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Article

How Collective Intelligence Fosters the Development of Incremental Innovation Capability

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Abstract: The study is to identify motivational factors that lead to collective intelligence and to understand how these factors relate to each other and to innovation capabilities in enterprises. The relationships between each of the sub-factors of the collective intelligence construct with the sub-factor of incremental innovation were examined. The study used the convenience sampling of corporate employees who use collective intelligence from corporate panel members (n=1500). Collective intelligence was found to affect work process, operations, and service innovation. This suggests that as work processes are made more innovative, the more actively collective intelligence is pursued, the greater the improvement in the performance of work processes, work procedures, work efficiency, customer satisfaction, and services. This study provides significant implications for corporations operating collective intelligence services such as online communities. First, such corporations vitalize their services by raising the quality of information and knowledge shared in their communities. Additionally, contribution motivations that take the characteristics of knowledge and information contributors into consideration require further development.

Keywords: Collective Intelligence; Social Contribution Motivation; Personal Contribution Motivation; Work Process, Operation; Service Innovation; Incremental Innovation Capability

1. Introduction

The ubiquity of information communication technologies increasingly brought on by recent breakthrough developments is becoming apparent as a means of inducing intrinsic yet innovative change across corporate management practices. Competition is becoming fiercer among corporations that are fighting for survival amidst a rapidly changing global economic environment. As a result, corporations have been keen on finding ways to build innovative capacity, which has required the introduction of collective intelligence as a means of solving problems through exchange and cooperation with groups that are both internal and external to a corporation.

Several researchers have raised the idea of launching a community focused on collective intelligence (here after CI) for the common good over recent years [1]. The challenges and opportunities in applying collective intelligence in enterprises are necessary to improve the effectiveness of decision making or to solve various business issues [1,2]. The possibility of combining collective intelligence with existing corporate perspectives, such as rapid decision-making and efficient use of internal resources, is becoming a key factor in determining future sustainable development.

"Collective intelligence increases the capacity for effective action in pursuit of common aims and finding emergent and sustainable solutions to the complex problems" [3].

The internal capacities of a corporation have perhaps reached their limit, and a new source of competitiveness is desperately needed to develop sustainable management practices. From the perspective of the business environment, collective intelligence is derived from the activities of internal and external participants who cooperate and compete to find solutions to difficult problems that typically cannot be solved by a specialized pool of professionals within a corporate organization.

However, research is lacking when it comes to identifying cause-and-effect relationships associated with collective intelligence. Moreover, previous studies did not cover to build a theoretical model that explains the relationship between collective intelligence and incremental innovation. Therefore, this study aims to explore motivational factors that lead to collective intelligence and understand how these factors relate to each other and to innovation capabilities in enterprises. The relationships between each of the sub-factors of the collective intelligence construct with the sub-factor of incremental innovation were examined. The perspective from the rsult will provide valuable data to support effective decision marking and various organizational strategies.

2.Literature Review

2.1. Collective Intelligence

Research on collective intelligence has explored the capabilities of a collective [4-6]. Collective intelligence is a topic that has typically been studied and applied in the fields of sociology, business management, and computer science; however, today it is being applied across all social phenomena. Collective intelligence, also known as swarm intelligence, has been a major interdisciplinary topic of research in the fields of entomology, sociology, computer science, and others [7]. Collective intelligence enables an idea to have a greater impact than any individual's idea on its own as a result of a process whereby the individual idea is combined with and evolves with others, creating a synergy effect. Wikipedia, a free encyclopedia created by the public where thousands of web users contribute written and edited articles based on their knowledge and information, was the first example of a website showcasing the existence of collective intelligence. Wikipedia is considered by some to be the most successful case of public collective intelligence in history.

The definition of collective intelligence varies. CI has been defined as the ability of a group to arrive at a solution that is better than what any of the members has achieved individually; it has also been defined as groups of individuals doing things collectively that seem intelligent [8,9]. Some scholars have defined

"CI as the capacity of human communities to evolve towards higher order complexity and harmony through such innovation mechanisms as variation-feedback-selection, differentiation-integration-transformation, and competition [10]".

Collective intelligence entails a process whereby individuals share, cooperate, and integrate their knowledge, information, and ideas, resulting in an intellectual capability that surpasses the intellectual capability of individuals; this process also results in the capabilities of a collective formed by the participation in and sharing of information and knowledge of many individuals [9]. Thus, collective intelligence has some characteristics that include the creation of new knowledge through co-creation with others as well as leading participation. Collective intelligence is assumed to be a collection of rational judgments made by individuals and is considered to be a source of better judgment than is possible with a small group of specialized professionals or the combined capabilities of an individual.

