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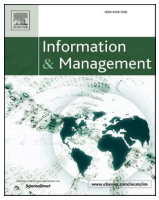

User incentive mechanism in blockchain-based online community: An empirical study of steemit

Zhiyong Liu, Yueping Li, Qingfei Min *, Mengting Chang

Dalian University of Technology, Dalian, China

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ABSTRACT

The rise of blockchain technology has brought innovations in various business domains and spawned a new form of organization—the decentralized autonomous organization (DAO). Steemit is recognized as one of the earliest blockchain-based online communities, and a typical example of DAO. By endowing community members with new roles, the decentralization of blockchain-based communities brings changes to the design of user incentive mechanisms. However, few studies have paid attention to the user incentive mechanism when users play the dual roles of social participant and community owner. On the basis of social capital theory and psychological ownership theory, this study explores Steemit's incentive mechanism by evaluating the impact of these dual roles on user active participation behavior. The study adopts a two-way fixed effect negative binomial regression to test the research model. The results show that users' social capital, share capital, social feedback, and economic feedback positively affect their active participation behavior. At the same time, social feedback and economic feedback play moderating roles on the effects of the dual capitals. Overall, this research provides both theoretical insights and practical implications for understanding, designing, and governing blockchain-based online communities.

1. Introduction

The rise of blockchain has promoted a paradigm shift in organizational structure and spawned a new form of organization—the decentralized autonomous organization (DAO). Hsieh and Vergne defined a DAO as a nonhierarchical organization that performs and records routine tasks on a peer-to-peer, cryptographically secure, public network and relies on the voluntary contributions of its internal stakeholders to operate, manage, and evolve the organization through a democratic consultation process [41]. Bitcoin represents the first implementation of a DAO, and it is the most established DAO to date. Since Bitcoin, there have been over 800 other DAOs created on the basis of a decentralized structure (e.g., La`Zooz and Slock.it). Traditional online social communities are mainly based on centralized platforms and systems. The centralized structure leads to several significant problems, such as inequity between user contribution and revenue, fake news, leakage of user privacy, and unauthorised use of user-generated content. In order to solve the defects of centralized online communities, blockchain-based decentralized autonomous online communities (DAOCs) have been developed rapidly [35]. DAOCs subvert the user participation mechanism in traditional communities, and no central entity has complete control over user-generated content and community management, which inevitably affects user participation behavior. Understanding and facilitating user active participation is critical for the success of both blockchain-based and traditional communities [50, 99].

Steemit is a typical example of the development of DAOs. It has more than 1 million registered users. By designing an unprecedented three-token system (STEEM, Steem Dollar (SBD), and Steem Power (SP)), Steemit rewards users' contribution behaviors, including content production, evaluation, and sharing. Both STEEM and SBD can be sold for real dollars on a token exchange. By January 2021, Steemit had awarded more than $96 million to its users (the market cap of STEEM and SBD). SP plays the role like stock shares: the number of SP held by users will determine the weight of their votes in community decision-making and the shares they earn in the reward pool. Both the decentralized structure and the economic reward mechanism differentiate Steemit by endowing members with a new role as community owners.

From the perspective of social capital, the interpersonal relationship between community members through various forms of interaction contains valuable productive resources which will affect their

* Corresponding author.
E-mail address: minqf@dlut.edu.cn (Q. Min).

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subsequent participation behavior. In blockchain-based communities such as Steemit, members also take the role of owners by holding share-like tokens (e.g., SP). Consequently, this kind of share can be viewed as a productive resource. Users can utilize their shares not only to get dividends but also to have greater psychological ownership in the community. However, it is still unclear whether the share capital will affect users' behavior patterns and further community development.

Their roles as users and owners will encourage blockchain-based online community members to build two types of capital: social capital and share capital. This research aims to study the user participation mechanism in blockchain-based online communities by investigating the influence of these two types of capital on user behavior. This paper intends to answer the following research questions:

(1) What are the differences between a blockchain-based online community and a traditional community?

(2) What is the underlying mechanism of a blockchain-based community and what are the effects of members' dual roles on their active participation behavior in a blockchain-based online community?

(3) In a blockchain-based content community, what are the influences of social and economic incentives and feedback?

This study makes several contributions to the current literature. First, by comparing blockchain-based online communities and traditional online communities, we extend our understandings of DAO communities. Second, on the basis of social capital theory and psychological ownership theory, we explore the influences of social capital and share capital on user participation behavior, as well as the moderating effect of different types of community feedbacks. This study enriches research on the incentive mechanism of online communities. Third, proving the interaction effect between the unique mechanism of blockchain-based communities and the traditional mechanism is an important theoretical contribution of this research. It reveals the relationship between these two types of mechanisms and providing a theoretical basis for explaining and building more complex online communities.

2. Theoretical background

2.1. Blockchain and decentralized autonomous organizations

Blockchain is emerging as a disruptive technology for organizations and society that is facilitating the realization of decentralization, stability, security, and non-modifiability. To conceptualize the rapid development process of blockchain technology, Swan [79] divided blockchain applications into three levels: digital currency, smart contract, and DAO. A DAO integrates organizational operating rules into the blockchain mechanism design, which is a new organization form in that the management and operational rules are typically encoded on blockchain in the form of smart contracts and can operate autonomously without centralized control or third-party intervention. Bitcoin represents the first real-world implementation of a DAO. In contrast to traditional organizations, Bitcoin does not have any headquarters, subsidiaries, or employees but rather a distributed network of users and miners who collect, verify, and update transactions on a shared public ledger that is publicly auditable. Decisions on code modifications are made through community-based democratic voting processes backed by miners' computing power for implementation [41, 59].

Some scholars have defined blockchain social networks (BSNs), which can also be referred to as distributed online social networks (DOSNs) [35] or decentralized online social networks (DOSNs) [36]. Even with different definitions, the characteristics of the blockchain-based online communities are similar, and such communities can be considered as a new type of organization: DAOCs. There are several reasons to adopt this terminology. First, the core characteristic of this new type of blockchain-based organization is decentralization. "Decentralization" most appropriately reflects the unique feature of a DAOC's organization and governance structure. Secondly, "autonomy" reflects the underlying operation mechanism of blockchain-based organizations, which is governed by predetermined algorithms and rules. Finally, social networks focus on users and their interconnections, while online communities focus on organization development. Considering this difference, we believe that blockchain-based applications such as Steemit are not only building online social networks but also online communities.

There are several common characteristics of DAOCs. First, in such communities, there is neither a core authority nor a management layer (i.e., decentralization). As for community governance, DAOCs operate according to a set of predetermined rules and realize autonomous operation, management, and development through a democratic consultation (voting) process among community members [6, 27]. Second, the communities design a series of incentive mechanisms to reward members' contributions, including content contributions, evaluations, and diffusions. The incentive and reward mechanisms are transparent because every user can track and audit transactions [27, 35, 49, 53, 65]. Third, the data in a blockchain are authentic, reliable, and safe, which helps the community to publicly save and share data, thereby facilitating inspection and verification [2, 57, 74]. Fourth, without the consent of all relevant stakeholders, data cannot be edited, erased, or changed. The community is built on permanent records [20, 65, 96].

2.2. Research on blockchain-based online communities

Since blockchain technology is technology that has emerged in recent years, research on blockchain-based online communities is relatively limited. Current research on such communities can be roughly divided into two dimensions, namely the impact of this new business model on user content creation and the effectiveness of token incentives.

With regard to research on the impact on user content creation, Thelwall [83] analyzed the content of posts on Steemit and found that the first posts of members are often self-introductions, indicating that community members generally recognize the importance of social capital. Through topic modeling analyses, Kapanova, Michienzi, Guidi, and Koidl [48] found that while personal mundane information still appears on Steemit, content about blockchain, cryptocurrency, and, more specifically, the Steemit community itself is becoming a very strong presence on the platform. R. Zhang, Park, and Ciriello [98] focused on the information quality of blockchain-based communities. They found that with regard to Steemit, the liquid digital token (STEEM) has no significant impact on information quality, whereas the vested token (SP) and the stable token (SBD) have a positive and significant impact.

Blockchain has also brought a new incentive mechanism to traditional communities, namely, token-based incentives. In a DAOC, the token is a digital value carrier and a proof of rights. The combination of tokens and a blockchain-based community can determine the authenticity and the uniqueness of assets through encryption algorithms and distributed ledgers, circulated through a consensus algorithm [20]. Members get tokens by participating in community activities, use tokens to obtain corresponding rights and interests, and enjoy community growth dividends through the tokens, thereby forming a two-way value co-creation between members and the blockchain-based community. In the research on the effectiveness of tokens, Bae and Cho [3] found that tokens have greater incentive effects among early platform participants, but they found no difference between token-incentivized and non-incentivized drivers among late participants. [47] revealed that a multi-token economy works well during the growing phase but does not function well in a recession. Kim and Chung [49] proposed a process for building a desirable model of a token economy based on the case of Steemit.

On the basis of previous studies, we find that the current research on blockchain-based communities focuses mainly on user content and less on other dimensions of user active participation (such as posts, votes, comments, etc.). Furthermore, the research methods used are mostly

text analysis related methods and case studies, and there are few empirical studies based on real platform data. Therefore, it is necessary to conduct further empirical research on the active participation behavior of users in blockchain-based online communities.

In order to further clarify the difference between a blockchain-based community and a conventional community, we select two communities that are currently well developed for comparison, namely Steemit and Reddit, as shown in Table 1.

Reddit is a typical conventional online community with millions of users and extensive influence. The Steemit and Reddit communities are functionally similar to each other. Users can post articles, build connections, give likes, and comment on the platform. However, the mechanisms underlying the operation of the two communities are very different. Therefore, a comparison of a blockchain-based community and a conventional community in terms of concept, organization type, incentive mechanism, and so forth is provided below to enrich our understanding of blockchain-based online communities.

Regarding the user incentive mechanism, both Reddit and Steemit have adopted a mechanism to evaluate the value of user contributions based on voting points and reputation score. Karma is an important indicator that reflects the level of user contributions in Reddit. Users can "like" or "dislike" on the basis of their evaluation of posts or comments, each like or dislike leading to an addition or reduction, respectively, of one Karma point. In Steemit, a reputation score is used to measure the value that users bring to the community. Unlike the "one user, one vote" system in Reddit, Steemit implements a "one SP, one vote" system. When user A "likes" user B's post or comment, user B's reputation will increase. The more SP user A has, the greater the effect of A's like vote will be and the more B's reputation will increase.

