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RESEARCH ARTICLE

Continued Participation in Crowdsourcing Innovation: The Role of Web-Specific Computer Self-Efficacy

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ABSTRACT The crowdsourcing innovation communities are user-centered, and their efficacy depends on the members' continued participation. This study investigated the impact of high web-specific computer self-efficacy and harmonious work climate on individuals' continued participation intention. In addition, the antecedents of high web-specific computer self-efficacy and harmonious work climate in the context of crowdsourcing innovation were also explored. Our research model was empirically examined using survey data collected from 291 members of a crowdsourcing innovation community (i.e., Xiaomi's online platforms). The Partial Least Squares technique was utilized to test the research model. The results reveal that high web-specific computer self-efficacy and harmonious work climate positively influence individuals' sustained participation intention; reasonable task recommendation and positive feedback are significant predictors of high web-specific computer self-efficacy; effective cooperation, fair competition, and positive feedback affect a harmonious work climate. Finally, this study discussed the theoretical and practical implications of these findings and provided possible directions for future research.

INDEX TERMS Crowdsourcing innovation, continued participation, high web-specific computer self-efficacy, harmonious work climate.

I. INTRODUCTION

Since innovation may create new markets and profit growth possibilities, new product development (NPD) plays a critical role in the survival and expansion of enterprises. With the rapid development of network information technology, it is difficult for the ''internal'' design model (which heavily relied on the designs proposed by designers and engineers) of the organization in the era of standardized mass manufacturing to adapt to the rapidly changing market demands and increasingly fierce competitive environment. With the sharp increase in research and development costs, shortened product lifecycle, and increasingly globalized competition, companies face practical difficulties such as increased design complexity, insufficient design capabilities, and increased research and development risks. How to perform product design and innovation better and more effectively has become a vital issue that urgently needs to be solved. Chesbrough considered that open innovation might solve the challenges faced by enterprises [1]. Open innovation can enable enterprises to quickly integrate external design resources and respond to the market, allowing external resources to participate in product innovation activities, effectively breaking organizational boundaries, and achieving rapid product development and iteration through diversified collaboration and cross-organizational design activities.

For the past few years, the flourishing of crowdsourcing and the gig economy triggered a transformation in product innovation; crowdsourcing has become the primary method for performing open innovation [2], [3], [4]. More and

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more businesses have become aware that consumers are significant external innovation resources and have initiated collaboration with them to work on new products or services. The advancement of Internet technologies has offered a stable channel for customers to participate in innovation events, promoting crowdsourcing innovation (CI) development. CI allows enterprises to assign part or all the innovation tasks (e.g., interaction design, product design) to customers with appropriate resources and capabilities through online platforms (i.e., crowdsourcing innovation communities, CICs) [5]. Consumers are encouraged to contribute content (e.g., ideas and designs) by posting messages and topics within these communities, which is the primary channel to participate in CI [6]. Pioneer firms, such as Haier, P&G, Ducati, Xiaomi, Local Motors, and Dell, have launched CICs to promote NPD. For instance, P&G puts its needs (e.g., bottleneck issues the enterprise encounters during product development) on a CIC named C+P and invites customers to contribute knowledge, ideas, and designs to solve these issues [7]. With the C+P strategy, P&G's NPD productivity has increased by almost 60%, and many of P&G's best-selling products come from C+P [8]. However, although CICs have experienced rapid growth, many firms failed to create value from these platforms [9]. Researchers considered that the lack of users' sustained participation (i.e., customers no longer take part in the activities of CICs) is the crucial reason for this result [10], [11]. Hence, there is a pressing need for both practitioners and scholars to understand better the profound factors that determine the formation of individuals' continued participation intention toward CICs.

Individuals' perceived efficacy in performing specific Internet-related tasks may significantly influence their follow-up behaviors [12]. A user with a strong sense of capability in dealing with a system is more willing to accept and use the system. Additionally, when the users consider that others approve of their generated content (e.g., ideas, opinions, design plans), they tend to continue their contribution behavior [13]. These phenomena often occur in the context of user-generated content (UGC) websites, primarily caused by computer self-efficacy (CSE) [14], [15]. People with high CSE exhibited more acceptance of information technologies and less resistance to technological change than those with a low degree of CSE [16], [17]. As a typical task-oriented UGC website, CIC users' participation behavior may be significantly affected by CSE. Nevertheless, prior studies have focused little on exploring individuals' behavior in the CIC context. Although CSE may influence a member's continuance intention toward CIC, no empirical work has been conducted to verify this view. Consequently, whether and how CSE affects continuous usage behavior concerning CIC remains an open question.

Unlike traditional innovation projects' close-knit, CI events are often loosely organized. Individuals can participate in these activities anytime and are free to stay or quit. Most participants evaluate the crowdsourcing projects' characteristics (e.g., competency, partners, income, feedback from others) at each stage (e.g., idea proposing, design optimization) to decide whether to continue participating. To influence participants' decisions on adoption behavior and increase their stickiness toward the projects, some firms such as Xiaomi and Local Motors try to make a harmonious crowdsourcing work climate within the CIC and create solid and emotional bonds among the crowdworkers [6]. Morschheuser et al. suggested that practical cooperation and fair competition may improve the work atmosphere and increase individuals' willingness to participate in crowdsourcing innovation [18]. Scholars also considered that a good work climate might drastically reduce crowdsourcing participant turnover rates and encourage them to be more active in the projects [2], [19], [20]. Hence, special attention should be paid to factors contributing to an excellent crowdsourcing work climate, which undoubtedly will provide leverage points to strengthen users' favorable perceptions and encourage them to continue using the CICs. Whereas, as far as we know, very little work has been done heretofore to probe the precursors of a harmonious work climate and its effects on users' continued intentions in the context of CICs.