CI is a form of intelligence that results from mutual engagement between people, which is thought to result in better solutions to problems than would otherwise be possible due to the synergistic effects that result from the collective handling of tasks and the aggregation of advice and criticism [11]. Collective intelligence is especially suited to work that demands innovation or creativity [5]. The collective intelligence approach adds a new perspective to technology to support energy awareness and eco-friendly choices [12,13]. Surowiceki argued that collective intelligence can move markets and society and that a collective always produces wiser judgments than an individual [4]. CI tools are conceived for situations of uncertainty about the impact of actions; collective intelligence can also be a valuable marketing tool [10].

The general idea behind collaboration is the notion that it is an activity that elicits a self-driven response among individuals vying to reach a common goal [14]. In the case of Wikipedia, active corrections and editing activities occur [15]. Leadbeater explains collective intelligence on the web based on Web 2.0 characteristics such as participation, sharing, and openness. Collective intelligence requires participation [16]. Individuals must be able to easily express their opinions, register new viewpoints, and solicit opinions from other sources. Collective intelligence emerges through continual voluntary participation of individuals.

Leadbeater emphasizes the importance of collaborative creativity and mentions participation, cooperation, openness, and sharing as necessary factors for collective intelligence. He argues that collaborative creativity results in the active formulation of ideas through the process of sharing and opening ideas between individuals that are later combined [16]. Sulis perceived collective intelligence as a probability-based aggregation of multiple semi-independent participants who communicate their ideas and freely engage with them in discussions within their environments [17]. Corporations are exploring various means of applying collective intelligence to business practices and are especially keen on utilizing collective intelligence to establish creative problem-solving methods.

Based on methods of mutual engagement and the level of cooperation, Dutton classified collective intelligence into three types: the sharing type, the contributing type, and the co-creating type [18]. These three

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classifications can be distinguished by their methods of mutual engagement. Sharing collective intelligence is typified by activities such as simple release of information and individual, one-on-one forms of mutual engagement. Contributing collective intelligence is typified by activities such as dialogue among participants as well as active responses regarding opinions, knowledge, and information. The active responses considered in this instance involve the evaluation of the opinions, information, and knowledge of one's counterpart that serve as the basis for developing opinions, information, and knowledge. Co-creating collective intelligence is typified by various active methods of mutual engagement, such as updating, editing, and debating, which seek to fine-tune opinions that lead to the production of knowledge or information. From this perspective, collective intelligence building through participants has included users' positive participation in space to develop personal knowledge, their career and recognition of their capability. The second aspect is that collective intelligence building through sharing, which includes tools to seek solutions to their problems and share and acquire new knowledge or information. The last aspect is that collective intelligence building through co-creation includes users' operation or management forming knowledge or information through collective intelligence. Thus, three types of collective intelligence building through participation, sharing, and co-creation are applied to this study.

2.2. Motivation Theory

This study begins its exploration of the motivational factors that lead to collective intelligence by examining the TPB and TRA (e.g., Theory of Planned Behavior and the Theory of Reasoned Action) proposed by Fishein and Ajzen [19]. These theories explain the psychological mechanisms at play that affect attitudes that lead to certain behaviors. The motivation behind the sharing of knowledge in online communities can be explained as an organized civil movement not influenced by any direct or clear perceptions of compensation carried out at the discretion of individuals [20].

Other scholars are also attempting to explain user motivations for knowledge sharing by applying expected compensation from economic exchange theory, expected association from social exchange theory, and expected contribution from social cognitive theory as variables that affect knowledge sharing [21]. The subjective norms and perceived behavioral controls that underlie knowledge sharing are closely related to knowledge donation and knowledge collection [22]. Liao, To and Hsu attempt to explain the knowledge-sharing attitudes of knowledge users by dividing them into groups motivated by utilitarian or hedonic motivations [23]. Wasko and Faraj add external rewards, a type of individual motivator, as a variable to explain the knowledge-sharing process [24].

The dispositions of people who contribute to collective intelligence compared with those of people who do not may differ. Nov provides a pioneering insight into this notion in his study exploring motivational factors among Wikipedians [25]. Nov adds two categories of motivation to categories posited in earlier studies that comprise six categories of motivation behind the behavior of volunteers—protective, values-based, career, social, understanding, and enhancement—namely fun and ideology, for a total of eight contribution motivations.

Through a series of surveys, Rafaeli et al. uncovered, in order of importance, cognitive needs (e.g., the desire for information acquisition or intellectual challenge), affective needs (e.g., the desire for emotional experiences), and integrative needs (e.g., the desire to share knowledge with others or contribute to others) as the contribution motivation behind Wikipedia. As additional topics of research related to motivation, Rafaeli and colleagues propose exploring the relative importance of psychological, social, communal, economic, gratifying, and mutually engaging aspects among various motivational factors [26].

Based on previous discussions, this study attempts to explain the motivation behind the use of collective intelligence by dividing the motives into groups reflecting social or individual objectives. In other words, the contribution motivations behind collective intelligence were categorized into social contribution motivations and individual contribution motivations. The former includes knowledge sharing, content correction, answering the questions of others, recognition of capability and acquisition of greater reputation, and a preference for knowledge cooperation. Individual contribution motivations include acquisition of new knowledge, expectations of responses from others, tangible and intangible compensation, exhibition of knowledge, and benefits to career development.