As for economic incentives, Reddit uses a "gold-plated" user reward mechanism in which users can choose to grant Reddit gold coins to the author of a good article. Each gold coin costs $3.99. However, this reward money wholly comes from other users, and the platform will not pay for the author's contribution. What Steemit has adopted is a comprehensive system of incentive mechanisms based on three tokens. The system identifies user contributions (postings, likes, comments) through community voting and distributes corresponding rewards in the form of tokens. In addition, STEEM and SBD can be exchanged in the secondary market for legal tender. The more SP users own, the more influence they have on voting for content evaluation and the more content rewards they can get. Steemit and its users have formed a better value co-creation process with a fair profit distribution mechanism.

2.3. User participation in online communities

User participation can be mainly divided into active participation and passive participation [70]. Researchers have further classified user participation into three dimensions: cognition, emotion, and behavior [38]. The cognitive dimension mainly refers to the user's interest in or attention to a specific object, and the emotional dimension describes the pride or a certain sense of motivation caused by a specific object. The behavior dimension refers to the actual behavior of users. Since this study focuses on the impact of community mechanisms, it pays more attention to the behavior dimension. According to previous studies, active participation behavior in communities is generally summarized into two categories. First, content contribution, which refers to original articles, videos, and other content that members actively publish, although some scholars also regard comments and likes as content-related participation behavior. Second, community participation, which refers to the interpersonal communication between members, such as discussing group issues and participating in or even holding community activities [93]. Passive participation is also known as diving behavior [21], which refers to simply viewing and reading the information in the community on online platforms.

Studies have pointed out that although a large number of "divers" may increase the popularity of an online community by increasing the number of visits and clicks on the website, they may not necessarily contribute to the success of the community in terms of content contribution [73]. Online community studies have shown that the active participation of users will lead to positive organizational output, such as promoting the spread of new products [84], enhancing customer loyalty [40], strengthening the commitment and reputation of the brand [30], improving perceived revenue [28], and commercializing monetization by using the network traffic from participation [42]. In general, the success of an online community depends largely on the active participation of its users. The existing literature has investigated user participation in various communities, including online Q&A communities, online travel communities, and B2C e-commerce communities.

Existing studies discuss various antecedent factors of active participation. First, *personal characteristics*. Current research focuses on the impact of users' extrovert personality, computer skills and willingness, educational background, and work experience on participation behavior [45, 62]. Nov et al. [62] found that extroverts are more inclined to socialize, share, and express opinions on the Internet. Second, *motivation*. Studies in this area mainly start from the perspective of users and emphasize the subjective state of users. Scholars have emphasized that understanding user motivation is a key issue for analysis because online community participation may be motivated by multiple motivations [31]. Studies have shown that participation motivation may vary depending on the type of community [78]. In Wikipedia, altruism and ideology are important driving forces [61]. Xu and Bailey [92] suggested that in the online photography community, users are actively involved in instrumental motivations, such as building relationships with other photographers. In addition, in the study of knowledge sharing behavior, benefits and costs are widely discussed as influencing factors. Social exchange theory shows that the cost-benefit ratio is the main driving force of social exchange. The lower is the cost-benefit ratio, the more active users' social activities are [24]. Third, *network characteristics*. Driven by Web 2.0, most knowledge communities have integrated the elements of a social network service and achieved great success [95]. Cross and Cummings [25] showed that for users of online communities, the number of social relationships and the quality of interpersonal relationships are directly related to the quality and quantity of their knowledge contributions and can enhance their perception of the usefulness of shared knowledge in the community. Burke, Marlow, and Lento [11] showed that users' posting behavior will be affected by their friends' posting behavior. The more feedback a new user receives for the first time, the more likely he/she is to continue posting. This group of studies explains active participation behavior from the perspective of the relationship between users.

Fourth, *mechanism design and policy*. Research in this area often involves the motivation of users as well, but it mainly starts from the perspective of community managers and emphasizes the design of mechanisms. In the research on the effects of rewards and incentives on participation, noneconomic incentives (such as a reputation reward mechanism) are considered to be the most effective incentives [64, 82]. Some studies have focused on exploring the impact of community status and badge mechanism on user active participation [44, 54, 81, 97]. Some researchers believe that as a typical gamification design, a status-level mechanism, such as badges, can enhance the user's sense of achievement and hedonic value [76, 77], as well as being an important manifestation of personal image [18]. Goes et al. [33] found that glory-based incentives may motivate users to contribute more before goals are reached. In the research related to community interaction, scholars have focused their research on the vote, comment, and follow mechanism [16, 29, 71]. The more feedback received from the community, the higher the user's perceived connection and the stronger their sense of belonging to the community, which in turn will affect their active participation behavior positively [16, 72]. Finally, in the research on economic incentives for user participation, Dong et al. [29] concluded that tangible virtual rewards (such as an electronic coupon, etc.) are important economic drivers of contribution behavior. However,

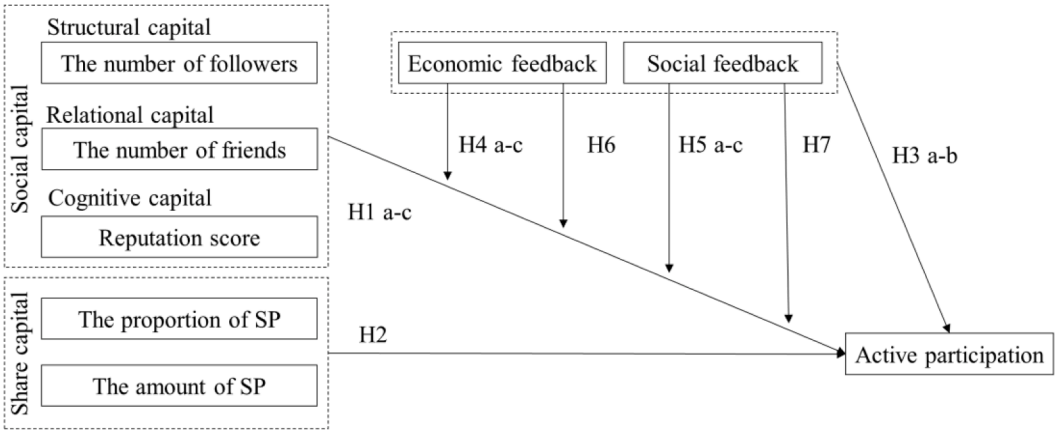

Fig. 1. Research Model.

the results of the discussion on the impact of economic incentives are not consistent. Most studies confirm that economic incentives increase content contribution and diversity but do not improve the quality of articles [12, 43].

On the basis of the summarization above, we believe that the social capital formed by the interpersonal relationships of community members is one prominent antecedent of user participation in online communities. This kind of social ties creates emotional and informational reciprocity among members [34]. The increase in users' social capital can enhance the motivational incentives of peer recognition while boosting the prosocial motivation of opinion leadership to contribute content in virtual communities [18, 29].

2.4. Social capital theory

In Bourdieu's social capital theory [9], social capital is the collection of real and virtual resources embedded in a person's continuous social network, the amount of which depends on the size of the network and the total amount of different types of capital (such as economic capital, cultural capital, symbolic capital). Nahapiet and Ghoshal [56] elaborated and differentiated the theory and defined social capital as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit." The central proposition of the theory is that networks of relationships constitute a valuable resource for the conduct of social affairs [9, 94].

The measurement of social capital is one of the focuses of relevant research on the theory. The three-dimensional measurement proposed by Nahapiet and Ghoshal [56], which divides social capital into structural capital, relational capital, and cognitive capital, is currently widely adopted. Structural capital refers to the overall network structure of the connection between individuals, which is the basis of social capital. Relational capital refers to the interpersonal relationship formed through historical interaction with others; this interpersonal relationship can be regarded as an asset. Cognitive capital refers to those resources providing shared representation, interpretations, and systems of meaning among members (such as shared language, professionalism, etc.) [34].

In recent years, with thsse rapid development of online communities, social capital theory has been used to explain the internal mechanisms of various pro-social behaviors, including knowledge-sharing behaviors, community participation, and knowledge consumption (as shown in Table 2). When studying user participation in social networks, Chen et al. [17] considered the influence of relational capital, such as community identity, perceived member reciprocity, and perceived member trust, but not that of the other two types of capital. Most of the existing studies used the survey method to measure social capital.

In a blockchain-based online community, members can form social capital through interpersonal relationship building in various interactions, such as content sharing and topic discussions. This kind of social capital is a valuable resource which affects members' subsequent participation. Therefore, on the basis of previous research, this paper proposes that the social capital accumulated by users in a blockchain-based online community will have a positive impact on their active participation behavior.

2.5. Psychological ownership theory

Psychological ownership is defined as a psychological state and refers to the "state where an individual feels as though the target of ownership or a piece of the target is 'theirs'" [66]. Users may have a sense of ownership of objects such as property or cars, but these perceptions are not limited to tangible objects. The concept of ownership was originally proposed from the legal perspective when it was observed that employees could psychologically "own" their working organization; scholars later extended the concept of ownership into the psychological dimension [88]. Management scholars have further extended the use of the concept to the context of organizational behavior [68].

Building psychological ownership includes both cognitive processes and emotional processes [32, 67, 87]. An individual's intellectual perception reflects their cognition of the ownership goal and their emotional connection with it [66]. Pierce et al. summarized three ways of generating psychological ownership: *perceived control, intimate knowledge*, and *self-investment*. First, the individual will regard the object they control as part of themselves or their extended self because control of the goal will produce a feeling of owning it. Second, due to the intimate relationship between the individual and the target, they will feel a sense of ownership. Third, they will invest time, energy, and mental energy into the target. In addition, psychological ownership can meet the basic needs of humans for efficacy, self-identity, and sense of belonging [66].

Previous studies have shown that when higher psychological ownership is generated on an organization, employees' commitment and job performance are higher. By studying psychological ownership within organizations, scholars have found that psychological ownership has a positive impact on organizations [63]. Pierce and O'Driscoll [68] believed that when employees have higher psychological ownership, they are more likely to have a positive influence on the organization's development than other employees and are willing to share more responsibilities for the organization.

In the management literature, employees' psychological ownership has mainly been studied from their perspective about participating in an employee stock ownership plan (ESOP). An ESOP is a plan that provides employees with an ownership interest in their company, allowing them

to hold a certain percentage of the company's internal shares. Enterprises expect to promote their management's effectiveness and improve their performance through such incentive mechanisms.