To address these research issues, we followed the theoretical framework proposed by Morschheuser et al. and proposed an integrated research model that utilized high web-based CSE, harmonious work climate, reasonable task recommendation, effective cooperation, fair competition, and positive feedback as constructs to explore individuals' continued participation behavior [18]. The paper is structured as follows. Section II reviews related research on the crowdsourcing innovation community, computer self-efficacy, and organizational climate. The research model and hypotheses are proposed in section III. The research methodology, which includes data collection and construct measurement, is described in section IV. Section V performs data analysis and shows hypothesis test results. The experimental results are discussed in section VI. The conclusions are drawn in section VII.

II. THEORETICAL BACKGROUND

A. CROWDSOURCING INNOVATION COMMUNITY

The term ''crowdsourcing'' was proposed by two editors at Wired, Jeff Howe and Mark Robinson, in 2005 to describe how businesses were utilizing the Internet to ''outsource work to the crowd'' [21]. Howe defined crowdsourcing as the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call [3]. Since crowdsourcing can effectively obtain external resources, it has been widely used in the commercial world, including creative crowdsourcing, crowdfunding, crowd solving, micro work, crowdsource workforce management, inducement prize contests, and crowd voting [22]. Particularly, creative crowdsourcing has increased with the rapid development of online platforms where businesses can solicit various creative

works at a lower cost than traditional methods. Creative crowdsourcing spans sourcing creative projects such as product design, graphic design, crowdsourcing architecture, apparel design, illustration, and writing [23].

Enterprises that desire to perform CI should continuously motivate users to contribute knowledge, ideas, and designs. An approach for enterprises to collect these resources is to run a CIC. Such a community often starts as a consumer support platform (e.g., brand community) in which customers exchange information (e.g., usage attentions, tips) of the company's products and evolves into a way by that users can put forward suggestions on product improvement and develop extensions [24], [25]. Some CICs provide users with creative tools like online computer-aided industrial design software to help them express their designs and ideas effectively. The companies may adopt some of the good ideas contributed by the customers and develop the products according to their needs [6]. Moreover, businesses often post the issues they meet in the process of NPD and encourage users to contribute content to solve these problems; sometimes, the users may provide unconventional but effective solutions. Although CIC has been widely used for implementing open innovation, prior literature has focused little on systematically exploring the users' features and participation behavior in such a context. Thus, more in-depth research is necessary.

B. COMPUTER SELF-EFFICACY

Self-efficacy affects an individual's choice of behavior, effort expenditure and persistence, thought patterns, and emotional reactions or arousal [12], [26]. Derived from the general concept of self-efficacy, Compeau and Higgins defined CSE as a personal judgment of one's capability to use a computer to accomplish a particular job or task [27]. CSE affects not only an individual's perceptions of their ability to perform a computing task but also their intentions toward future use of online platforms [17]. Chiu and Wang explored web-based learning continuance intention; they found that CSE, performance expectancy, effort expectancy, attainment value, utility value, and intrinsic value were significant predictors of individuals' intentions to continue using web-based learning [28]. Lallmahomed et al. probed factors influencing the adoption of e-Government services; their results revealed that CSE exerts negative effects on an individual's behavioral intention [29]. Alqurashi investigated student satisfaction within online learning environments; the research results confirmed that online learning self-efficacy positively influences student satisfaction and perceived learning [30]. Prior research has well discussed the relationships between CSE and users' usage intentions towards e-learning systems, while the effects of CSE on individuals' behavioral intentions in other kinds of information systems need further exploration.

Previous literature considered that CSE is a multilevel construct operating at two distinct levels: the general computing level (general CSE) and the specific application level (specific CSE) [12], [31]. General CSE refers to a user's judgment of their ability to perform across multiple computer application domains, while specific CSE refers to a user's judgment of their ability to for computing subdomains, including applications (e.g., word processing, databases, and web-based systems) or environments (e.g., Windows and Macintosh) [12]. Hsu and Chiu extended the understanding of self-efficacy in the Internet context; they distinguished general CSE and web-specific CSE (WSE) [16]. WSE refers to an individual's perception of efficacy in using a specific WWW application (service) within the domain of general Internet computing [16]. Reddy et al. explored the acceptance of technology for learning and found that CSE is a significant predictor of students' intention to continue using technology for learning [32]. Tu et al. probed the role of hardiness in securities practitioners' web-based continuing learning; the research results revealed that WSE positively influences users' attitudes towards web-based continuing learning [33]. Kao et al. investigated factors affecting volunteers' intention to engage in citizen science; they considered that WSE significantly influences individuals' satisfaction and sustained intentions [34]. Concerning the predictors of WSE in the context of online innovation, scholars considered that cooperation, competition, and feedback-related factors might affect the development of individuals' WSE. For instance, Lyles et al. performed a longitudinal analysis of virtual community cohesion; they found that friendly competition and cooperation may influence individuals' evaluations of themselves and the virtual group, which may affect their WSE and cohesion [35]. Zhang et al. explored promoting the intention of students to continue their participation in e-learning systems; they considered that a good communication climate (e.g., efficient interaction and timely feedback) significantly influences individuals' WSE [36]. Compared with general CSE, WSE may better describe individuals' behavioral features in the context of online innovation platforms [16]; hence, WSE was utilized to understand users' discontinuance intention in our work.

C. ORGANIZATIONAL CLIMATE

Organizational climate can be defined as the shared perceptions of and the meaning attached to the policies, practices, and procedures employees experience and the behaviors they observe getting rewarded and that are supported and expected [20]. The climate has a strong influence on employee attitudes regarding their sense of belonging, personal relationships, and work performance [37]. Concepts such as job satisfaction, need for achievement, affiliation, and power, overall organizational effectiveness and performance, and organizational commitment are found to be the consequences of perceived organizational climate [38]. From an organizational perspective, online communities resemble informal organizations, which are ''the aggregate of the personal contacts and interactions and the associated groupings of people''; the organizational climate is also assumed to influence the attitudes and behaviors of community members [39]. Previous literature considered that the

organizational climate in the online community could be divided into supportive and controlled climates [39], [40], [41]. The former is the level of support its members perceive or receive from the online communities; when members' needs for esteem, approval, and affiliation are fulfilled, or they get help and replies from other community members, they may feel a supportive community climate [42]. The latter is the one in which members perceive obstacles and impediments from the community; an online community with a controlled climate may influence its members to develop self-control based on the values and rules set by the operators [39], [41].