2.3. *Incremental Innovation*

What is an incremental innovation? Some scholars have argued that it is defined as "not-radical" [27], which can be seen as an unsatisfying definition. Theoretical contexts that touch on the topic of incremental innovation include innovation and technology studies and industrial organization literature.

Taruss, Boit, and Korir defined as

"incremental improvements to existing products, services and organizational routines can enhance performance, quality, and usefulness and are vital to making more competitively advanced products and services [28-31]".

Incremental innovation vies for improvements in the status quo and is both continual and improves on

existing assets. Previous research divides incremental innovation factors into three categories: work process and procedure innovation, operational innovation, and service innovation [8,32]. First, work process and procedure innovation are related to the recycling and partial substitution of items associated with the production or specifications of a product. For instance, in terms of the field of service, this implies innovation associated with the simplification of management processes, work processes, or existing internal regulations; reduction of costs; and enhanced work efficiency [33,34].

Second, operational innovation includes innovations associated with redesigning methods and work plans for manufacturing products, and changes in methods, numbers of operations, and services related to reliability and quality. Third, service innovation includes innovations associated with the integration of lower-tier systems aimed at reconfiguring production systems that provide flexibility in operations and facilities. In the service sector, this entails innovations associated with improved services and customer satisfaction and rapid customer service response to customer complaints [34]. In light of the above, this study attempts to understand how collective intelligence is related to incremental innovation, such as work processes, operations, and services innovation.

3. Hypotheses

3.1. The Relationship between Two Contribution Motivations and Collective Intelligence

Research by Nam, Ackerman, and Adamic includes altruism and the ability to learn as individual motivators of knowledge sharing [35]. Wasko and Faraj include external rewards, a type of individual motivator, as a variable to explain the knowledge-sharing process [24]. The process of sharing knowledge produces joy as it entails the thought of helping others. According to social exchange theory, knowledge contribution motivation variables affect attitudes regarding knowledge sharing, with attitudes regarding knowledge sharing affecting the intent to share knowledge, and the intent to share knowledge being closely related to the act of sharing knowledge [21]. According to the expanded TPB (theory of planned behavior), intent to share knowledge is affected by attitudes regarding knowledge sharing, subjective norms regarding knowledge sharing, technical norms regarding knowledge sharing, knowledge sharing itself, and limitations. The intent to share knowledge thereafter affects the act of sharing knowledge [36]. As shown in the above discussion, the assumptions that can be applied to motivation research regarding collective intelligence include categories of motivations such as protective, value, career, social, understanding, and enhancement as well as contribution motivations such as cognitive needs, affective needs, and integrative needs [26]. Thus, such individual motivators and social orientation relationships can be expected to affect the onset of collective intelligence. Therefore, this study intends to explore two contribution motivations for collective intelligence.

H1. Social contribution motivations are positively related to sub-factors of collective intelligence building through participating (H1-1), sharing (H1-2), and co-creation (H1-3).

H2. Personal contribution motivations are positively related to sub-factors of collective intelligence building through participating (H2-1), sharing (H2-2), and co-creation (H2-3).

Evaluations of collective intelligence may vary depending on the level of active evaluation of information or knowledge. The degree to which knowledge or information is produced is also expected to become an important factor in evaluating collective intelligence [14,15,18]. Boder predicts that collective intelligence will play an essential role in corporate knowledge management. He notes that collective intelligence will bring new knowledge and innovation that will resolve core problems faced by corporations and mentions the need to construct collective intelligence that includes the expertise of individuals associated with specialized knowledge of particular fields within an organization as well as cultural norms, informal networks, and strategic market-related knowledge [37].

Engel et al. noted that collective intelligence is a critical factor to improve decision making in groups and to produce higher group performance [38]. Collective intelligence was then shown to predict a team's future performance on more complex tasks [39]. It can be assumed that collective intelligence is built upon some combination of individual members' attributes and group structures, processes, and norms.

Innovation is in demand not only from corporations that are keen on adapting to globalization and rapidly changing domestic and international environments but also from governments and all other sectors that strive to bring change to organizations and processes to enhance competitiveness and adaptability. In general, innovation entails incremental or radical change associated with objects, thinking, and the status of progress or services [40]. As mentioned above, incremental innovation naturally occurs in the work environment or corporate work processes. Several studies clarify the relationship between a corporation's organizational structure and culture with incremental innovation. This study predicts that collective intelligence, a form of intelligence that encompasses knowledge and information produced through user participation, sharing, and collaboration created to improve individual work processes and procedures,

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product development, idea development, operations, and services, is closely related to incremental innovation. Most corporations emphasize process innovations that reduce costs, assist in product development, and make organizational management more efficient for the purposes of satisfying customer needs.