In Steemit, a community-designed token incentive mechanism allows members to hold shares (SP). When community members hold SP, they can obtain three rights that are similar to company shares: (1) *right to earnings*—15% of the tokens in the STEEM blockchain will be proportionally awarded to members who own SP; (2) *right to information*—shareholders can be involved in the supervision, management, and governance of the community, making suggestions, or consultations; (3) *right to control*—when voting (likes and dislikes) on posts/comments, the more SP held by the user, the greater the weight of their votes. Therefore, the SP held by users in Steemit can be regarded as a valuable productive resource, referred to as share capital. The share capital (legal ownership) held by users will also have a significant impact on their active participation behavior.

3. Research model and hypotheses development

This study integrates social capital theory and psychological ownership theory to explain the incentive mechanism of DAOCs and its impact on user active participation behavior. The theoretical model is presented in Fig. 1. Specifically, on the basis of the roles of online community members, we propose that users can build social relationships and consolidate their social position (i.e., obtain social capital) in the Steemit community. Being given the role of owners, users can obtain economic rewards and become involved in the community's governance by earning and owning SP, which is regarded as holding a kind of share capital. These two types of capital will in turn affect users' attitudes and behavior towards the community. In addition, the number of rewards (social and economic feedback) will also play a moderating role.

3.1. Social capital and user active participation

Social capital refers to the collective resources emerging from and embedded inside a social network as a result of the interconnected relationships of its members [56]. The foundation of structural capital is social interaction, which reflects the structural characteristics of individual social networks. Nahapiet and Ghoshal [56] believed that "the fundamental proposition of social capital theory is that network ties provide access to resources." Wang, Gill, Mohanla, Zheng, and Zhao [89] believed that Weibo users with more fans have more structural capital; such users will receive more likes and readings and are more likely to attract attention. Steemit possesses the characteristics of a social network in which members can access what they are interested in by actively following others. In other words, members can share and spread content through their social connections, which attract more readers and votes for themselves and their content. Therefore, users form a social network by being followed and following others in the Steemit community. Kang, Jiang, and Tan [46] verified structural capital on the basis of the number of crowdfunding project advocates and argued that it has a significant positive impact on the amount of funds raised and the financing performance of a project. Therefore, in this study, we choose number of followers as an indicator to measure users' structural capital and hypothesize as follows:

H1a: The amount of structural capital owned by users will have a positive impact on their active participation in blockchain-based online communities.

The relationship dimension of social capital refers to the interpersonal relationships of participants in social interactions (e.g., trust and reciprocity). Since members are usually anonymous in Steemit, the reliability of other user actions and commitments cannot be guaranteed. Scholars have found that the higher the emotional connection of the group, the more willing individuals are to participate in group-level interactions and share information [56]. Chen et al. [17] believed that when the relational capital between individuals and other members of the community is high, it will encourage them to contribute knowledge actively. Yan et al. [94] also showed that number of friends (mutual following) has a positive impact on the quantity and quality of users' knowledge contribution in the community. Therefore, we hypothesize as follows:

H1b: The amount of relational capital owned by users will have a positive impact on their active participation in a blockchain-based online community.

Cognitive capital refers to the resources that can achieve a common interpretation and meaning in a collective [90]. A meaningful knowledge exchange requires at least some degree of mutual understanding between different parties [56]. Wasko and Faraj [90] used expertise to represent cognitive capital. Cognitive capital can help individuals understand common goals and visions in the community. Researchers have found that users with higher cognitive capital are more likely to provide useful suggestions in online communities than those with lower cognitive capital [90]. Besides, in a knowledge community, the user will only be able to contribute if he/she reaches the required knowledge level. In Steemit, the cognitive capital of users can be measured by their reputation scores. The reputation score, determined by the number of votes obtained from previous posts, reflects a general evaluation of a user's knowledge level. Therefore, users with high reputation scores are more likely to share content with other members.

H1c: The amount of cognitive capital owned by users will have a positive impact on their active participation in blockchain-based online communities.

3.2. Share capital and user active participation

A large number of studies in the field of management have pointed out that ESOPs have a positive impact on employee performance and corporate development [5, 23, 39]. Kramer [51] compared the personal sales of the employees of more than 300 companies in the United States that had either implemented or not implemented an ESOP and found that the average sales of employees holding share capital increased significantly. Pierce, Rubenfeld, and Morgan [69] proposed the positive effect of ESOPs on employees' organizational behavior and pointed out the mediating role of psychological ownership. Similar to ESOPs, some blockchain-based online communities have already designed an equity mechanism so that members can hold shares (such as SP) and enjoy the corresponding rights. Therefore, we claim that the share capital in a blockchain-based community refers to the shares held by users in the community, which determines the rights owned by users and triggers their psychological ownership. The amount of share capital held by users enhances their commitment to the community and strengthens their owner role [98]. According to the possession theory, members with psychological ownership will take action to maintain and support community development.

In addition, a DAOC does not have any authority in the community, which means that it is actually owned by the members who own shares. The benefits and risks of holding share capital are similar to those of holding shares in a traditional company. On the one hand, holding SP can bring stable dividends. On the other hand, SP cannot be directly exchanged for fiat money. Therefore, the amount of share capital reflects the commitment and long-term expectation of users in the community. This study adopts the number of shares (SP) held by members and the proportion of shares (SP) in their total assets as two indicators of share capital.

H2: The amount of share capital owned by users will have a positive impact on their active participation in blockchain-based online communities.

3.3. Social feedback and economic feedback

In Steemit, the incentive mechanism provides two forms of rewards to community contributors, namely social feedback and economic

feedback. Social feedback refers to positive feedback, approval, and status improvement from social relationships. Studies have shown that social feedback such as upvoting will be internalized into positive psychological results (such as enjoyment, a feeling of competence, and recognition of abilities), which in turn will affect users' continued participation and contribution behavior [16, 29, 71]. Economic feedback refers to the distribution of monetary benefits from the community based on user contributions. The positive feedback that users receive from the community reflects peer recognition to a certain extent [18, 29].

Many studies have confirmed that feedback can encourage user contribution behavior. Using empirical data on social media, Brzozowski, Sandholm, and Hogg [10] found that new users who receive feedback tend to contribute more. Macy's research indicated that if a user's first post gets a positive review, he/she may soon contribute a second post [55]. Rui and Whinston [75] found that users seek information and attention on Twitter and that the information-sharing behavior of users is greatly affected by the number of followers. Guan et al. [34] found that the more positive feedback users receive, the more likely it is that they will continue to participate in community activities.

Since voting is the main form of content evaluation and approval for contributors in Steemit, this study uses number of votes to measure the received social feedback. Rewards for posting and voting are used to recognize user active participation in community contributions. Byron and Khazanchi [13] conducted a meta-analysis of 60 empirical and nonempirical studies to analyze the relationship between the rewards received by users and their creativity, and they concluded that positive feedback can promote user creativity. Reciprocity theory and reinforcement theory both suggest that feedback can affect members' subsequent behavior [34]. In other words, the more positive feedback users receive, the more likely they will be to continue participating in community activities.

H3a: The social feedback received by users will have a positive impact on their active participation in blockchain-based online communities.

H3b: The economic feedback received by users will have a positive impact on their active participation in blockchain-based online communities.

Most of the content of online communities comes from members' posts, comments, and other behaviors. Contributors are not rewarded directly by the community, and there is no direct value recognition from the community. However, in Steemit, the main purpose is to motivate users who contribute quality content, and so the economic feedback can be considered as the community's recognition of user value. The posting rewards received by users are mainly determined by other members' voting, and the amount of economic feedback is calculated by the underlying algorithm, that is, economic feedback = (number of votes × weight/weight of all articles at the same time) × the total value of rewards issued by the community. Therefore, in addition to being an economic incentive, economic feedback can also be a kind of value recognition.

Users with social capital intend to interact with others by posting and use their expertise to help individuals understand the common goals and visions of the community, thereby enhancing their status in social networks and gaining a higher social position [14, 15, 22, 34]. When a user receives high economic feedback, it indicates that the community recognizes their contribution and shows their influence; it also further strengthens the user's motivation to participate by increasing their social capital. Furthermore, users who receive high economic feedback benefit from extensive social connections and the maintenance of interpersonal relationships within the community. Therefore, compared with users who receive low economic feedback, users who receive high economic feedback will strengthen the positive impact of social capital on their active participation behavior.

On the other hand, economic feedback is an economic incentive. Users holding share capital try to obtain higher economic benefits by actively participating in community activities as they have a higher economic tendency [29, 37]. Therefore, when users receive higher economic feedback, it will strengthen their willingness to participate.

H4 (a-c): The impacts of social capitals (structural/relational/cognitive) on active participation behavior are positively moderated by economic feedback.

H6: The impacts of share capital on active participation behavior are positively moderated by economic feedback.

The positive social feedback received from other members represents the level of recognition and the popularity of a user's posts and shows the user's social status and reputation in the community. Many studies have shown that recognition from other users is an important factor to motivate users to contribute knowledge to the content community ([16, 18]), and the degree of recognition can positively affect members' contributions [29, 71]. The social capital of members is accumulated through interactions with other members, and the share capital comes from their own input. Therefore, we believe that a user's social capital is based on relationships, while share capital is based on the individual.

As regards the capital based on relationships, users hope to show their self-image better by establishing more social ties [18, 71, 85]. Social feedback can amplify the internal utility that users obtain in the contribution process: that is, when the content contributed by users receives more upvotes and recognition, users can get more psychological rewards from the self-expression process [80, 85]. Therefore, users who receive high social feedback will strengthen the positive impact of social capital on their active participation behavior.

From the perspective of the signal theory, social feedback may also have a moderating effect on the impacts of social capital and share capital. Users with higher economic tendencies will focus on economic feedback. Users receiving high social feedback will stimulate their sense of owner role and enhance their responsibility for the community. That will bring more quality and generous contributions and inhibit shortsighted and benefit-seeking behaviors that weaken the impact of share capital (Yan, Lini, Ni, & Hong, 2019). Therefore, when users receive social feedback, they will associate these social benefits with the results of active interactions rather than with share capital.

H5 (a-c): The impacts of social capitals (structural/relational/cognitive) on active participation behavior are positively moderated by social feedback.

H7: The impacts of share capitals on active participation behavior are negatively moderated by social feedback.

4. Research method

4.1. Background

Steemit is a content-sharing community built on a blockchain. It was launched in 2016 and had more than 1.3 million users in 2020. Compared with traditional communities, in addition to being a decentralized community, Steemit adopts an economic incentive mechanism based on tokens and provides a fair reward system to identify user contributions, encouraging them to participate in the community. The three tokens used, namely STEEM, SP, and SBD, are designed for different purposes.