A good and harmonious work climate in the online innovation platform can be regarded as a supportive climate, which is beneficial for organizations to encourage individuals to engage in innovation activities. The willingness of a member to be involved in and to interact with others largely depends on the climate they perceive from the online communities [42]. Shih et al. probed the effects of a harmonious work climate in promoting members' online behavior in information systems and found that the more positive the individuals perceive an organizational climate, the stronger their involvement will become in the online platforms [41]. Zhang and Liu explored the characteristics of work climate; the research results showed that work climate has significant effects on turnover intention, job satisfaction, and work efficacy; additionally, their results revealed that management-related factors such as task assignment and feedback from managers might influence work climate [44]. Sun et al. considered that supportive climate affects online community members' social value, information value, and hedonic value [45]. Therefore, we have reasons to believe that the work climate is vital to eliciting individuals' sustained participation behaviors toward particular online organizations [46].

III. RESEARCH MODEL AND HYPOTHESES

Morschheuser et al. suggested that friendly cooperation and competition may significantly influence the crowdsourcing climate and individuals' self-evaluations, and then, affect participants' continued intentions [18]. The current paper established a research model based on Morschheuser's theoretical framework and applied high WSE and harmonious work climate as the predictors of continuance usage intention; following previous literature, reasonable task recommendation, effective cooperation, fair competition, and positive feedback were utilized as the antecedents of high WSE and harmonious work climate [18], [34], [35], [36], [41], [44]. Figure 1 depicts the research model and the hypothesized relationships proposed in this study.

A. LINKING HIGH WSE AND CONTINUANCE USAGE INTENTION

High WSE reflects that a CIC member's perception of self-efficacy in using services provided by the online community and participating in crowdsourcing innovation activities is high. The CIC members with high WSE are very familiar

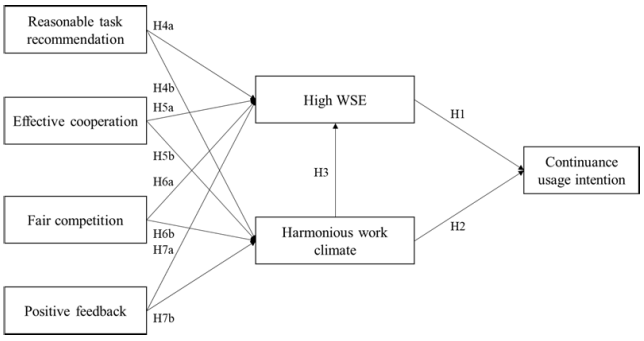

FIGURE 1. Research model.

with various functions of the community and the procedures of the innovation events. Compared with individuals with low self-efficacy, those with higher self-efficacy often exhibit more confidence when facing challenges such as complex tasks, and they are more active in participating in innovation projects. Hence, members with high WSE are in a dominant position in innovation activities, and their turnover cost is higher than the ones with low WSE. Additionally, high WSE members may usually participate in the online activities initiated by the CIC, and they have more chances to interact and cooperate with other users; within these interactions and cooperations, they may gradually develop social ties with other members, which can facilitate individuals' continued intentions [6]. Malik and Rao investigated the continued usage of on-demand ride services/ride-hailing applications and found that WSE significantly influences users' continuance intentions [47]. Tu et al. explored securities practitioners' web-based learning behavior and suggested that WSE affect individuals' continued usage behavior [33]. Kuo et al. probed learning engagement in MOOCs; their research results showed that web-based learning self-efficacy positively influences users' participation behavior [48]. Thus, we proposed the hypothesis as follows:

H1: High WSE positively influences users' continuance usage intention.

B. LINKING HARMONIOUS WORK CLIMATE, HIGH WSE AND CONTINUANCE USAGE INTENTION

When employees perceive the work climate as accommodating and friendly, they are more likely to presume they will not need to cope with aggressive or uncommunicative behavior among coworkers [49]. Reade and McKenna described this kind of work climate as ''harmonious'' since the levels of cohesiveness and relationship quality are high in such a climate [50]. In a harmonious work climate, the managers of the CIC pay more attention to members' needs, provide all necessary resources and help promptly, which may facilitate the cultivation of individuals' positive emotional tendencies toward the platform. The managers may also put forward numerous measures to encourage members' open and free information communication and new ideas generation [40]. Besides, the interactions among the CIC

members are frequent and friendly in harmonious climates, which may promote the development of social relationships, shared vision, shared values, and shared language. Liang et al. considered that stable social relationships might facilitate the formation of individuals' sustained participation intentions toward online platforms [7].

A harmonious environment is beneficial for the community operators to encourage members to participate in innovation, and interaction, share knowledge, and engage in constructive conflict resolution freely and openly [51]. In a friendly work climate, the CIC members respect each other, cooperate happily, and articulate opinions freely, which may enhance individuals' satisfaction and self-confidence. The positive psychological state can improve members' perceptions toward the CIC and self-evaluation [6], [7]. Meristo and Eisenschmidt explored the effects of organizational climate on individuals' self-evaluation and considered that a supportive organizational climate positively influences self-efficacy [52]. Tang et al. probed the antecedents of learning persistence in the context of a college education; their research results revealed that climate significantly affects individuals' self-efficacy [53]. Thus, we proposed the hypothesis as follows:

H2: Harmonious work climate positively influences users' continuance usage intention.

H3: Harmonious work climate positively influences high WSE.

