ignorance, and thereby launch entrepreneurial activities [39]. Opportunity belief is primarily measured through two dimensions: the perceived fit between supply approach and target market, and the perceived feasibility of the opportunity [26][27], signifying the entrepreneur' s transition from idea (with correct knowledge and motivation) to action (believing they have identified an opportunity) stage, which is also the startup phase of entrepreneurial activities. In this stage, entrepreneurs need to continuously validate their entrepreneurial ideas, increase commitment confidence, and subsequently sustain entrepreneurial actions.

During the startup phase, social capital obtained by entrepreneurs through relational networks is an important channel for acquiring and evaluating entrepreneurial opportunity information [50]. However, in digital ecosystems, the formation paths of social capital and its mechanisms of action on opportunity beliefs have also changed accordingly. The accumulation of structural capital signifies the degree to which new ventures utilize modular resources in the ecosystem, affecting entrepreneurs' (complementors') specific asset investments in the ecosystem, which in turn triggers entrepreneurs' re-evaluation of technological and market risks [45]. Risk assessment is an important stage in subjective belief formation, further influencing entrepreneurs' opportunity evaluation. Relational capital signifies the degree of effective cooperation with other ecosystem actors and the maintenance of close and frequent interactions. The establish-

ment of relational capital further reflects the closeness of inter-actor cooperation. Through knowledge and information exchange with internal and external ecosystem units, it provides new ventures with numerous learning opportunities about markets and technologies [18][28][29]. Particularly, timely interaction with users through social media, online communities, and other platforms stimulates entrepreneurs' effectual thinking [22], further examining and evaluating their original business ideas, and helping entrepreneurs verify the fit between supply approach and target market, increase confidence investment, and influence opportunity belief formation. Cognitive capital signifies shared values, interests, paradigms, and interpretations among ecosystem members, facilitating knowledge sharing, information dissemination, and common understanding among participants [6]. The establishment of cognitive capital signifies that entrepreneurs identify themselves as members of the platform (ecosystem), further influencing entrepreneurs'commitment to and investment in entrepreneurial opportunities within specific platforms (ecosystems) [52], thereby affecting opportunity belief formation. Therefore, we propose Proposition 2.

Proposition 2: Social capital accumulated in digital ecosystems contributes to the formation of entrepreneurs' opportunity beliefs.

(2) The Moderating Role of Entrepreneurs' Cognitive Monitoring

Digital platforms (innovation ecosystems) provide a foundation for entrepreneurs to expand and exploit opportunities. Based on the open and easily editable nature of digital products, entrepreneurs can more easily test ideas and solutions in a timely manner, revise and adjust business models, and even generate new opportunities, but this also presents new challenges. On the one hand, they must conduct entrepreneurial activities within the vision, goals, and structure set by platform leaders; on the other hand, they must achieve differentiation through unique value propositions to ensure enterprise survival and development [52]. In other words, entrepreneurs in ecosystems face the challenge of balancing an "independent mindset" with an "ecosystem mindset." Cognitive monitoring reflects individuals' ability to supervise and reflect on cognitive processes and to capture and utilize environmental cues [31], helping decision-makers maintain competitive advantages in complex and dynamic business environments. Specifically, as cognitive monitoring increases, entrepreneurs will be able to effectively respond to new environmental changes and reduce "cognitive dissonance," particularly in handling coopetitive relationships with platform leaders and other types of participants within the ecosystem, correctly understanding user psychology and behavior, and obtaining key information [48], thereby transforming accumulated ecosystem resources into actionable "means-ends" matching relationships to solve market problems and form opportunity beliefs. Furthermore, in digital ecosystems, rapid opportunity iteration and entrepreneurial model innovation have become mainstream. Self-regulating cognitive processes allow entrepreneurs to continuously reflect, timely grasp potential changes, and form an innovation-facilitating strategic mindset [7], helping entrepreneurs adapt

to the new characteristics of opportunity changes in the digital ecosystem context, grasp and utilize ecosystem resources, and form effective opportunity commitments and judgments. Therefore, building upon the main effects in the previous section, this study argues that entrepreneurs' cognitive monitoring plays a moderating role, demonstrating and measuring the new cognitive characteristics of entrepreneurs in responding to changes and self-adjusting in the digital entrepreneurial competitive environment. Thus, we propose Proposition 3.

Proposition 3: Entrepreneurs' cognitive monitoring positively moderates the relationship between social capital and opportunity beliefs.

3.3 Research Module 3: The Evolution Patterns of Entrepreneurial Opportunity Sets in the Digital Ecosystem Context

From the "individual-opportunity nexus" paradigm, building upon the "desirability" evaluation of opportunities from the entrepreneur' s perspective in the previous section, this section examines the impact of social capital on opportunity set expansion in the digital ecosystem context from the "content" dimension of opportunities [19], demonstrating the evolution of entrepreneurial opportunities during the scaling phase of new ventures.