Taking into account the scholarly definition of incremental innovation, collective intelligence will play a significant role in improving corporate work processes, management procedures, and customer satisfaction services as well as enhancing work efficiency associated with idea development, product development, and strategic thinking. From the perspective, it is expected that collective intelligence-building leads to incremental innovation. Therefore, our hypotheses are stated as follows:

H3. Collective intelligence building through participation is positively related to work process innovation (H3-1), operation innovation (H3-2), and service innovation (H3-3) as sub-factors of incremental innovation.

H4. Collective intelligence building through sharing is positively related to work process innovation (H4-1), operation innovation (H4-2), and service innovation (H4-3) as sub-factors of incremental innovation.

H5. Collective intelligence building through co-creation is positively related to work process innovation (H5-1), operation innovation (H5-2), and service innovation (H5-3) as sub-factors of incremental innovation.

3.2. Suggested Research Model

To guide the analysis of the data collected for this study, the study devised the following suggested research model to illustrate the relationships between the two contribution motivations, collective intelligence, and incremental innovation (Figure 1).

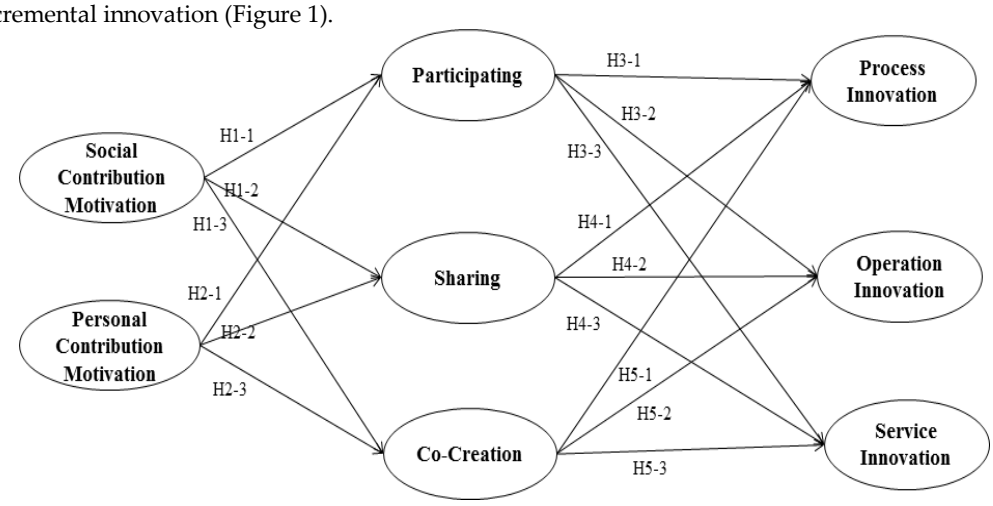

Figure 1. Suggested Research Model

4. Method

4.1. Sampling and Data Collection

A pretest was administered to 30 corporate employees who use collective intelligence. The measurement tools used in the study and based on the literature review related to participants' motivations and were also measured as exogenous variables; collective intelligence, acceptance intention, and incremental innovation were also measured as endogenous variables. The study used the convenience sampling of corporate employees who use collective intelligence from corporate panel members. They were then contacted by e-mail and phone and were asked to participate. The explanation of collective intelligence was placed in the first section of the questionnaire. A total of 1,500 corporate employees participated in this study and were given gift cards by the investigator.

As seen in Table 1 below, over 75% of participants were 20–49 years of age and over 90% had received college-level instruction. On average, respondents occupied positions in accounting and management, strategic planning, production and research, and operations.

Table 1. Demographic Profiles

n=1500		*Frequency*	*%*
Sex	Male	760	50.7
	Female	740	49.3

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Education	High School	102	6.8
	College Student	367	24.5
	Bachelor's degree	678	45.2
	Over M.A Degree	353	23.5
Ages	20–29 years	361	24.1
	30–39 years	401	26.7
	40–49 years	367	24.5
	50–59 years	321	21.4
	Over 60 years	50	3.3
Position	Accounting and Management	455	30.3
	Operations	242	16.1
	Strategic Planning	318	21.2
	Production and Research	269	17.9
	Others	216	14.4
Firm Size	10 and fewer employees	219	14.6
	10–30 employees	284	18.9
	30–50 employees	138	9.2
	50–100 employees	199	13.3
	100–300 employees	272	18.1
	Over 300 employees	389	25.9

4.3. Instrument Construction

4.3.1. Exogenous Variables

Contribution motivations were measured by social and personal contribution motivations as exogenous variables. Social contribution motivations can be defined as embracing the objective of collective intelligence to share information, edit or modify content, resolve curiosity, co-create information, and acquire fame. Questions about social contribution motivations used in this study consist of a total of five items developed in light of the existing literature [25,26]. Personal contribution motivations comprise a total of five items developed from existing research by defining the degree of desire to acquire new information, expectation about another's responses, compensation, showing the ability to offer information, and work efficiency [20,21,23.24].