C. THE PRECURSORS OF HARMONIOUS WORK CLIMATE AND HIGH WSE

1) REASONABLE TASK RECOMMENDATION

In the initial stage of traditional innovation projects, managers divide large design tasks into many smaller ones that can be carried out in parallel; and they allot tasks based on participants' abilities and expertise. Participants complete the assigned tasks within the specified time. In CI, most task publishers post their requests vaguely [7]. Therefore, the CIC operators have to assist the publishers in splitting the task into small ones and recommending the divided tasks to suitable candidates with sufficient abilities and innovation experience. Since the CICs evaluate users' abilities and expertise based on their self-report information and online behavioral records (such as generating and browsing content), there may be some errors in the analysis results. When the recommended task accurately matches the participant's abilities, and they can complete the tasks, their WSE may be enhanced. On the contrary, their WSE may decrease. Silvia considered that if individuals are competent for the assigned job, their self-efficacy will be improved [54]. Additionally, if most recommendations suit the participants, the overall satisfaction and enthusiasm of the CIC users may be increased, and the community atmosphere may be improved, which may promote a positive work climate. Hasan and Teng suggested reasonable work arrangements significantly influence employees' satisfaction and perceptions toward the employer, and employees' satisfaction may improve the work climate [55]. Embuldeniya probed the effects of job satisfaction on employee productivity and found that employee satisfaction significantly influences the organizational climate [56]. Thus, we proposed the hypothesis as follows:

H4a: Reasonable task recommendation positively influences high WSE.

H4b: Reasonable task recommendation positively influences harmonious work climate.

2) EFFECTIVE COOPERATION

Cooperation is a complex procedure in which stakeholders strive to obtain certain benefits that would be difficult to get individually [57]. Effective cooperation can be defined as a collaboration status in that the complex tasks are reasonably divided, and participants work together to achieve mutual goals [58]. In traditional innovation, operators propose numerous measures, such as assigning tasks to participants based on their abilities, and designing a well-planned task list, to promote effective cooperation; participants belong to specific organizations and must obey the management rules, which may facilitate the formation of effective cooperation. However, crowdsourcing projects are loosely organized, and managers cannot issue orders to participants (e.g., managers cannot force participants to stay or leave). Although most members aim to participate in innovation activities in CIC, their motivation for participation varies, and sustained involvement cannot be guaranteed. Some members wait to choose the most suitable or profitable project, while others may quit the innovation events when they feel tired or their perceived benefits are less than expected. Therefore, compared with traditional innovation, managers are more difficult to initiate effective cooperation in crowdsourcing innovation.

Though it is difficult to facilitate effective cooperation in the CIC, its positive effects cannot be ignored. High-quality cooperation can fully stimulate the work enthusiasm of participants and quickly and effectively complete innovation tasks [59]. The users who participate in effective cooperation may have a higher level of satisfaction than other community members, and their perception of the online platform may be optimistic. These individuals' positive attitudes can exert significant influences on other participants and then improve the work climate of the projects. Zhang et al. considered that effective cooperation could promote the development of positive emotions among the participants and facilitate the formation of a harmonious work climate [60]. Additionally, good cooperation may allow participants to showcase their talents, making them known and recognized by others, which may meet their reputation needs and increase their WSE. De Cremer and Van Vugt suggested that well-organized cooperation may promote an individual's identification and self-efficacy [61]. Thus, we proposed the hypothesis as follows:

H5a: Effective cooperation positively influences high WSE.

H5b: Effective cooperation positively influences harmonious work climate.

3) FAIR COMPETITION

In the context of crowdsourcing, fair competition is competition that is based on quality, efficiency, cost, and service rather than unfair practices. Although participants can cooperate to complete crowdsourcing projects, they may also strive for the opportunity to complete tasks independently. Sometimes, to recruit qualified contractors, CI task publishers may propose a simple task before initiating the formal projects and encourage as many users as possible to participate. Participants submit their ideas and designs to compete with others to get the opportunity to undertake the project. The publishers evaluate the participants' designs to determine the most suitable participant for the project. When most competition in the CIC is fair and friendly, participants can focus on innovation and will not have too many concerns during the competitions with others. The fair competition allows participants to perform at their best, which may enhance their self-efficacy. Dissanayake et al. considered that a good competitive atmosphere might increase individuals' self-efficacy [62]. Chan and Lam suggested that fair competition positively influence individuals' self-efficacy [63]. Additionally, as an integral part of the work climate, the competition atmosphere may significantly affect the formation of a harmonious environment. Koh and Boo explored the link between organizational ethics and job satisfaction and considered that fair competition might exert effects on the development of a good work atmosphere [64]. Thus, we proposed the hypothesis as follows:

H6a: Fair competition positively influences high WSE.

H6b: Fair competition positively influences harmonious work climate.

4) POSITIVE FEEDBACK

Healthy and benign interaction is essential for promoting the effective implementation of crowdsourcing innovation projects. Numerous interaction scenarios exist in the community, such as the interactions among participants, between operators and participants, and between crowdsourcing task publishers. Participants can post their ideas, designs, opinions in the CIC, and operators, task publishers, and other participants may comment on their posts. Friendly discussions, suggestions, evaluations, etc., can be regarded as positive feedback from others. While abuse, ridicule, disregard, and posting invalid information can be considered negative feedback. Additionally, when CIC members' queries and complaints are posted in the community, the operator's reaction attitude and efficiency will significantly impact their emotional tendency. Positive feedback can be viewed as others' affirmations of participants, which may facilitate the formation of individuals' self-confidence and enhance participants' self-efficacy [6]. Peifer et al. probed the effects of positive feedback on perceived self-efficacy, flow, and performance in a mental arithmetic task, and considered that there is a positive relationship between positive feedback and perceived self-efficacy [65]. Besides, if most individuals can positively respond to others, the work climate of the CIC may be improved. Guo et al. suggested that numerous positive feedback in the community may influence members' interaction habits and promote a pleasant climate [6]. Thus, we proposed the hypothesis as follows:

H7a: Positive feedback positively influences high WSE.

H7b: Positive feedback positively influences harmonious work climate.