The research question is further refined into:

(1) The Relationship Between Social Capital and Opportunity Sets in Digital Ecosystems

Literature research reveals that beyond the innovative attribute of opportunities, digital entrepreneurial opportunities also exhibit characteristics of iterativity, ecology, and interactivity, making a single, static opportunity perspective inadequate to capture the essence of entrepreneurial opportunities in digital ecosystem contexts. Similarly, traditional entrepreneurship research focuses on how individual entrepreneurs obtain entrepreneurial performance by providing a single product/service. In the digital ecosystem context, it is also necessary to consider how products/services connect with platforms, complementary components, and consumers in digital networks. The openness of platform architecture and the governance model of ecosystems will further influence the depth and breadth of opportunities and affect opportunity monetization methods [44]. Drawing on concepts of opportunity sets [32][1] and opportunity portfolios [15] in entrepreneurship research, and building upon opportunity belief formation, this section aims to explore the evolution patterns of opportunity sets in the digital entrepreneurship ecosystem context during the scaling phase of new ventures. Opportunity sets are not static but change with shifts in inter-actor relationships and the addition of other actors. The addition of other actors expands the original actors' information, resource, and cognitive interactions, generating more related entrepreneurial opportunities—a process known as opportunity set expansion [1]. In interdependent, open, and collaborative digital ecosystems, new ventures' opportunity sets have natural expansion space, reflecting the es-

sential characteristics of digital entrepreneurial opportunities during the scaling phase.

In existing entrepreneurship research, entrepreneurs' social capital not only affects whether entrepreneurs can discover opportunities but also what types of opportunities they discover [8]. Entrepreneurs with higher social capital levels have access to greater quantity and higher quality of opportunity information [38], thereby influencing opportunity identification types. In digital ecosystems, cross-level and cross-domain innovation cooperation and high-frequency user participation become possible, providing conditions for digital resource synergy among participating actors and helping new ventures achieve new value creation paths [59]. The construction of digital commercial channels greatly shortens the distance between products and users, not only facilitating agile innovation through rapid market response but also promoting rapid product commercialization [6]. Opportunity iterativity manifests as the possibility of swift action and multiple improvement actions [14], while opportunity innovativeness has a broader extension. Beyond the single enterprise technology-oriented innovation paradigm, opportunities in digital ecosystems can also be manifested through cross-boundary innovation, reflected in opportunity set expansion brought about by business model innovation and horizontal knowledge spillover [12]. Therefore, the structure and type of social capital that new ventures obtain by embedding themselves in ecosystem networks not only affect entrepreneurs' opportunity identification and evaluation during the startup phase but further influence opportunity evolution and exploitation during the scaling phase. Furthermore, new ventures utilize the modular and interface design, access rules, and communication rules provided by digital ecosystems to conduct innovation. Structural capital accumulation signifies the degree of modular resource utilization, and loose coupling with other platform modules facilitates the generation of more iterative and cross-boundary innovations [4]. Meanwhile, virtualized participating actors can overcome temporal and spatial barriers among innovation actors, enhancing innovation speed. Whether through user participation on crowdfunding platforms [20] or user co-creation in open-source communities [35], relational capital established with users and ecosystem participants helps new ventures expand their resource pool and improve innovation efficiency. Finally, shared values, interests, paradigms, and interpretations further promote cooperation and synergy within ecosystems, generating more vertical/horizontal knowledge spillover. Ecological inter-actor relationships facilitate new product combinations and solutions through cross-level resource complementarity and sharing, providing new paths for innovation actors' value creation [6]. Thus, we propose Proposition 4.

Proposition 4: In digital ecosystems, social capital contributes to opportunity set expansion, enhancing the iterativity and innovativeness of entrepreneurial opportunity sets.

(2) The Moderating Role of New Ventures' Degree of Digitalization

The difference between digital platforms and traditional platforms lies in the

dissemination and application of digital technology and the continuous stream of entrepreneurial opportunities it brings [51]. Digital infrastructure and users, as core elements of digital ecosystems, provide possibilities for opportunity set expansion [54], but the key lies in how ecosystem participants utilize digital technology to develop existing resources and the degree of disruption and innovation this brings. Therefore, for new ventures in digital ecosystems, the higher the degree of digital technology utilization—manifested in the ability to develop digital products and to access and utilize digital platforms and digital infrastructure—the more effectively it can promote entrepreneurs' opportunity development and monetization [45]. Specifically, internet technology, open-source software, and cloud computing technology can not only greatly reduce trial-and-error costs but also accelerate opportunity iterativity [57]. The higher the degree of opportunity digitalization, the higher the possibility of contacting different external entities [44], meaning new ventures can more effectively access ecosystem boundary resources and generate more innovations based on existing program interfaces. Particularly, digital technology is an important determinant of user-driven growth [51]. Based on social capital formed through user interaction, utilizing digital technology to develop user value, especially using complements to provide consumers with more plug-and-play options, will further promote cross-boundary innovation [53]. Therefore, building upon the main effects in the previous section, this study argues that new ventures' degree of digitalization plays a moderating role, demonstrating the important boundary conditions of social capital for opportunity iteration and innovation in the digital entrepreneurship context. Thus, we propose Proposition 5.