STEEM: STEEM is the basic token in the community and the foundation of all tokens. The STEEM token is a liquid token that users can transact as a form of payment or trade for other external tokens, cryptocurrencies, and fiat money, such as US dollars.

Steem Power (SP): SP is positioned as a share or stake, and it is also a token that measures the influence of a user in Steemit. SP is a kind of long-term investment because it cannot directly trade in the secondary market. Converting SP to STEEM takes 13 weeks.

Steem Dollar (SBD): SBD is a stable token pegged to the value of the US dollar that can be viewed as a form of debt with a relatively static value. SBD can be directly converted into fiat money and can also be used to purchase goods directly (e.g., through PeerHub.com). One

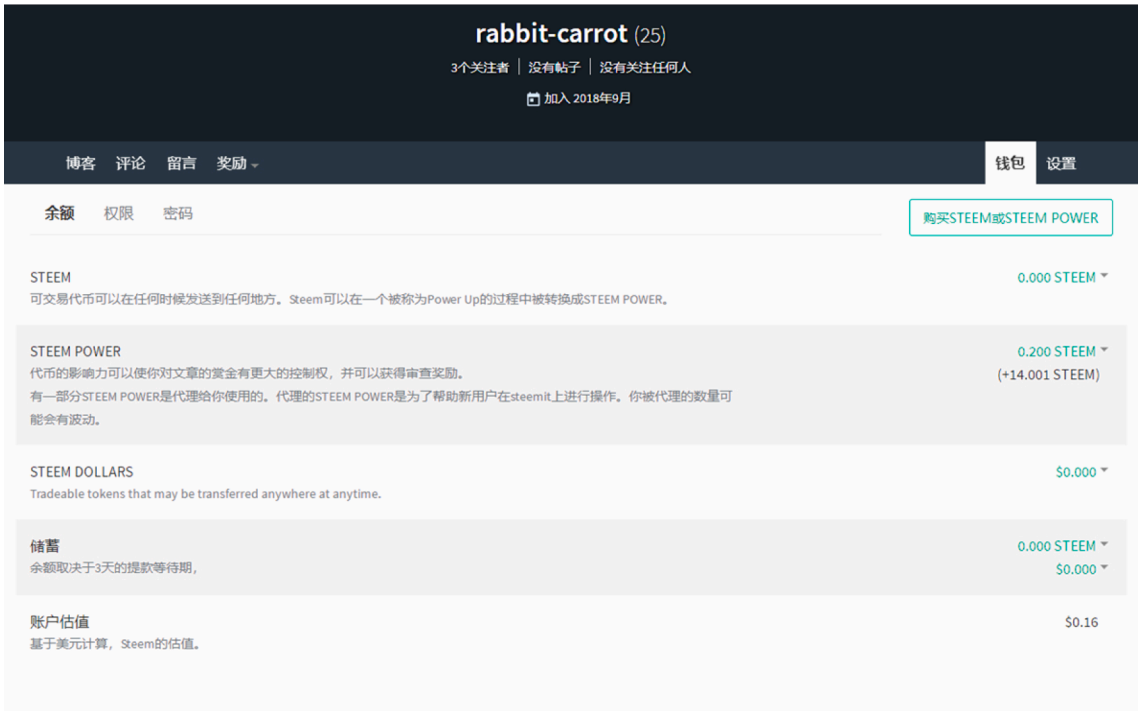

Fig. 2. Example of a Steemit User's Wallet Profile.

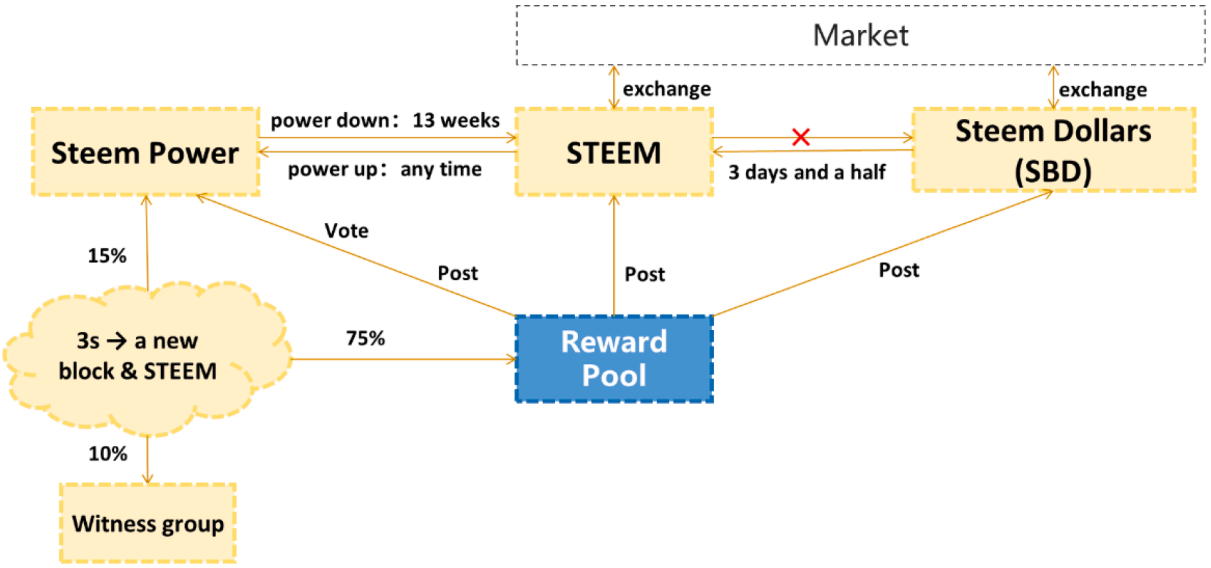

Fig. 3. Steemit Economic Ecosystem (from Steemit whitepaper).

Steemit user's Wallet Profile is shown in Fig. 2.

To handle rewards, the STEEM token is set at a 9.5% annual inflation rate (meaning that the number of issued tokens increases by 9.5% annually). It is estimated that over the period from December 2016 to 2030, about 800 million STEEM tokens will be released. In the blockchain of Steemit, a block is generated every 3 s and a certain number of STEEM tokens are released. These STEEM tokens are divided into three parts:

- 75% enter a reward pool, which will be distributed to users who post articles, write comments, and/or give likes on articles. The amount of revenue a user gets from posting articles depends on the number of users who upvote him/her and the number of SP held by the users who upvote him/her. Users who have more SP likes will bring more benefits to the author. At the same time, users who give votes and comments can also get a share of benefits.
- 15% of the tokens are awarded to users who hold SP.
- 10% of the tokens are awarded to data nodes in Steemit, who are similar to the miners in Bitcoin.

Users can get certain tokens for posting, voting, and commenting, and the tokens can be exchanged for fiat money in the secondary market. The economic ecosystem of Steemit is shown in Fig. 3.

STEEM and SBD are listed and exchanged freely, while SP is not exchanged on the external markets. Users can always transfer from STEEM to SP ("powering up") or from SP to STEEM ("powering down") according to the ratio of the amount of STEEM they hold to the total amount of SP. SP and SBD are designed to take 13 weeks and 3.5 days,

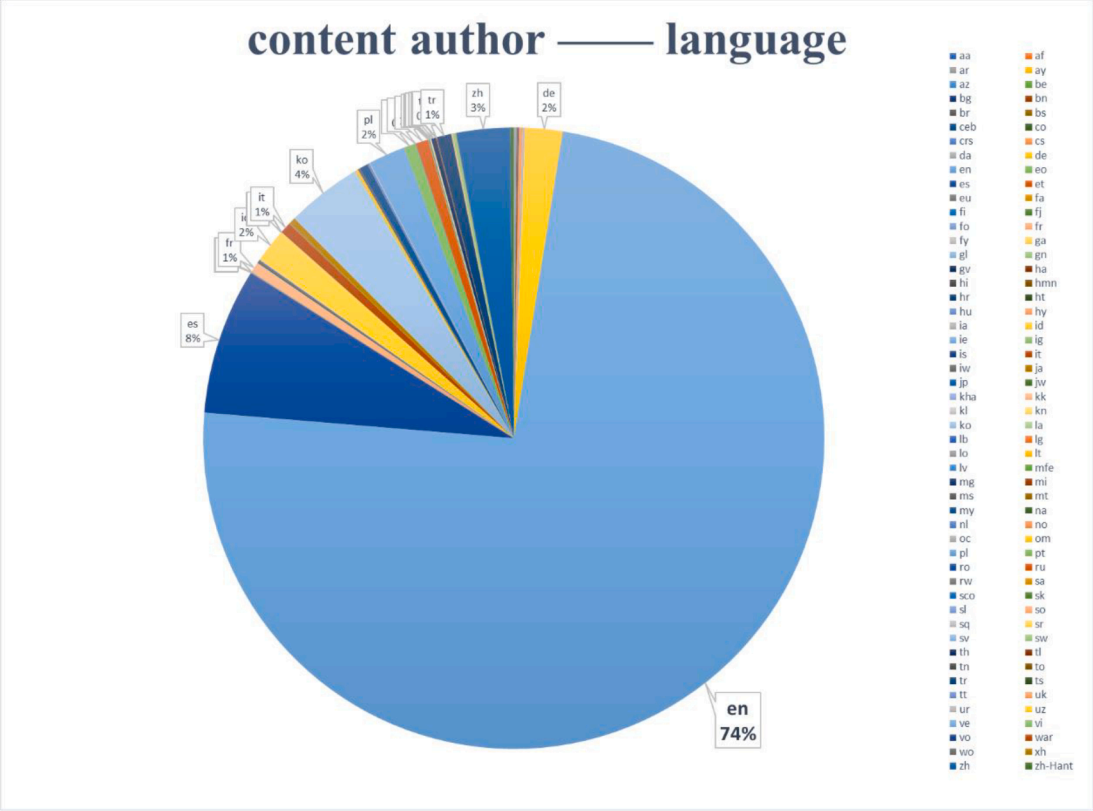

Fig. 4. Distribution of Language Usage in Steemit.

respectively, to be transferred to STEEM, partly to prevent opportunistic-behavior-related timing. Since SP cannot directly trade in the secondary market, users who have more SP indicate that they have more confidence in the community, and the community will also amplify the user's privileges, such as giving them more voting power (making their vote more influential) and additional dividends.