4.3.2. Endogenous Variables: collective intelligence, incremental innovation capability

Collective intelligence was classified with collective intelligence building through participation, sharing, and co-creation. Collective intelligence building through participation included users' positive participation in space to develop personal knowledge, their career and recognition of their capability. Collective intelligence building through sharing included tools to seek solutions to their problems and share and acquire their new knowledge or information. Collective intelligence building through co-creation included users' operation or management forming knowledge, or information through collective intelligence. Collective intelligence is assumed to be a collection of rational judgments made by individuals and is considered to be a source of better judgment than is possible with a small group of specialized professionals or the combined capabilities of a single individual. Measurement tools for collective intelligence used in this study consist of a total of 13 items taken from the existing literature [15,18,24,37].

Incremental innovation was measured by work process innovation, operation innovation, and service innovation. Work process innovation included degree of improvement over the past, management process, work efficiency and cost reduction. Operation innovation represented the degree of improvement of welfare, work satisfaction, and relationships with others in the organization. Service innovation was defined as the degree of improvement in customer service, response to complaints, and satisfaction. Twelve items for incremental innovation were developed or adopted from previous studies [8,32-34]. All items used in this study were scored on 5-point Likert scales.

Appendix A. Statistics of Construct Items

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Construct	*Survey Measures*
Social contribution motivation	I wish to contribute my knowledge for the purpose of sharing it with others (sharing contribution)
	I wish to add or correct wrong information in the public based on my knowledge (addition · correction)
	I wish to help others find answers to their questions (answer questions)
	I wish to exhibit my knowledge to large numbers of people (knowledge exhibition)
	I like to cooperate with others to create knowledge (knowledge collaboration)
Personal contribution motivation	I can acquire new knowledge and skills by contributing (skill acquisition)
	I find it helps my career (career development)
	I am curious about the responses of others regarding my knowledge (response of others)
	I like to be compensated for the provision of knowledge (tangible/intangible compensation)
	I wish to be recognized for my capability and seek a greater reputation (recognition and reputation)
Participation	I can easily express my work-related opinions using collective intelligence
	I can easily post work-related opinions using collective intelligence
	I can easily solicit work-related opinions from other organization members using collective intelligence
	I can express work-related ideas using collective intelligence.
	I can post unique work-related opinions to organization members using collective intelligence
Sharing	I use collective intelligence to acquire new knowledge or information
	I use collective intelligence to share knowledge or information with other people
	I use collective intelligence to acquire knowledge or information not found in other places
	I use collective intelligence to find solutions to my problems
	I like to post new writings, pictures, and videos using collective intelligence
Co-Creation	I use knowledge or information from collective intelligence after correcting, editing, or reprocessing it
	I directly operate or manage a means of collective intelligence
	I make an effort to continually post new information to collective intelligence
Process Innovation	In-house rules and work processes have improved compared with the past
	The management process has improved compared with the past.
	The purposes of reducing costs have improved compared with the past.
	The work efficiency has improved compared with the past.
Operation Innovation	The welfare of employees has improved compared with the past.
	Work satisfaction among members have enhanced compared with the past.
	The work of members has improved compared with the past.
	Personal relationships among workers have improved compared with the past.
Service Innovation	Visiting customers have increased compared with the past
	Customer satisfaction raised compared with the past.
	Our response to customer complaints have improved compared with the past.
	The speed of customer service has improved compared with the past.

5. Data analysis

5.1. Assessment of the Measurement Model

To analyze the data, the study used EQS6b and SPSS. In order to verify the hypotheses proposed in this study, correlations, validity and reliability were examined. We conducted verification tests to determine tests for the measurement model's validity using EQS6b. As shown in Table 2 and 3, the standard acceptance norm satisfies the requirement of reliability and validity by suggested by Bagozzi and Yi [41] and Hair et al [42] and composite construct reliability and Average Variance Extracted (AVE) following Fornell and Larker [43]. Discriminant validity was assessed by comparing the correlation of components to AVE. As seen in Table 2, the

result of Bartlett's test of sphericity was found to be significant (χ^2=7959.3, *df* =741, p< .001), while the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.947 for the variables [44]. The result of the EFA (exploratory factor analysis) were described in Table 2. An exploratory factor analysis of all of our scale items revealed two factors explaining 56.08% of the variance in our study's constructs, with the first factor explaining 30.42% and the last factor explaining 25.67% of the total variance for independent variables. Discriminant validity was assessed by comparing the correlation of components to AVE.