Proposition 5: New ventures' degree of digitalization positively moderates the relationship between social capital and opportunity set expansion.

4. Theoretical Contributions

This study takes the digital ecosystem as an important context for digital entrepreneurship research. Based on analyzing the uniqueness of the digital ecosystem context, it interprets the patterns of new ventures' entrepreneurial activities utilizing digital ecosystem resources from social capital theory, further revealing the micro-mechanisms of entrepreneurial opportunity formation and development to ground digital entrepreneurship research. It mainly extends existing research in the following three aspects.

First, this study redefines the research context of digital entrepreneurship. Although digital entrepreneurship research is burgeoning, most studies focus on a single phenomenon or cross-section, lacking a more structured or holistic perspective [34]. As Sussan and Acs [54] note, entrepreneurship research has neither focused on the role of digital technology in entrepreneurship research nor on the roles played by users and various actors in digital entrepreneurship. This study takes digital ecosystems as an important context for digital entrepreneurship research, combining relevant research findings on digital platforms and innovation ecosystems from the strategic management field. Starting from the core element

of entrepreneurship research—entrepreneurial opportunity research—it explores how digital entrepreneurship ecosystems affect opportunity formation and development. Digital ecosystem contextual characteristics influence opportunity formation and development through a series of mechanisms such as knowledge sharing, resource exchange, and cooperative co-creation mechanisms, but the effects of these mechanisms warrant further investigation. Taking the openness characteristic as an example, openness in digital ecosystems is a double-edged sword. High openness benefits new ventures' effective utilization of ecological resources, but more open platforms lead to increased competition among complementors, and new ventures also face trade-offs and choices in conducting entrepreneurship in one or multiple platforms (ecosystems) [52], which will inevitably affect entrepreneurs' opportunity evaluation and opportunity iteration and development. Therefore, future research should adopt diverse research methods, select typical research subjects such as new ventures within digital platforms or digital incubators, and employ historical analysis and longitudinal study methods, using the comparability of multiple case studies to further illustrate the boundary conditions of digital ecosystem resource utilization on entrepreneurial opportunities.

Second, this study employs social capital theory and affordance theory to dissect the changing patterns of entrepreneurial behavior in digital ecosystem contexts, using them as a bridge to connect entrepreneurial opportunity research. Unlike traditional entrepreneurship research that focuses on entrepreneurs' personal social networks and "heroic individualism" entrepreneurial behavior, new ventures' network behavior and social capital in digital ecosystems are endowed with new connotations. This study argues that social capital in digital ecosystems refers to the sum of actual and potential resources that new ventures obtain from ecosystem relationship networks. It expands the application context of traditional social capital theory, and the three dimensions of social capital—structural, relational, and cognitive capital—are also endowed with new contextual meanings. To ground this influence, future research needs to further improve the revision and development of social capital measurement scales. Based on exploratory case studies, the applicability of social capital in digital ecosystems should be tested through interview surveys, scale revision, and small-scale testing methods to prepare for large-scale empirical research. Meanwhile, social capital is a neutral resource with both positive and negative effects. This study preliminarily constructs a relationship model between social capital and entrepreneurial opportunities in digital ecosystems. This interaction mechanism needs to be further unpacked regarding how different social capital dimensions affect participants' group identity, knowledge sharing, resource allocation, and innovative behavior within organizations [5], thereby influencing innovation and entrepreneurship outcomes, which requires introducing more research variables or adopting process-oriented research designs to open the black box.

Finally, this study adopts a dynamic opportunity perspective, using changes from "opportunity belief" to "opportunity set" to describe and measure entrepreneurial opportunities, which accommodates both the desirability and con-

tent dimensions of opportunities [19] and distinguishes key stages of the entrepreneurial process [52]. Entrepreneurial opportunity has always been a core issue in entrepreneurship research. For a long time, due to unclear conceptualization of the "opportunity" construct and inconsistent units of analysis in empirical research, entrepreneurial opportunity research has been active but with insufficient progress. With the rise of the digital entrepreneurship wave, digital ecosystems, as a research frontier, provide a new application scenario for deepening and expanding entrepreneurial opportunity research. To comprehensively depict the essential attributes of entrepreneurial opportunities in digital ecosystems, this project adopts a dynamic opportunity perspective, deconstructing the process from entrepreneurs' "idea" to "action" and entrepreneurial opportunities' "formation" to "evolution," and starting from how digital ecosystem characteristics trigger opportunity change patterns to provide targeted insights for digital entrepreneurship. However, in this study, the contextual description of digital ecosystems only proceeds from the whole, making inferences based on core ecosystem attributes. Different types of digital ecosystems, platform ecosystems, and even different evolution stages of ecosystems exhibit considerable differences, which will trigger different underlying logics for new ventures entering platforms or even ecosystems. Future research can select more specific research contexts, such as innovation platforms, transaction platforms, and industrial internet platforms, to examine the relationships between new ventures' platform entry strategies, post-entry network behavior, and opportunity changes, providing more differentiated explanations and continuing to push entrepreneurial opportunity research forward in the digital entrepreneurship context.

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