From the perspective of investment, the success of the community means an increase in the number of users and an improvement in word of mouth and popularity, which reflects an increase in community value. This in turn leads to an increase in future returns for users and an increase in the investment value of the community. As SP represents user equity, its investment value depends on the long-term development of the community. Therefore, the success of the community will increase the value of SP, and the proportion of SP in users' wallet portfolios reflects the level of their future expectations, long-term investment intentions, and commitment to the community.

4.2. Data collection

Steemit is one of the earliest social communities built on the blockchain. In the past two and a half years, it has held the leading position. In addition, the STEEM token has the highest market value among all the cryptocurrencies issued by blockchain-based social network projects. Therefore, we choose Steemit as our data source to verify the model.

The advantages of Steemit are as follows. First, compared with other blockchain-based online communities, Steemit has a large number of users and user activities. As of March 2019, Steemit had over 1.2 million registered users and 200,000 monthly active users. Therefore, we can obtain bigger samples from Steemit and avoid the bias caused by sample selection. Second, Steemit covers a wide range of topics. There are various subsections under the main section of Steemit, including a professional subject knowledge section and a social hot event section, so users with different knowledge backgrounds can be attracted to participate in the community. This richness of content and members can enhance the generalizability of this study greatly. Third, the openness of Steemit data: In Steemit, the posts, comments, and likes; the revenue of each post; and the distribution of the three cryptocurrencies are displayed on the personal homepage. In addition, community transaction data are recorded on the underlying blockchain, and the openness of Steemit's user data facilitates the collection of data for empirical research.

This study uses Steemit's public database Steemsql to capture panel data of users for 11 weeks from March 4, 2019, to May 20, 2019; the initial number of users is 80,000. After checking the recent community activity records of each user, users who did not post in the previous three months are deleted. At the same time, users whose registration time is later than March 4, 2019, are also deleted. The final data set contains a total of 25,466 users.

We collect users' participation data from their profiles. The profile includes each user's demographic (such as name and introduction), network (following and followers), contributions (postings, comments, etc.), reputation, and account data.

4.3. Measures

The measures of active participation are different in various communities. Previous research has shown that the core of online communities is information sharing and active participation, which can be measured by the number of posts [60, 70]. Since Steemit is a content-based community, this study chooses the number of user posts to measure the level of active participation.

For the measurement of social capital, this study chooses the measures that have been verified by previous scholars. Structural capital reflects the characteristics of a network's structure. The core structure of a community social network consists of social ties which are formed by following a user [26, 91]. The more followers a user has, the more

Table 1
Comparison of a Blockchain-based Community and a Conventional Community.

			Blockchain-based Community (Steemit)	Conventional Community (Reddit)
Difference	Community concept		Identify everyone's contributions through community voting and give them corresponding token rewards to encourage the production and spread of premium content	Putting fresh events and hot events on the homepage through community voting
	Organization type	Organization structure	Decentralized autonomous community	Centralized content community
		Operation rule	Preset rules Democratic consultation and autonomous operation	Platform development Moderator and administrator operation
		Information storage	On the blockchain Cannot delete or modify High security	On the external server Can be deleted or modified Low security
	Underlying technology		STEEM blockchain	Amazon Web Services
	Economic profit		Content contributors, value discoverers (voters), SP holders	Platform, very few users
	Community power structure		Equal rights based on shareholding	Higher rights given to those in positions of high authority
	Incentive mechanism	Economic incentive	Token incentive mechanism	User reward mechanism
		Noneconomic incentive	Visual reputation score incentive	Visual point incentive
Similarity			Social community based on user-generated content	

closely the user moves towards the core structure of an online community [1, 7]. Therefore, we choose number of followers as an indicator of structural capital, which is consistent with previous research [34, 46, 94]. As for relational capital, social networks and social media-related research [8, 25, 86] have indicated that when individuals choose to care about each other, they tend to trust each other and are willing to interact for mutual benefit. Therefore, we measure relationship capital by counting the number of bidirectional connections between users, which is consistent with [94]. As for cognitive capital, Wasko and Faraj [90] used expertise to represent the cognitive capital; in Steemit, expertise is represented by the reputation score.

In addition, some control variables are added to the model. First, the tenure of the user: In the literature, tenure is one of a few potential determinants of knowledge contribution that are generally considered [90]. Second, since Steemit is a blockchain-based community, the price of the base token STEEM in the secondary market represents the value and prospects of the community in users' minds. Therefore, we add the exchange rate of STEEM to the US dollar as a control variable. Third, the amount of STEEM and SBD held by the user: The amount of these two

Table 2
Research on Social Capital.

Research	Research Context	Data collection	Research focus	Research result
[22]	Online Q&A Community	Survey	The influence of social capital on the quantity and quality of knowledge sharing	Social interaction, reciprocity, and identification increase the amount of personal knowledge sharing, but not the quality of knowledge. Trust does not significantly affect the amount of knowledge sharing.
[17]	Social networking sites	Survey	Relationship capital's impact on users' continuous participation	Community identity directly promotes the continuous participation of members. Perceived member trust and perceived member reciprocity indirectly affect the continuous participation through the mediating role of community identification.
(Chen, Ma, Wei, & Yang, 2020)	Online content community (WeChat official accounts)	Survey	The impact of structural capital, relational capital, and cognitive capital on seeking and sharing information	Trust, perceived similarity, and social interaction have a positive impact on seeking information and sharing comments in WeChat official accounts activity.
[58]	Online brand community	Survey	The impact of cognitive capital on active participation	Users' expectations of enhanced professional knowledge are directly proportional to their contribution to the community.
[94]	Online user community	Archive of online activities	The two-way relationship between social capital and knowledge contribution	There is a two-way relationship between social capital and knowledge contribution between users at the secondary participation levels. For users at the core participation level, their knowledge contribution is not mainly caused by the social capital they own in the community.

Table 3
Variable Measurements.

Variable type	Variable	Measure item	Description
Dependent variable	Active participation	$post_{it}$	The number of posts provided by user i during period t
Independent variable	Structural capital	$follower_{it}$	The number of followers of user i from registration to current period t
	Relational capital	$friend_{it}$	The number of friends of user i in time period t (following each other)
	Cognitive capital	$reputation_{it}$	Reputation score of user i in time t
	Share capital	sp_num_{it}	The number of SP held by user i during time t
		sp_pro_{it}	The proportion of SP held by user i during t period to all of its assets
Moderating variable	Social feedback	so_fe_{it}	The number of likes received by user i during time t
	Economic feedback	eco_fe_{it}	The economic return of user i's posts at time t
Control variable	Tenure	$tenure_{it}$	Number of weeks since user i registered
	Token price	$steem2usd_t$	Exchange rate of STEEM to US dollars during time t
		$steem_{it}$	The number of STEEM held by user i during time t
		sbd_{it}	The number of SBD held by user i during time t
		get_flag_{it}	The number of dislikes received by user i during time t
		$flag_{it}$	The number of posts that user i disliked during time t
	Social learning	$following_{it}$	The number of followees of user i from registration to current period t
	Self-disclosure	$self\_pre_{it}$	The amount of personal information displayed by user i during time t

currencies in the user's wallet represents two investment preferences to a certain extent; STEEM represents high risk and high return, while SBD benchmarks against the US dollar, which has good stability and represents low risk and medium return.

In addition, this study uses "the number of get_flag" and "the number of flag" in Steemit as control variables, for the reason that when a user's post receives a "flag" (the same as "dislike"), it may be given to the user with negative feedback; as a result, the user's willingness to post may also be changed. "The number of flag" represents the number of users who dislike other users' posts. This kind of behavior also contributes to the good environment of the community. Therefore, we believe that the "number of flag" will also have a certain impact on the active participation of users. Finally, we also include social learning and self-disclosure as control variables. Social learning is the result of observing the behavior of others [29]. Individuals who accumulate more and more abilities through social learning can connect with their own knowledge systems more easily and may further increase their productivity. Self-disclosure refers to the amount of personal information disclosed by users in the community, including image, location, and external social networking information; to a certain extent, it reflects the user's level of commitment and sense of belonging. Variable measurements are shown in Table 3.

We conduct the descriptive statistical analysis and correlation analysis on the processed data. As shown in Table 4, users publish an average of 1.94 posts per week, while the most active user provide 398 posts in a week. In addition, we can see that the horizontal distribution of the data is wide, and the variables have large variances (such as the number of user posts, friends, followers, SP, likes, STEEM, and SBD) and tend to shift to the right, which may affect the accuracy of the data analysis. We adopt the logarithmic process for variables with large variances to uniform the magnitude of variables.

The results of the correlation analysis are shown in Table 5. The correlation coefficients of each variable are relatively small, all less than 0.5, indicating that there is no strong correlation between variables. In addition, to further test whether the problem of multicollinearity exists, we conduct a variable expansion coefficient test and find that the distribution range of the VIF values is 1–2.39, which is far less than 10. Therefore, we believe that there is no serious multicollinearity among the variables.

4.4. Model Specification and Estimation

The dependent variable is measured by the number of posts, a nonnegative count variable. In this case, Poisson regression or negative binomial regression can be adopted to analyze the data [4]. However, the Poisson model requires satisfying the premise that the mean and variance of variables are equal, but this requirement could not be met in this study. Therefore, we choose a negative binomial model to explore the active participation behavior of users in Steemit.

After conducting a Hausman's specification test on the estimation model, we find that the fixed-effects model is appropriate ($p < 0.001$). Time fixed effects should be considered in this case, which aims to solve the problem of omitted variables that do not change with individuals but change with time. Therefore, time dummy variables are added to the model, and the joint significance of dummy variables is simultaneously tested. We then conduct the Wald test on the model; the result significantly rejects the null hypothesis of "no time effect" ($p < 0.001$), and so the time effect should be considered in the model.