IV. RESEARCH METHODOLOGY

A. MEASUREMENTS

Prior literature considered that the reflective measurement model, whose indicators are influenced by the constructs, is suitable for analyzing the relationships between online community environment-related factors and users' behavior intentions [6], [7], [10]. Thus, we employed the reflective model to measure the seven constructs of this study. Most of the items we set on the questionnaire were adapted from measures validated by previous studies. The scale measuring continuance usage intention was adapted from prior research on users' sustained participation in the context of online platforms [6], [7]; while the items for high WSE and harmonious work climate were adapted from Liang et al. [10], Malik and Rao [47], and Meristo and Eisenschmidt [52]. The constructs of effective cooperation, fair competition, and positive feedback were developed based on Guo et al. [6], López-Cózar-Navarro et al. [66], Kazakova et al. [67], and Shang and Lyv [68]; and the items to measure reasonable task recommendation were self-developed. Since most scales were initially set in English, we translated them into Chinese and made necessary improvements to make them easier to understand. All items applied a 7-point Likert scale anchored from strongly disagree (1) to strongly agree (7). These items are listed in Appendix.

B. DATA COLLECTION

The research model and hypotheses were empirically examined with samples from Xiaomi's online platforms. Xiaomi is an intelligent hardware manufacturer headquartered in China that is committed to solving the issues met in product development through crowdsourcing [7]. Xiaomi's online innovation platforms were initiated in 2010, which include open platform (https://dev.mi.com/platform), IoT developer platform (https://iot.mi.com/), AI open platform (https://developers.xiaoai.mi.com/), and community (https://www.xiaomi.cn/); they have over 70 million registered users, and around 65 percent are active members [6]. Xiaomi sets several sections, such as functional development, tips & tutorials, and performance testing, to satisfy the different needs of the customers and developers, and provides

TABLE 1. Demographic characteristics of the respondents (N=291).

Measure	Items	Frequency	Percentage (%)
Gender	Male	207	71.1
	Female	84	28.9
Age	21-30	183	62.9
	31-40	69	23.7
	41 or above	39	13.4
Education	High school or below	9	3.1
	University/ college	182	62.5
	Graduate school	100	34.4
Number of posts per month	Less than 10	55	18.9
	11-20	176	60.5
	21 or above	60	20.6
Average community usage time per week	2-3h	208	71.5
	4-6 h	52	17.8
	7 h or above	31	10.7
Membership history	6 months- 8 months	57	19.6
	9 months- 11 months	81	27.8
	1 year or above	153	52.6
Number of participated crowdsourcing innovation events	4-6	122	41.9
	7-9	135	46.4
	10 or above	34	11.7

a sophisticated rank system to facilitate members' continuance behaviors. Xiaomi obtains many valuable designs and ideas from its online platforms, which help the enterprise develop many cost-effective products. Hence, Xiaomi's online platforms are an ideal setting for our research. In this work, Xiaomi's online platforms are called the Xiaomi forum. 34 experienced users (e.g., members who have participated in at least 4 CI projects) of the Xiaomi forum were invited to participate in a pilot survey. Based on their suggestions, we revised the formal questionnaire and published it on a professional internet survey website, WJX. The link to our online survey was posted on the home page of the Xiaomi forum, and the purpose of this work was explained on the first page of the questionnaire; individuals who take part in the survey may have a chance to get a prize. Due to the survey platform's rules, the questionnaires finished in less than a minute would be discarded, and respondents couldn't submit incomplete questionnaires. We also checked respondents' identities via email addresses and Ips to avoid potential replications. The survey lasted for seven weeks, and 291 valid questionnaires were collected for the data analysis. The demographic characteristics of the respondents are shown in table 1.

V. DATA ANALYSIS AND RESULTS

Partial Least Squares (PLS) is a widely utilized method for dealing with latent variables with multiple indicators in a single model, which employs component-based estimation and maximizes the variance explained in the dependent variable [69], [70]. PLS has less demand on sample size and is suitable when research data is non-normally distributed; it is a preferred approach for theory development, exploratory research, and existed theory extension [69], [70]. As the primary purposes of this work are to extend computer self-efficacy theory and explain the endogenous constructs' variance, we applied the PLS technique to test the research model.

A two-step approach to was used to perform the data analysis: first, the quality of the measurement model was evaluated via reliability and validity test.; second, the structural model was employed to test the hypotheses. We utilized SmartPLS version 3.2 to conduct the data analysis in our work [71].

A. RELIABILITY AND VALIDITY

We assessed the discriminant validity, convergent validity, and reliability of all the constructs to verify the measurement model. Table 2 shows that the values of composite reliability (CR) and Cronbach's Alpha of the constructs were greater than 0.7, indicating adequate reliability [70], [72]. Moreover, to prove the convergent validity, the item loadings should exceed 0.7, and the average variance extracted (AVE) of the constructs should be greater than 0.5 [73]. Table 2 reveals that all the constructs' AVEs and all indicator loadings meet the requirements, indicating adequate convergent validity.

Three criteria were utilized to evaluate the discriminant validity: first, Hair et al. considered that the factor loading indicators on the assigned construct must be higher than all loading of other constructs with the condition that the cut-off value of factor loading is higher than 0.70 [69]. We performed a cross-loading analysis and confirmed that our data met the criterion. Second, Kline suggested that when the heterotrait-monotrait ratio of correlations (HTMT) among the constructs are below 0.85, the measurement model has an adequate level of discriminant validity [74]. The HTMT of our study was computed, as shown in table 3, and the results revealed that all the correlation values among the constructs were below the recommended threshold value of 0.85; thus, all the constructs fulfilled this criterion. Third, Fornell and Larcker argued that if the correlations among the constructs are smaller than the square roots of the AVE for each construct, the model has an acceptable discriminant validity [73]. As shown in table 4, the elements on the diagonal (i.e., the square roots of the AVEs) are larger than those under the diagonal (i.e., correlations among the constructs), demonstrating good discriminant validity.

Since all the samples were collected with self-report measures simultaneously in this work, common method bias (CMB) might be a possible issue that should be tested. According to Podsakoff and Organ, Harmon's one-factor test was performed to evaluate the CMB [75]. The test results reflected that the first factor accounted for 30.9% of the variance. Therefore, no single factor accounted for most of the variance in the measurement model. Additionally, Pavlou et al. considered that when the correlations among the constructs exceed 0.9, the validity of the data may

TABLE 2. Construct statistics, reliability, and convergent validity.