Table 2. Results of Factor Analysis

Independent Variables			*Mediated Variable*		
Construct	Items	F.L	Construct	Items	F.L
	SCM1	.758	Co-Creation	COC1	.845
	SCM2	.778		COC1	.863
Social Contribution	SCM3	.764		COC1	.846
Motivation	SCM4	.791		COC1	.916
	SCM5	.794	Dependent Variables		
			Process Innovation	PI1	.938
Personal Contribution	PCM1	.793		PI1	.934
Motivation	PCM2	.802		PI1	.837
	PCM3	.812		PI1	.747
	PCM4	.789		PI1	.840
	PCM5	.762	Operation Innovation	OI1	.847
Mediated Variables				OI2	.830
Participation	PAR1	.734		OI3	
	PAR2	.690		OI4	.808
	PAR3	.725	Service Innovation	SI1	
	PAR4	.702		SI2	
	PAR5	.723		SI3	
Sharing	SHA1	.693		SI4	
	SHA2	.723			
	SHA3	.704			
	SHA4	.791			

Independent Variables			Dependent Variables		
Factor	Eigenvalues	% of Variance	Factor	Eigenvalues	% of Variance
Factor 1	4.183	30.416	Factor 1	4.355	27.217
Factor 2	1.425	25.663	Factor 2	3.849	24.056
% of total variance extracted		56.079	Factor 3	3.064	19.149
			% of total variance extracted		70.422

Mediated Variables		
Factor	Eigenvalues	% of Variance
Factor 1	3.645	29.042

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Factor 2	2.929	22.528
Factor 3	1.761	13.546
% of total variance extracted		64.116

Note: F.L: Factor Loadings.

As seen in Table 3, the Cronbach's alpha mean for all concepts is above 0.7 [44]. The study's AVE also satisfies the standard of 0.5 for the requirement for convergent validity.

Table 3. Internal Consistency of the Constructs

Variables	*Items*	*M*	*S.D*	*α*	*C.R*
Social Contribution	5	3.71	0.55	.804	.882
Personal Contribution	5	3.68	0.54	.835	.930
Participating	5	3.69	0.52	.803	.880
Sharing	4	3.74	0.56	.810	.885
Co-Creation	4	3.16	0.81	.844	.898
Process Innovation	4	3.44	0.67	.837	.937
Operation Innovation	4	3.40	0.74	.893	.958
Service Innovation	4	3.38	0.78	.916	.967

Note: M: Mean, S.D; Standard Deviation, α: Cronbach's alpha, C.R: Composite Reliability

As seen in Table 4, the extracted AVE is between .648 and .764, and the means of the squares of the correlation coefficients are between -.001 and .482, which results in an AVE that is higher than the means of the squares of the correlation coefficients (r^2), also ensuring that the data collected for verification have sufficient discriminant validity [43].

Table 4. Analysis of Discriminant Validity using Average Variance Extracted

	AVE	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	.673	1							
2	.764	.013	1						
3	.769	.482	.111	1					
4	.648	.328	.063	.366	1				
5	.687	.324	.139	.041	.012	1			
6	.749	.001	.200	.041	.011	.120	1		
7	.751	.159	.278	.119	.014	.133	.387	1	
8	.760	.005	.107	.022	.060	.010	.344	.507	1

Note: * squared the correlation coefficients, 1: Social Contribution, 2: Personal Contribution, 3: Participating, 4: Sharing, 5: Co-Creation, 6: Process Innovation, 7: Operation Innovation, 8: Service Innovation

5.2. Tests of Hypotheses

As proven previously, hypotheses for this study based on the research model satisfy the advised base values. The goodness of fit of the model hypotheses yielded χ^2=(11107.2)=652, p=.000, CFI=.946, NFI=.908, NNFI=.946, GFI=.878, AGFI=.858, SRMR=.110, RMSEA=.048, which means that the model's goodness of fit satisfies the advised base values.

Table 5. Summary of Hypothesis Tests

Hypothesis	*S.E*	*Standardized Coefficient*	*Support*

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H1-1: Social Contribution -> Participating	.035	.213***(.278)/z=7.763	Yes
H1-2: Social Contribution -> Sharing	.144	.317***(.402)/z=10.211	Yes
H1-3: Social Contribution -> Co-Creation	.052	.325***(.503)/z=11.012	Yes
H2-1: Personal Contribution -> Participating	.054	.492***(.571)/z=12.352	Yes
H2-2: Personal Contribution -> Sharing	.071	.664***(.744)/z=13.423	Yes
H2-3: Personal Contribution -> Co-Creation	.056	.532***(.602)/z=12.985	Yes
H3-1: Participating -> Process	.055	.249***(.307)/z=8.974	Yes
H3-2: Participating -> Operation	.063	.210***(.346)/z=13.321	Yes
H3-3: Participating -> Service	.058	.356***(.472)/z=15.742	Yes
H4-1: Sharing -> Process	.052	.291***(.395)/z=14.213	Yes
H4-2: Sharing -> Operation	.048	.259***(.325)/z=10.855	Yes
H4-3: Sharing -> Service	.055	.309***(.412)/z=10.512	Yes
H5-1: Co-creation -> Process	.056	.307***(.410)/z=10.103	Yes
H5-2: Co-creation -> Operation	.068	.306***(.406)/z=11.317	Yes
H5-3: Co-creation -> Service	.075	.392***(.502)/z=12.308	Yes