Table 4
Descriptive Statistics.

variable	obs	Mean	Std. Dev.	min	max	VIF	1/VIF
post	280,126	1.94	4.59	0	398	Mean VIF=1.55	
follower	280,126	619.66	1723.75	0	102,022	1.86	0.54
friend	280,126	116.75	721.76	0	42,882	2.39	0.42
reputation	280,126	46.12	14.36	−15.20	84.56	1.8	0.56
sp_num	280,126	1753.41	35,070.49	0	5,484,764.5	1.95	0.51
sp_pro	280,126	0.74	0.34	0	1	1.29	0.77
so_fe	280,126	114.11	524.22	0	29,372	1.28	0.78
eco_fe	280,126	10.69	81.51	0	7510.63	1.46	0.69
tenure	280,126	55.74	34.30	0	163.43	1.64	0.61
steem2usd	280,126	0.42	0.06	0.32	0.52	1.01	0.99
steem	280,126	108.99	2361.75	0	300,745.91	1.88	0.53
sbd	280,126	21.82	318.82	0	47,279.28	1.33	0.75
get_flag	280,126	0.56	23.34	0	7435	1	1
flag	280,126	0.33	37.64	0	14,334	1	1
following	280,126	506.18	6230.60	0	442,839	2.01	0.5
self_pre	280,126	2.54	1.48	0	4	1.29	0.78

Table 5
Correlation Matrix*4.4 Model Specification and Estimation.*

Variables	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
V1 *follower*	1														
V2 *friend*	0.486	1													
V3 *reputation*	0.329	0.089	1												
V4 *sp_num*	0.216	0.009	0.076	1											
V5 *sp_pro*	0.128	0.056	0.396	0.034	1										
V6 *so_fe*	0.237	0.037	0.244	0.078	0.104	1									
V7 *eco_fe*	0.347	0.017	0.202	0.282	0.069	0.429	1								
V8 *tenure*	0.370	0.127	0.082	0.075	0.399	0.104	0.094	1							
V9 *steem2usd*	-0.002	-0.001	-0.031	-0.001	-0.037	0.003	0.004	-0.064	1						
V10 *steem*	0.189	0.001	0.059	0.363	-0.031	0.020	0.193	0.054	-0.001	1					
V11 *sbd*	0.189	0.004	0.087	0.439	-0.019	0.070	0.227	0.083	-0.002	0.434	1				
V12 *get_flag*	0.040	0.007	0.013	0.018	0.013	0.036	0.034	0.017	0.002	0.005	0.004	1			
V13 *flag*	0.017	-0.001	0.010	0.005	0.006	0.006	0.011	0.006	0.003	0.003	0.000	0.039	1		
V14 *following*	0.332	0.707	0.027	0.001	0.021	0.008	0.004	0.061	0.000	-0.001	0.001	0.004	0.000	1	
V15 *self_pre*	0.164	0.068	0.453	0.004	0.280	0.103	0.058	0.315	-0.009	0.002	0.011	0.003	-0.001	0.0354	1

Table 6
Results of Two-Way Fixed Effect Negative Binomial Model.

	PM1	PM2	PM3	PM4
follower		0.1274***	0.1475***	0.1866***
friend		0.0242***	0.0178**	-0.0199***
reputation		0.7842***	0.5245***	0.3427***
sp_num		0.1186***	0.0756***	0.0969***
sp_pro		0.4454***	0.4066***	0.4432***
eco_fe		0.0571***	-0.2854***	-0.3087***
so_fe		0.1065***	0.0838***	0.0902***
*eco_fe * sp_num*			0.0495***	0.0856***
*eco_fe * sp_pro*			0.0178^{+}	0.0970***
*eco_fe * follower*			-0.0205***	0.0229***
*eco_fe * friend*			0.0127***	0.0068^{+}
*eco_fe * reputation*			0.1636***	0.0609***
*so_fe * sp_num*				-0.0631***
*so_fe * sp_pro*				-0.0849***
*so_fe * follower*				-0.0796***
*so_fe * friend*				0.0283***
*so_fe * reputation*				0.1772***
tenure	0.4352***	-0.0272***	-0.0051	-0.0106
steem2usd	1.3001***	2.9404***	2.9487***	2.7772***
steem	0.0380***	0.0187***	0.0194***	0.0197***
sbd	0.0825***	-0.0022	0.0009	0.0006
get_flag	0.0884***	-0.0198***	-0.0201***	-0.0176***
flag	0.0274**	-0.0702***	-0.0511***	-0.0521***
following	0.0970***	-0.0585***	-0.0726***	-0.0550***
self_pre	0.0963***	-0.0422***	-0.0463***	-0.0534***
individual fixed-effects	Yes	Yes	Yes	Yes
time fixed-effects	Yes	Yes	Yes	Yes
_cons	-2.6205***	-5.2723***	-4.3445***	-3.8050***
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	-840,078.49	-817,498.29	-813,260.01	-810,316.34

Notes: $^{+}$ p < 0.1;* p < 0.05;** p < 0.01;*** p < 0.001.

In summary, we employ the two-way fixed effect negative binomial model to test our hypotheses. At the same time, to test the influence of various variables, we use the hierarchical regression method. The regression model is as follows:

$$\ln(post_{i,t}) = \alpha_i + ctrl_j + \beta_9 lnfollower_{i,t-1} + \beta_{10} lnfriend_{i,t-1} + \beta_{11} reputation_{i,t-1} + \beta_{12} lnsp_{num\,i,t-1} + \beta_{13} sp_{pro\,i,t-1} + \beta_{14} lneco_{fe_{i,t-1}} + \beta_{15} lnso_{fe_{i,t-1}} + \beta_{16} lneco_{fe_{i,t-1}} * sp_{num\,i,t-1} + \beta_{17} lneco_{fe_{i,t-1}} * sp_{pro\,i,t-1} + \beta_{18} lneco_{fe_{i,t-1}} * follower_{i,t-1} + \beta_{19} lneco_{fe_{i,t-1}} * friend_{i,t-1} + \beta_{20} lneco_{fe_{i,t-1}} * reputation_{i,t-1} + \beta_{21} lnso_{fe_{i,t-1}} * sp_{num\,i,t-1} + \beta_{22} lnso_{fe_{i,t-1}} * sp_{pro\,i,t-1} + \beta_{23} lnso_{fe_{i,t-1}} * follower_{i,t-1} + \beta_{24} lnso_{fe_{i,t-1}} * friend_{i,t-1} + \beta_{25} lnso_{fe_{i,t-1}} * reputation_{i,t-1} + \mu_i + \lambda_i + \varepsilon_{i,}$$

Table 7
Group Analysis of Social Feedback Sources.

	Group 1: Likes mainly come from non-fans		Group 2: Likes mainly come from fans	
tenure	0.0162	0.0126	0.1047	0.1132
steem2usd	2.0720***	2.1436***	1.6621***	1.7382***
steem	0.0040*	0.0037*	0.0003	0.0002
sbd	-0.0014	0.0002	0.0061	0.0049
get_flag	-0.0249***	-0.0249***	-0.0109	-0.0109
flag	-0.0650***	-0.0566***	-0.0146	-0.0129
following	-0.1023***	-0.1163***	-0.2819***	-0.2942***
self_pre	-0.0403***	-0.0398***	-0.1215***	-0.1125***
follower	0.0335***	0.0740***	0.2438***	0.5216***
friend	0.1393***	0.1554***	0.3537***	0.4365***
reputation	0.5358***	0.1873***	0.9161***	1.4594***
sp_num	0.1194***	0.1158***	0.1749***	0.0759
sp_pro	0.2142***	0.2337***	0.0767*	0.2396
eco_fe	0.0380***	-0.1069***	0.0375***	0.2699*
so_fe	0.0823***	0.0689***	0.0579***	0.071
*eco_fe * sp_num*		0.0660***		0.3294***
*eco_fe * sp_pro*		-0.0143		-0.2839*
*eco_fe * follower*		0.0022		0.0257
*eco_fe * friend*		0.0048		0.0877**
*eco_fe * reputation*		0.0359***		-0.4066***
*so_fe * sp_num*		-0.0494***		-0.2024***
*so_fe * sp_pro*		-0.0324**		0.0986
*so_fe * follower*		-0.0255***		0.1683***
*so_fe * friend*		0.0133***		0.1293***
*so_fe * reputation*		0.1135***		0.0588
individual fixed-effects	Yes	Yes	Yes	Yes
time fixed-effects	Yes	Yes	Yes	Yes
_cons	-3.0524***	-2.0682***	-1.9204***	-2.7379***
Wald chi2(d. f.)	1945.65	1982.56	353.09	390.79
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	-131,856.27	-131,829.07	-4941.7008	-4917.6062

Notes: $^{+}$ p < 0.1;* p < 0.05;** p < 0.01;*** p < 0.001.

Table 8
Group Analysis of Novice Users and Mature Users.

	Group 1: Novice Users		Group 2: Mature Users	
Tenure	0.0099***	0.0094***	-0.0059***	-0.0057***
steem2usd	7.0088***	6.7768***	0.9556***	0.8559***
Steem	0.0161***	0.0215***	0.0113***	0.0112***
Sbd	0.0034	0.0134**	-0.0057*	-0.0043*
get_flag	-0.0115	-0.0183*	-0.0179***	-0.0170***
Flag	0.0489*	0.0610***	−0.0808***	-0.0738***
Following	-0.0497***	-0.0395***	-0.0601***	-0.065***
self_pre	-0.1178***	-0.1272***	0.0433***	0.0393***
Follower	0.1342***	0.2156***	0.1228***	0.1197***
Friend	-0.0233**	-0.1177***	0.06320***	0.07020***
Reputation	0.5505***	0.1229***	0.8307***	0.6169***
sp_num	0.0726***	0.0941***	0.1845***	0.1138***
sp_pro	0.5777***	0.5906***	0.1597***	0.1419***
eco_fe	0.0569***	-0.4000***	.0551***	-0.2383***
so_fe	0.1571***	0.0935***	0.07700***	0.0683***
*eco_fe * sp_num*		0.0617***		0.1176***
*eco_fe * sp_pro*		0.1357***		0.1048***
*eco_fe * follower*		-0.0111*		0.1014***
*eco_fe * friend*		0.0404***		-0.0221***
*eco_fe * reputation*		0.1263***		-0.0843***
*so_fe * sp_num*		-0.0803***		-0.0537***
*so_fe * sp_pro*		-0.0820***		-0.0694***
*so_fe * follower*		-0.0862***		-0.0724
*so_fe * friend*		0.0572***		0.0051***
*so_fe * reputation*		0.1751***		0.1815***
individual fixed-effects	Yes	Yes	Yes	Yes
time fixed-effects	Yes	Yes	Yes	Yes
_cons	-5.9369***	-4.4942***	-4.8100***	-3.9119***
Wald chi2(d. f.)	42,362.45	44,483.39	41,545.71	44,413.72
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	-369,995.31	-366,514.08	-444,885.59	-441,627.58

Notes:$^{+}$ p<0.1;* p < 0.05;** p < 0.01;*** p < 0.001.

Table 9
Robustness Check (a).