Construct	Item	Mean	SD	Loading	CR	Cronbach's Alpha	AVE
Continuance usage intention (CI)					0.924	0.875	0.804
	CI1	5.107	0.970	0.944			
	CI2	4.622	1.036	0.789			
	CI3	5.065	1.005	0.948			
High WSE (HW)					0.902	0.838	0.755
	HW1	4.313	0.924	0.854			
	HW2	4.557	0.824	0.872			
	HW3	4.457	1.019	0.880			
Harmonious work climate (HWC)					0.923	0.888	0.749
	HWC1	3.808	1.102	0.873			
	HWC2	4.275	0.963	0.866			
	HWC3	3.948	0.956	0.827			
	HWC4	4.182	0.940	0.893			
Reasonable task recommendation (RTR)					0.905	0.843	0.761
	RTR1	4.835	0.833	0.870			
	RTR2	4.292	0.908	0.856			
	RTR3	4.151	0.914	0.891			
Effective cooperation (EC)					0.892	0.819	0.735
	EC1	4.546	0.870	0.876			
	EC2	4.165	0.885	0.820			
	EC3	4.663	0.810	0.874			
Fair competition (FC)					0.923	0.876	0.801
	FC1	3.983	0.951	0.891			
	FC2	4.292	0.978	0.891			
	FC3	3.969	1.006	0.902			
Positive feedback (PF)					0.869	0.773	0.688
	PF1	4.715	0.884	0.808			
	PF2	4.653	0.877	0.858			
	PF3	4.330	0.995	0.821			

TABLE 3. The heterotrait-monotrait ratio of correlations.

Construct	CI	EC	FC	HW	HWC	PF	RTR
CI							
EC	0.460						
FC	0.269	0.400					
HW	0.668	0.378	0.211				
HWC	0.438	0.468	0.385	0.274			
PF	0.647	0.446	0.190	0.753	0.361		
RTR	0.458	0.421	0.238	0.774	0.296	0.658	

TABLE 4. Construct correlation and discriminant validity.

Construct	CI	EC	FC	HW	HWC	PF	RTR
CI	0.897						
EC	0.394	0.857					
FC	0.238	0.340	0.895				
HW	0.576	0.313	0.182	0.869			
HWC	0.386	0.405	0.337	0.242	0.866		
PF	0.538	0.355	0.160	0.605	0.309	0.829	
RTR	0.397	0.351	0.205	0.651	0.262	0.533	0.872

Note: The square roots of the average variance extracted (AVE) are shown on diagonal (in shade). For discriminant validity, the elements on diagonal should be larger than those under diagonal.

be influenced by the CMB [76]. Table 4 reveals that all the correlations among the constructs are below the 0.9 thresholds. Thereby, the CMB is not a significant issue for our study.

The variance inflation factor (VIF) values for the constructs in the research model were calculated to estimate multicollinearity concerns. Hair et al. suggested that the multicollinearity is not significant when VIF is below 10 [77]. We conducted the VIF tests, and the results showed that the VIF is below 3.09, which indicated no serious multicollinearity issue.

B. STRUCTURAL MODEL ANALYSIS

We employed the bootstrapping technique to determine the structural model's explanatory power and path significance to evaluate the research model and hypotheses. We set the sample size of bootstrapping to 500. The corresponding significance level and standardized path coefficients are shown in Figure 2.

Figure 2 shows that high WSE (=0.513, $p<0.001$) and harmonious work climate (=0.262, $p<0.001$) are strong predictors of continuance usage intention, supporting hypotheses H1 and H2. Regarding the predictors of high WSE, the evaluation result reveals that reasonable task recommendation (=0.449, $p<0.001$) and positive feedback (=0.355, $p<0.001$) affect the development of high WSE significantly, supporting hypotheses H4a and H7a. Meanwhile, effective cooperation (=0.261, $p<0.001$), fair competition (=0.215, $p<0.001$), and

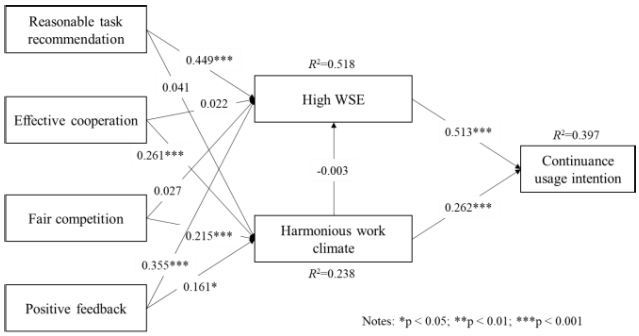

FIGURE 2. Structural model results.

TABLE 5. Path coefficients and significance level.

Paths	Path coefficients	T statistics	p values	f^2	Hypothesis support
EC→HW	0.022	0.355	0.723	0.001	Unsupported
EC→HWC	0.261	4.321***	0.000	0.069	Supported
FC→HW	0.027	0.559	0.576	0.001	Unsupported
FC→HWC	0.215	3.965***	0.000	0.053	Supported
HW→CI	0.513	8.067***	0.000	0.410	Supported
HWC→CI	0.262	5.485***	0.000	0.107	Supported
HWC→HW	-0.003	0.068	0.946	0.000	Unsupported
PF→HW	0.355	5.805***	0.000	0.175	Supported
PF→HWC	0.161	2.308*	0.021	0.023	Supported
RTR→HW	0.449	6.549***	0.000	0.285	Supported
RTR→HWC	0.041	0.572	0.568	0.001	Unsupported

Note: *p<0.05, **p<0.01, ***p<0.001.

positive feedback (=0.161, p<0.05) influence the formation of harmonious work climate. Thus, hypotheses H5b, H6b, and H7b are supported. Table 5 shows the statistics of paths.

The explanatory power of independent variables was measured with R2 values. As shown in Figure 2, the theoretical model explained 39.7% of the variance in continuance usage intention, 51.8% of the variance in high WSE, and 23.8% of variance in harmonious work climate. The significance of most path coefficients offers strong support for the proposed model. Additionally, the results for f2 in table 5 show that most paths supporting the hypotheses are more significant than 0.02 except H3, H4b, H5a, and H6a, which shows that the effect sizes of these paths are acceptable except H3, H4b, H5a, and H6a [78].