Notes: *** p<.05, (Unstandardized) Coefficient

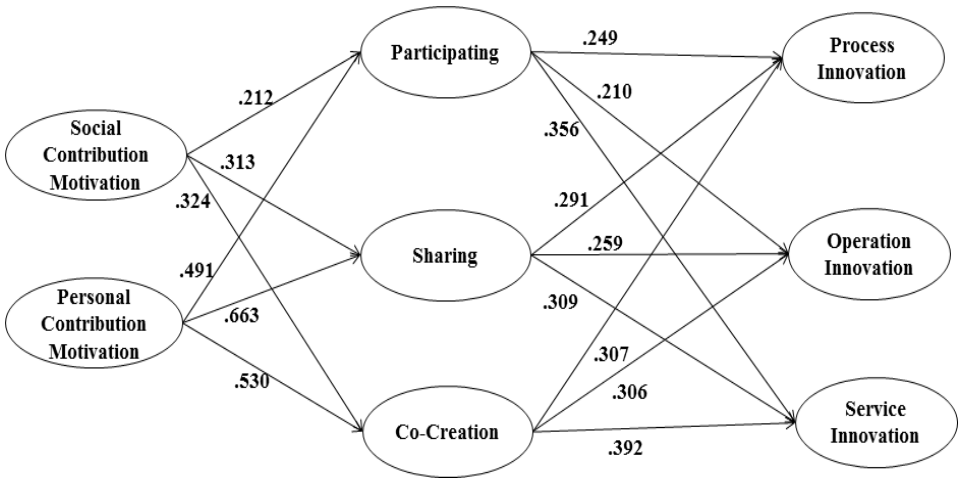

Figure 2. Results of Suggested Research Model with Path Coefficients

To test structural relationships, the hypothesized causal paths were estimated. Eight hypotheses were supported, and one was not supported. The results are shown in Figure 2 and Table 4. For H1-1, H1-2, and H1-3, the results indicate that social contribution motivations are closely related to collective intelligence building through participation. The suggested path was statistically significant in the hypothesized direction (social contribution motivations, with a standardized path coefficient for collective intelligence building through participating: γ= .213, p< .001 for H1-1). Thus, hypothesis H1-1 was supported. Social contribution motivations are closely related to collective intelligence building through sharing. The suggested path was significant in the hypothesized direction (social contribution motivations, with a standardized path coefficient for collective intelligence building through sharing: γ= .317, p< .001 for H1-2). Thus, hypothesis H1-2 was supported. Social contribution motivations are closely related to collective intelligence building through co-creation. The suggested path was statistically significant in the hypothesized direction (social contribution motivations, with a standardized path coefficient for collective intelligence building through co-creation: γ= .325, p< .001 for H1-3). Thus, hypothesis H1-3 was supported.

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For H2-1, H2-2, and H2-3, the results indicate that personal contribution motivations are closely related to collective intelligence building through participating. The suggested path was statistically significant in the hypothesized direction (personal contribution motivations, with a standardized path coefficient for collective intelligence building through participation: γ= .492, p< .001 for H2-1). Thus, hypothesis H2-1 was supported. Personal contribution motivations are closely related to collective intelligence building through sharing. The suggested path was statistically significant in the hypothesized direction (personal contribution motivations, with a standardized path coefficient for collective intelligence building through sharing: γ= .664, p< .001 for H2-2). Thus, hypothesis H2-2 was supported. Social contribution motivations are positively related to collective intelligence building through co-creation. The suggested path was significant in the hypothesized direction (personal contribution motivations, with a standardized path coefficient for collective intelligence building through co-creation: γ= .532, p< .001 for H2-3). Thus, hypothesis H2-3 was supported.

For H3-1, H3-2, and H3-3, the results indicate that collective intelligence building through participation is closely related to process, operation, and service innovation as sub-factors of incremental innovation. The proposed path was statistically significant in the hypothesized direction (collective intelligence building through participation, with a standardized path coefficient for process, operation, and service innovation: γ= .249, .210, 356, p< .001 for H3-1, H3-2, and H3-3, respectively). Thus, hypotheses H3-1, H3-2, and H3-3 were supported.

For H4-1, H4-2, and H4-3, the results indicate that collective intelligence building through sharing is closely related to process, operation, and service innovation as sub-factors of incremental innovation. The suggested path was statistically significant in the hypothesized direction (collective intelligence building through sharing, with a standardized path coefficient for process, operation, and service innovation: γ= .291, .259, 309, p< .001 for H4-1, H4-2, and H4-3, respectively). Thus, hypotheses H4-1, H4-2, and H4-3 were supported.