	Negative binomial model with random effects		Negative binomial model with fixed effects DV=Posts+Likes+Comments	
	(1)	(2)	(3)	(4)
Tenure	-0.0681***	-0.0520***	-0.0254***	-0.0084
steem2usd	2.7095***	2.5156***	2.9737***	2.8165***
Steem	0.0198***	0.0213***	0.0186***	0.0196***
Sbd	-0.0054**	-0.0025	-0.0028	0
get_flag	-0.0181***	-0.0159***	-0.0196***	-0.0173***
Flag	-0.0709***	-0.0522***	-0.0697***	-0.0517***
Following	-0.0273***	-0.0159**	-0.0562***	-0.0526***
self_pre	-0.0490***	-0.0592***	-0.0415***	-0.0526***
follower	0.1140***	0.1645***	0.1250***	0.1839***
friend	0.0121*	-0.0338***	0.0241***	-0.0204***
reputation	0.7146***	0.2621***	0.7873***	0.3462***
sp_num	0.1309***	0.1034***	0.1176***	0.0963***
sp_pro	0.4664***	0.4623***	0.4467***	0.4433***
eco_fe	0.0625***	-0.3413***	0.0570***	-0.3158***
so_fe	0.1135***	0.0942***	0.1068***	0.0918***
*eco_fe * sp_num*		0.0948***		0.0846***
*eco_fe * sp_pro*		0.1146***		0.1029***
*eco_fe * follower*		0.0415***		0.0214***
*eco_fe * friend*		-0.001		0.0085*
*eco_fe * reputation*		0.0540***		0.0629***
*so_fe * sp_num*		-0.0666***		-0.0630***
*so_fe * sp_pro*		-0.0842***		-0.0857***
*so_fe * follower*		-0.0839***		-0.0786***
*so_fe * friend*		0.0293***		0.0277***
*so_fe * reputation*		0.1850***		0.1760***
individual fixed-effects	No	No	Yes	Yes
time fixed-effects	No	No	Yes	Yes
_cons	-4.8286***	-3.3114***	-5.3001***	-3.8360***
/ln_r	-0.5518***	-0.4768***		
/ln_s	0.6710***	0.7940***		
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	-991,056.34	-982,586.77	-817,638.29	-810,486.59

Notes:$^{+}$ p<0.1;* p < 0.05;** p < 0.01;*** p < 0.001.

where $ctrl_j$ represents all control variables ($j = 1,2\ldots\ldots8$) ; α_i is a constant term; β_i are the parameters we intend to estimate; μ_i indicates multiplicative individual fixed effects with the intent to control for individual, time-invariant heterogeneity; λ_i indicates multiplicative time fixed-effects; and ε_i is the error term.

5. Data analysis and results

5.1. Estimation results

The results of the parameter estimation are shown in Table 6. Model PM1 contains only the control variables. We build Model PM2, which verifies the direct impact of social capital and share capital on the dependent variable, by adding independent variables to Model PM1. Next, to verify the moderating effect of social feedback and economic feedback, we build models PM3 and PM4 by adding the multiplication terms of social feedback/economic feedback and social capital/share capital to Model PM2.

The impacts of the three dimensions of social capital are all significantly positive. The number of fans (β_9 = 0.1274, p<0.001); the number of friends (β_10=0.0242, p<0.001); and the reputation score (β_11=0.7842, p<0.001) all have positive impacts on the number of users' posts. The above results support hypotheses H1a, H1b, and H1c.

The number of SP held by user has a positive effect on posting behavior (β_12=0.1186, $p < 0.001$), which supports H2. The proportion of SP in assets held by user has a positive effect on posting behavior (β_13=0.4454, $p < 0.001$), which also supports H2. Specifically, in Steemit, the more shares users hold, the more they will invest in the community. According to the possession theory, members will have a sense of ownership of the community. The higher the proportion of SP held by users in their assets, the more they tend to convert assets into long-term investments, which also shows their commitment to the community, and so they will actively contribute to the community. In summary, users' share capital is verified to have a positive effect on their active participation behavior.

The economic feedback received by user has a positive impact on the number of user posts (β_14 = 0.0571, $p < 0.001$), as does the social feedback received by user (β_15 = 0.1065, $p < 0.001$). Both reciprocity theory and reinforcement theory show that the feedback received by users will affect their follow-up behaviors in the community. The above results support H3a and H3b.

In addition to the main effects, this study also tests the moderating effects of social feedback and economic feedback. Regarding the moderating effect of economic feedback, the results of Model PM4 (β_18 = 0.0229, $p < 0.001$, β_19 = 0.0068, $p = 0.061 < 0.1$, β_20 = 0.0609, $p < 0.001$) support H4a, H4b, and H4c. In addition to being an economic incentive, economic feedback can also be considered as the recognition of users' value to the community. Secondly, the maintenance and development of social connections and interpersonal relationships are significant ways to increase social interaction and further economic feedback in the community. Therefore, economic feedback will positively strengthen the positive effect of structural capital, relational capital, and cognitive capital on users' active participation behavior. According to the coefficient of the multiplication of economic feedback and SP quantity (β_16 = 0.0856, $p < 0.001$) and the coefficient of the multiplication of economic feedback and SP_pro (β_17= 0.0970, $p < 0.001$), H6 is supported. This shows that when users receive higher economic feedback, their economic tendencies will be higher and they will intend to take full advantage of share capital by actively participating in community activities.

Regarding social feedback, the influence of relationship capital and cognitive capital on users' active participation is positively moderated

Table 10
Robustness Check (b).

	Add control variable (Language)	
	(1)	(2)
Tenure	-0.0032***	-0.0031***
steem2usd	0.6831***	0.6330***
Steem	0.0194***	0.0206***
Sbd	-0.0016	0.0012
get_flag	-0.0186***	-0.0166***
Flag	-0.0695***	-0.0527***
following	-0.0829***	-0.0807***
self_pre	-0.0474***	-0.0574***
lan_en	0.0074	0.0139
lan_es	0.0021	-0.0235
follower	0.1542***	0.2141***
Friend	0.0440***	0.0015
reputation	0.7828***	0.3494***
sp_num	0.1243***	0.1021***
sp_pro	0.4596***	0.4726***
eco_fe	0.0551***	-0.2959***
so_fe	0.1059***	0.0926***
*eco_fe * sp_num*		0.0844***
*eco_fe * sp_pro*		0.0857***
*eco_fe * follower*		0.0271***
*eco_fe * friend*		0.0072*
*eco_fe * reputation*		0.0552***
*so_fe * sp_num*		-0.0623***
*so_fe * sp_pro*		-0.0884***
*so_fe * follower*		-0.0804***
*so_fe * friend*		0.0272***
*so_fe * reputation*		0.1783***
individual fixed-effects	Yes	Yes
time fixed-effects	Yes	Yes
_cons	-4.5431***	-3.1126***
Prob > chi2	0.0000	0.0000
Log likelihood	-817,286.09	-810,119.36

Notes: $^{+}$ p<0.1;* p < 0.05;** p < 0.01;*** p < 0.001.

Table 11
Robustness Check (c).

	Negative binomial model with fixed effects T = 2019.3.4–2019.8.12			
	PM1	PM2	PM3	PM4
tenure	0.0655***	-0.2431***	-0.2038***	-0.1915***
steem2usd	2.4619***	2.7340***	2.2922***	2.2711***
steem	0.0326***	0.0056***	0.0054***	0.0051***
sbd	0.1339***	0.0032**	0.0083***	0.0083***
get_flag	0.1693***	-0.0385***	-0.0385***	-0.0317***
flag	0.1727***	0.0444***	0.0348***	0.0305***
following	0.0725***	-0.1520***	-0.1692***	-0.1665***
self_pre	0.1804***	0.0505***	0.0500***	0.0486***
follower		0.1429***	0.1516***	0.1573***
friend		0.1088***	0.1417***	0.1287***
reputation		0.1087***	-0.0514***	-0.0687***
sp_num		0.1359***	0.0498***	0.0526***
sp_pro		0.5173***	0.4822***	0.4992***
eco_fe		0.0859***	-0.4445***	-0.5521***
so_fe		0.1309***	0.0723***	0.1890***
*eco_fe * sp_pro*			0.0065***	0.1667***
*eco_fe * follower*			0.0108***	0.0516***
*eco_fe * friend*			-0.0657***	-0.0938***
*eco_fe * reputation*			0.2719***	0.1968***
*so_fe * sp_num*				-0.0586***
*so_fe * sp_pro*				-0.1432***
*so_fe * follower*				-0.0709***
*so_fe * friend*				0.0574***
*so_fe * reputation*				0.1056***
individual fixed-effects	Yes	Yes	Yes	Yes
time fixed-effects	Yes	Yes	Yes	Yes
_cons	-2.3992***	-2.1067***	-1.4775***	-1.4861***
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	-4,039,673.4	-3,932,960.9	-3,894,095.5	-3,888,415.4

Notes: $^{+}$ p<0.1;* p<0.05;** p < 0.01;*** p < 0.001.

by social feedback ($\beta\_24 = 0.0283, p < 0.001, \beta\_25 = 0.1772, p < 0.001$), thus supporting H5b and H5c. However, when more social feedback is received, the positive effect of number of fans on posting behavior is weakened (β_23 = -0.0796, $p < 0.001$); thus, H5a is not verified. This may be because most of the likes received by users do not come from their fans. We investigate this point further in the subsequent additional analysis.

We find that when the number of votes received by users increases, the economic motivation of users is weakened and replaced by social motivation, and the positive effect of share capital on active participation behavior decreases with the increase in social feedback (β_21 = -0.0631, $p < 0.001$, β_22 = -0.0849, $p < 0.001$); thus, H7 is supported. Users who hold share capital are more concerned about whether their activities can raise their share in the community, which will make them have more ownership in the community. The recognition of others brought by social feedback cannot substantially improve their ownership of the community. Therefore, compared with low social feedback, the effect of share capital on active participation behavior will be weakened for users who receive high social feedback.

5.2. Additional analysis

According to the results of the parameter estimation, H5a is not verified. Social feedback does not positively moderate the effect of number of fans on posting behavior. This may be because the majority of "likes" received by users do not come from their direct fans. Through the statistical analysis, we find that most of the social feedback received by users comes from "non-fan users". However, non-fan users do not bring the expected attention and recognition to users, which may reduce the positive impact of number of fans on posting behavior.

To further verify the moderating effect of social feedback on number of fans, we analyze the sources of the "likes" received by users within 11 weeks and thus divide users into two groups. The first group consists of the users who mainly receive "likes" from non-fan users rather than fans every week; the second group consists of the users who mainly receive "likes" from fans rather than non-fans every week. The analysis results are shown in Table 7.