VI. DISCUSSION

This work aims to explore the determinants of individuals' continued participation in crowdsourcing innovation. We established the research model from the perspective of computer self-efficacy. The analysis results strongly support the proposed research model, and several findings need to be discussed.

First, the results confirmed the positive relationship between high WSE and continuance usage intention, which aligns with previous studies [33], [47], [48]. This result further highlighted that CIC is vital in organizing CI activities. As asserted, the CIC members with high self-efficacy often exhibit more confidence when facing challenges and are more active in innovation events and interactions. They are in the dominant position of the innovation activities and have built strong social ties among the CIC members; therefore, their turnover cost is higher than the ones with low self-efficacy. The empirical results also confirmed the significant effects of a harmonious work climate forming the CIC members' continuance usage intention. This finding implies that the atmosphere can significantly influence participants' behavioral intentions, even in loosely organized virtual groups. Additionally, contrary to our expectation, a harmonious work climate was proved to exert no effects on high WSE, which is inconsistent with previous research [52], [53]. A harmonious work climate is characterized by positive relationships between colleagues and an absence of conflicts, which can create a sense of support and safety for individuals. This environment will likely foster a sense of confidence and self-assurance in individuals. However, in the virtual world, participants do not need to meet face-to-face and maintain good relationships with the people they don't like. Hence, a possible explanation for this result is that in the online context, participants can independently and freely complete most tasks without handling interpersonal relationships. The impact of work climate on self-efficacy is minimal. Further investigations are encouraged to examine whether there is an association between social relationships and self-efficacy in online communities.

Regarding the predictors of high WSE, we found that reasonable task recommendation and positive feedback positively affect the establishment of high WSE, which is consistent with the results of prior research [54], [65]. This finding indicated that participants' self-efficacy is mainly influenced by task publisher and operator-related factors in online crowdsourcing projects. If publishers and operators can decompose tasks reasonably and recommend them accurately, provide practical innovation and communication tools, and respond to users promptly and kindly, the participants' self-efficacy may be improved. Nevertheless, the results suggested that effective cooperation and fair competition didn't exert a significant influence on high WSE, which contradicts the previous literature that demonstrated a positive effect of collaboration and competition on individuals' self-efficacy [61], [62], [63]. In traditional innovation events, working cooperatively with others can provide individuals with support, feedback, and encouragement. Practical cooperation can allow individuals to learn from others, gain new perspectives, and develop new skills. Besides, fair competition creates a level playing field where individuals have equal opportunities to succeed based on their skills and abilities. When individuals participate in fair competition, they often learn new skills and improve existing ones, which can increase their sense of competence. However, individuals in the virtual environment cannot interact, collaborate, or compete face-to-face with other users, leading to a lack of realism and security. The benefits,

such as gaining new perspectives and developing new skills, obtained by participants from the cooperation and competition in CI activities are relatively limited, which may not enhance their self-efficacy. Future research may explore the differences in forming self-efficacy between the online and offline contexts.

Moreover, effective cooperation, fair competition, and positive feedback were found to have strong effects on harmonious work climate. These results suggested that participants working together effectively can develop positive relationships, a sense of shared purpose, and belonging to the team. Effective cooperation can help create a sense of trust and loyalty among team members, which may promote mutual understanding, respect, and appreciation, creating a harmonious work environment. In addition, fair competition that encourages positive behaviors such as teamwork, collaboration, and mutual support can also motivate and create a shared sense of purpose and identity among team members. This sense of cooperation and shared goals can help promote a positive work climate. Besides, positive feedback is a powerful tool that can help individuals feel valued and recognized for their contributions, leading to increased motivation, job satisfaction, and well-being. When individuals receive positive feedback, it can lead to a sense of accomplishment and pride in their work, increasing their commitment and engagement in their tasks. Positive feedback can also contribute to developing positive relationships and trust among colleagues, which can help foster a harmonious work climate. Nevertheless, the relationship between reasonable task recommendation and harmonious work climate was insignificant, contradicting the prior research that considered proper work arrangement may improve work climate [55]. In traditional innovation, when individuals are assigned tasks that align with their skills and abilities, they feel more confident, leading to job satisfaction and positive morale, which can contribute to a pleasant work climate. However, in CI, if tasks are assigned without consideration for the individuals' skillset, they may be unable to perform to the best of their abilities, which may result in the participants quitting the task. Thus, unreasonable task recommendations in CI may cause participants to churn instead of a bad work environment. Further studies should be performed to investigate the influence of task recommendation and assignment on participants' behavior in CI.

VII. CONCLUSION

A. THEORETICAL IMPLICATIONS

The present research contributes to the study of CI in several aspects. First, we provide opinions regarding how participants' continued participation intention can be cultivated in the CICs. Since very few empirical studies have been done hitherto to explore individuals' sustained participation in CICs from the WSE perspective, we examined the effect of the constructs in promoting continuance participation by developing an integrated theoretical model. The research findings suggested that high WSE and a harmonious work climate significantly influence users' sustained participation; these results are consistent with prior literature [33], [47], [48], [51]. Our work lays a foundation for future research on individuals' participation in the online crowdsourcing innovation context from a perspective of WSE. Besides, the results negated our hypothesis about the relationship between harmonious work climate and high WSE, which contradicts prior studies [52], [53]. Further work may explore whether the insignificant correlation between these two constructs is due to the innovation context.

Second, although CIC has experienced rapid growth, little research has been conducted to probe its members' behavioral features. In addition, no empirical work explored the antecedents of WSE in the innovation context. Our research has taken an exploratory step. The analysis results proved that reasonable task recommendation and positive feedback play critical roles in developing individuals' high WSE, which is congruent with previous studies [54], [65]. Moreover, prior literature considered that good competition and cooperation might also cultivate individuals' self-efficacy [61], [62], [63]. But interestingly, our research results showed that these factors have no effects on the formation of individuals' high WSE, highlighting the distinctions between CICs and other kinds of professional online communities (e.g., knowledge-sharing platforms). This finding suggests many differences between virtual and offline cooperation/competition; face-to-face communication may be essential in developing individuals' self-efficacy. Hence, more in-depth investigations of the precursors of high WSE in CI are necessary.