As shown in Table 7, the results for both groups verify the positive effects of users' social capital, share capital, social feedback, and economic feedback on active participation. As for the moderating effect, we focus on the moderating effect of social feedback on the number of fans. By comparing the results, we find that in the first group, the positive effect of number of fans on number of posts is negatively impacted by social feedback (β= -0.0255, $p < 0.001$). However, in the second group, the positive effect of number of fans on number of posts is positively impacted by social feedback (β= 0.1683, $p < 0.001$), which partly confirms H5a.

Combining the two sets of results, we find that for users whose "likes" come mainly from non-fans, those likes do not bring them the expected recognition, so the social feedback they receive will weaken the impact of number of fans on posting behavior. It seems reasonable that the results we obtained in the empirical part tend to be consistent with the first group because most of the "likes" the users receive come from non-fans. Therefore, social feedback has opposite effects on the influence of number of fans in the "non-fan group" and the "fan group".

In addition, the significance level of economic feedback's moderating effect on relational capital is low ($\beta\_19 = 0.0068 > 0, p = 0.061 < 0.1$). We think that this may be due to the differences in the perception of relational capital between novice and mature users in the community. Therefore, we further group the data according to user registration time. The first group is composed of novice users whose registration time is less than the mean value (including 12,455 users), and the second group is composed of mature users whose registration time is larger than the mean value (including 13,011 users). The sample sizes of the two subsamples are similar. The analysis results are shown in Table 8.

As shown in Table 8, the main effects are all verified, except for the

relational capital. Comparing the results of the two groups, we find that the coefficient of novice users' relational capital is β= -0.0233<0, p< 0.001, indicating that the amount of relational capital owned by novice users will have a negative impact on their active participation behavior. As for mature users, the influence coefficient of relational capital is β=0.6320>0, $p < 0.0001$, which is consistent with H2. Combining the two groups of results, we find that as novice users have not been in the community for a long time, they have not yet formed a certain level of social ties. Whereas the average number of friends is 201 for mature users, for novice users, it is only 28. Therefore, there may be a certain deviation in novice users' perception of relational capital, resulting in a result contrary to the hypothesis. After the novice and mature users are mixed, the results for the overall sample are more inclined toward mature users, and so the impact of overall relational capital on participation is verified.

With regard to the moderating effect, because of the deviation in the perception of relational capital between the novice and mature users, the two groups do not show consistent results on the coefficients of the interaction term between economic feedback and relational capital, which may ultimately lead to the weak significance.

6. Robustness test

Using alternative models is an effective method for testing robustness [29]. First, we adopt the negative binomial model with random effects (considering the individual and time effects). As shown in columns (1) and (2) of Table 8, the main results and moderating effect of the model are consistent with our analysis. Second, choosing different measurement methods for dependent variables is also an effective method [16]. Previous empirical studies have used different measurements to measure active participation behaviors, such as the number of posts and comments and the average time users spend on a platform. Therefore, we take the sum of the number of posts, likes, and comments as an alternative way to measure active participation and build the negative binomial model with fixed effects to test the robustness. Columns (3) and (4) in Table 9 show that the coefficient estimates maintain the same direction and significance as PM2 and PM4 in Table 6, which further verifies the robustness of our model.

To exclude the influence of the heterogeneity of users' country or language on the results of the model, we add the control variable of language to the model. The 25,466 users in the data set use 102 languages, and English users account for nearly 74% of the sample. The distribution of language usage is shown in Fig. 4. The top 10 languages in terms of usage are English, Spanish, Korean, Chinese, German, Polish, Indonesian, Turkish, and Russian. Language usage also reflects the distribution of user countries to a certain extent. Since users who use English or Spanish account for more than 80% of all users, we set the control variable of language as a three-category dummy variable (English, Spanish, neither English nor Spanish).

Table 10 shows the results after adding the control variable of language. The results are basically consistent with the original model, but the influence of language itself is not significant, possibly because of the concentrated use of user language.

In addition, we further examine the results by using alternative sample periods. To retest the model, we select the independent variables from March 4, 2019 to August 5, 2019 and the dependent variables from March 11, 2019 to August 12, 2019. The results are consistent with Table 6, which further demonstrates the robustness of our results, as shown in Table 11.

7. Discussion

7.1. Theoretical implications

Traditional online communities have usually been designed as centralized organizations. Due to the rapid development of blockchain technology, various DAOs have been established. Steemit is representative of a DAO and a typical blockchain-based online community which illustrates the great shift in incentive mechanism design. This paper is among the earliest attempts to explain the effect of the incentive mechanism of blockchain-based online communities on user active participation behavior from the perspectives of social capital and psychological ownership.

The theoretical contributions of this study are three-fold. First, it compares typical blockchain-based online communities and traditional communities, and identifies their differences and similarities. Further, it discusses the incentive mechanisms based on the blockchain-based economic system and their impact on user behavior. Compared with traditional communities, blockchain-based communities have formed better value co-creation and achieved incentive compatibility with users. The characteristics of DAOs lead to different user participation behaviors. Existing discussions on blockchain-based communities are still in the initial stage and often focus on the conceptualization and construction of the platforms. This study enriches our understanding of the inherent mechanisms of user active participation behavior in DAO.

Second, existing studies have extensively explored the incentive mechanism and participation behavior of users in traditional communities on the basis of the perspective of social capital. Steemit has extended the incentive mechanism by designing a three-token system. This design endows community members with two different roles: participant and owner. As participants, users build social relationships, own social capital, and earn social benefits by using Steemit, just like users in other traditional social communities. As owners, users obtain specific economic incentives by earning and holding share capital (SP). These two types of capitals change the mechanisms underlying community governance and user behavior. This study explains the effects of these two roles and the corresponding user incentive mechanisms, and their influences on user participation behavior.

Third, this study enriches the related research on the incentive mechanism of online communities. As for traditional communities, our model verifies the effects of social capital (structural, relational and cognitive capital) and social feedback on the active participation of users. These results also provide theoretical guidance for the design of incentive mechanisms in traditional communities. As for blockchain-based communities, token-based incentive mechanisms are provided. Therefore, this paper explores the impacts of these unique mechanisms and factors (e.g. share capital and economic feedback) of the blockchain-based community. The research results increase our understanding of the knowledge community's incentive mechanism. In addition, the interaction effect between the unique mechanism of blockchain-based communities and traditional mechanism is an important theoretical innovation, which reveals the relationship between the two types of mechanism and providing a theoretical basis for explaining and building more complex online communities.

Finally, this study complements the study of psychological ownership in online communities. Most of the previous research has studied psychological ownership in the organizational context. This study introduces psychological ownership theory to explain the internal mechanism of the effect of share capital, which enriches our understanding and application of psychological ownership theory in the field of online community.

7.2. Practical implications

This research also provides practical implications for the operation and governance of blockchain-based content communities.

First, the empirical results reveal that the social capital and share capital held by users have a significant positive effect on posting behavior. Therefore, online communities should reinforce social functions and encourage users to accumulate social capital to motivate them to contribute. For example, techniques displaying number of fans,

information about friends, expertise level, and so forth will positively influence user participation.

Compared with traditional online communities, blockchain-based online communities (e.g., Steemit) utilize unique token-based incentive mechanisms. In the Steemit community, STEEM, SP, and SBD can be analogized to cash, shares, and debt in a common economic system. The results show that users who hold a large amount of SP or have a higher proportion of SP are more willing to participate in active activities. We believe that these users have a stronger sense of community belonging and may regard themselves as the owners of the community. As Steemit is typical of a blockchain-based online community, its token-based mechanisms are worth investigating. The results can be generalized to the transformation of traditional communities, where operators can adopt novel incentive mechanisms to increase users' psychological ownership of the community and inspire their contributions.

Secondly, the results of this study also show that, in a decentralized autonomous community, economic feedback has a positive role in promoting users' posting behaviors. Furthermore, the impacts of users' social capital and share capital on posting behaviors are positively moderated by economic feedback. In the mechanism design of communities, economic feedback is not only an economic incentive but also considered as a kind of recognition and identification from the community. From the perspective of community governance, a token-based reward mechanism takes multiple dimensions of users' needs into consideration and provides comprehensive driving forces to promote user contribution and community development. In this way, users' positive contributions are recognized and rewarded, which will help to strengthen their contributing behaviors and form a healthy community ecology.

7.3. Limitations

This study has several limitations. First, the data source was from one site. This study selected the blockchain-based online community as an object, and the data set was obtained from Steemit. Although Steemit is a typical example of a blockchain-based online community, different mechanisms are adopted by various communities, and users' participation behavior may also be different. Therefore, to obtain more universal results, future research should obtain data from other communities to triangulate the results.

Second, the measurement can be further improved. In this study, the measurement of social capital was based on three dimensions. In previous studies, social capital has mostly been measured through a survey. Existing measurement methods for structural capital and cognitive capital are unified. At the same time, there are few measurement methods for relational capital, which is more subjective and difficult to measure through objective data. Although our measurement method is consistent with [94], future research could alternatively use subjective measurements (e.g., self-report or survey) to supplement the findings.

Third, the limitation of research methods: According to the research context and research model of this study, we used the collected objective panel data to test the hypotheses. However, second-hand data cannot easily reflect users' subjective perceptions and cannot reveal the actual psychological process. In the future, surveys and experiments could be utilized to enrich the results.

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Zhiyong Liu is Associate Professor of information systems at School of Economics and Management, Dalian University of Technology, China. His research interests include blockchain technology, AI innovations, business process modeling, cross-border e-commerce. He received his Ph.D. in Information Systems from a joint program of City University of Hong Kong and University of Science and Technology of China. He has published several studies in Decision Support Systems, Information Processing and Management, Internet Research, International Journal of Information Management, as well as some leading international conferences.

Yueping Li is a Master Student of Management Science and Engineering at the School of Economics and Management, Dalian University of Technology, China. Her research focuses on blockchain-based community.

Qingfei Min is Professor of information systems at School of Economics and Management, Dalian University of Technology, China. His research interests include IT/IS implementation and adoption, e-commerce /m-commerce behavior and strategies, global virtual team, social medias and AI innovations. He received his Ph.D. in Information Systems from Dalian University of Technology. He has published several studies in Information & Management, International Journal of Mobile Commerce, Computers in Human Behavior as well as in some Chinese academic journals and international conferences.

Mengting Chang is a Master Student of Management Science and Engineering at the School of Economics and Management, Dalian University of Technology, China. Her research focuses on social media.