Third, this study probed the predictors of the harmonious work climate in the CI context and found that effective cooperation, fair competition, and positive feedback affect participants' perceived harmonious work climate, consistent with previous studies [6], [60], [64]. These results revealed that the formation process of a friendly work environment in the CIC is similar to the ones in traditional innovation. Furthermore, contrary to our hypothesis, reasonable task recommendation was proved to have no impact on the harmonious work climate. The result is odd with prior studies, which claimed that reasonable task arrangement plays a positive role in promoting the development of a harmonious work climate [55], [56]. Since participants of online task distribution websites can quit the projects when they meet the unreasonable task allocation, the task recommendation may exert a relatively limited influence on the work climate. This study offers a possible direction for future explorations to investigate the effects of task assignments on CI participants' behavior.

B. PRACTICAL IMPLICATIONS

Our research also provides several practical implications for CIC management. First, the research findings confirmed the influence of high WSE on users' continued participation intention. Therefore, the CIC operators should put more effort into strengthening service capacities. One way to strengthen

TABLE 6. Measurement items.

Item	Question	Source
	Continuance usage intention	adapted from [6], [7]
CI1	I would say positive things about Xiaomi Forum to my friends and relatives.	
CI2	I would recommend Xiaomi Forum to someone who seeks my advice.	
CI3	I plan to continue using Xiaomi Forum in the future.	
	High WSE	adapted from [47]
HW1	I feel confident mastering the various functions of Xiaomi Forum.	
HW2	I feel confident finding suitable innovation tools in Xiaomi Forum.	
HW3	I feel confident participating in the online crowdsourcing innovation events hosted by Xiaomi Forum.	
	Harmonious work climate	adapted from [10], [52]
HWC1	I feel wanted and needed in the online crowdsourcing innovation events hosted by Xiaomi Forum.	
HWC2	Both operators and members of this community are amicable.	
HWC3	Most members of the Xiaomi Forum behave in a consistent manner.	
HWC4	Participants in Xiaomi Forum are seeking better ways of innovating and interacting.	
	Reasonable task recommendation	
RTR1	I can complete the tasks recommended by Xiaomi Forum.	
RTR2	The tasks recommended by this community match my abilities and expertise.	
RTR3	Most of the tasks recommended by Xiaomi Forum with precise descriptions and objectives.	
	Effective cooperation	adapted from [66]
EC1	In the CI projects hosted by Xiaomi Forum, the division of labor among most participants is reasonable and clear.	
EC2	Most community members are willing to cooperate to achieve innovation goals.	
EC3	Most collaborative tasks in Xiaomi Forum are completed on time, with quality and quantity guaranteed.	
	Fair competition	adapted from [67], [68]
FC1	Most members of Xiaomi Forum participate in competitions under the constraints of community rules and regulations.	
FC2	Few members of Xiaomi Forum use unfair means in competition.	
FC3	Community managers have proposed numerous measures to ensure fairness in competition.	
	Positive feedback	adapted from [6]
PF1	Other members of the Xiaomi Forum consider my posts valuable.	
PF2	Other members of the Xiaomi Forum responded to my posts friendly.	
PF3	The operators of Xiaomi Forum always respond positively to my request.	

service capacities is to enhance the analysis ability of user capability characteristics. By analyzing user capability features, such as skills, experience, and expertise, the community operators can recommend tasks more accurately to users, reducing task rejection and improving overall task quality. This can promote user engagement and satisfaction, leading to a more vibrant and collaborative community. Another critical aspect of strengthening service capacities is to respond to users timely and friendly. Convenient and friendly responses can help build trust with users and foster a positive culture of communication and collaboration. It can also help mitigate potential issues or misunderstandings, promoting a better atmosphere.

Second, a harmonious work climate influences users' continuance intention significantly. The community managers are expected to throw more measures to promote effective cooperation and fair competition. Effective cooperation is essential in the CIC, and community operators need to implement measures that promote collaboration among members. Some measures that managers can take include providing incentives for cooperation and teamwork, fostering a culture of mutual respect and communication, and creating opportunities for members to work together on projects or tasks. These measures can help to build trust and foster collaboration, leading to a more vibrant and prosperous community. Fair competition is also essential in CICs, and managers must ensure that the competition remains healthy and fine. One way to promote fair competition is to implement clear and transparent guidelines and rules that govern the competition. These guidelines should be communicated clearly to all members to ensure everyone has a fair chance to compete.

Moreover, the CIC operators should provide users with appropriate training and support to complete tasks more efficiently and effectively. This can include providing training resources, tutorials, and helpdesk support to address any issues or concerns that users may have. Enhancing service capacities can promote user learning and growth, leading to a more innovative and collaborative community.

Finally, community managers can put in place monitoring mechanisms that allow them to detect and prevent fraud, cheating, or any other misconduct that may undermine the integrity of the competition. This can include implementing security measures to prevent cheating, such as using secure platforms or tools to detect plagiarism and other types of cheating.

C. LIMITATIONS

As with all empirical research, our work is also restricted by some limitations. First, our study's sample includes only Chinese-speaking users of CICs. Thus, the analysis results have limited generalizability to CICs in diverse cultures.

More extensive work is expected to demonstrate if these findings could be extended to other countries and regions.

Second, since the analysis data were collected by anonymous online survey, we could not cross-validate their self-reported measures for the extent and tenure of usage or track the respondents' actual future behavior. Future research may employ supplementary data on participants' sequent acts to follow their further behavior accurately.

Third, as our study aims to explore the precursors of CIC members' sustained participation from the WSE perspective, the constructs applied in the study cannot fully reflect all determinants. Hence, future studies are encouraged to probe other factors motivating the formation of CIC participants' sustained participation to extend existing research.

APPENDIX
MEASUREMENT ITEMS

See Table 6.

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