For H4-1, H4-2, and H4-3, the results indicate that collective intelligence building through co-creation is closely related to process, operation, and service innovation as sub-factors of incremental innovation. The suggested path was statistically significant in the hypothesized direction (collective intelligence building through co-creation, with a standardized path coefficient for process, operation, and service innovation: γ= .307, .306, 392, p< .001 for H5-1, H5-2, and H5-3, respectively). Thus, hypotheses H5-1, H5-2, and H5-3 were supported.

6. Discussion

This study proposes an acceptance model regarding corporate collective intelligence. The motivators of collective intelligence associated with corporate employees were divided into social and individual contribution motivations where such motivations were found to directly affect collective intelligence. The motivation for using collective intelligence was found to be more likely to come from social contribution motivations than from individual contribution motivations. Collective intelligence was divided into collective intelligence building through participation, sharing, and co-collaboration, and its relationship to incremental innovation was studied. The more knowledge that was shared with colleagues or strangers, the more tasks were undertaken via co-collaborative or creative efforts with colleagues. This result indicated that personal contribution motivation (e.g., career development) is a higher perception of collective intelligence than the social contribution motivation including sharing knowledge or collaboration with others

Such collective intelligence was found to be closely linked to work process, operation, and service innovations. Online communities used by corporations are products of collective intelligence. Such online communities are considered necessary for the effectiveness and efficiency of processing work. Additionally, corporate employees were found to have the desire to use collective intelligence to produce innovation in their work processes, operations and service.

This study provides significant implications for corporations operating collective intelligence services such as online communities. First, such corporations vitalize their services by raising the quality of information and knowledge shared in their communities. Contribution motivations that take the characteristics of knowledge and information contributors into consideration also need to be developed.

6.1. Theoretical Implications

The study attempted to identify cause-and-effect relationships associated with collective intelligence as well as explain a theoretical model that covers the relationship between collective intelligence and incremental innovation. The casual relationship and theoretical model suggested by study might be provide valuable assets for further study when exploring the classification of collective intelligence. They might also help in defining determinant factors leading to collective intelligence and in understanding how these factors relate to each other and to innovation capabilities in enterprises. The results of this study have valuable information to build

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or develop effective decision making based on collective intelligence as well as understanding the cause-and-effect relationships associated with collective intelligence in the academic area.

The results of this study indicated that collective intelligence is built upon some combination of individual members' attributes and group structures, processes, and norms. Collective intelligence plays an important role in improving decision making in groups; it also produces higher group performance and predicts a group's future performance on more complex tasks and problems [35,38].

The collective intelligence found within cyberspace, which is the topic of interest in this study, has been the focus in various academic fields. Human societies have cultivated collective intelligence through the utilization of science and technology while communicating shared intellectual capabilities and assets with one another. Humanity can overcome space and time limitations and achieve true integration that will lead to a new level of evolutionary accomplishment through collective intelligence. Therefore, exploring collective intelligence in cyberspace and the casual relationship between CI and any other outcome is a subject for further study.

Collective intelligence is difficult to achieve in traditional hierarchical structures. Collective intelligence requires freedom, volunteerism, and candid opinion formation. Collaborative leadership is important in such a context. Leadership that lends an ear to even obnoxious or seemingly nonsensical thoughts is needed.

Another point of caution when seeking the results of collective intelligence is that collective intelligence will not immediately produce positive results but must be systematically managed and organized by individual intelligence. In the case of Wikipedia, large numbers of people from the general public can freely add new content and edit articles, but a site manager must approve of the changes before they are applied to the website. Linux also allows various developers to freely add and correct its functions. However, Linus Benedict Torvalds and other core personnel have the final say in what items are to be included in the regular kernel build. Therefore, collective intelligence requires an appropriate mix of active participation by organizational members and also wise decision-making on the part of leadership.

Such collective intelligence yields powerful results in cases that require creative solutions such as the initial concept phase of developing new technologies or products. However, for proprietary items that must be kept confidential, or in areas that require extremely high levels of expertise, collective intelligence may be impossible or unnecessary. In light of this, the content to be shared for utilization by collective intelligence and its associated expected gains must first be clarified before making use of collective intelligence. Further research on collective intelligence needs to focus on corporate strategies or a comprehensive approach towards business architecture or user interfaces with the relevant services.

The rise in success cases involving collective intelligence has resulted in the expansion of its application across all corporate activities, including product development, marketing, product manufacturing, and customer support. Corporations willing to introduce collective intelligence must establish a platform from which it can work and establish a network that must be continually managed during the process. The establishment of windows of communication, an open and cooperative corporate culture, and participation by organizational members with varying knowledge and experience are needed where incentives for knowledge or information sharers may also prove to be useful.

6.2. Managerial Implications

In a digital society, a corporate organization improves performance, competitiveness, and productivity through division of knowledge. Corporations are formed from organic connections between groups (organizations). In light of these considerations, it is hoped that this study's results will help corporations tap into collective intelligence as a resource, improve its functioning, and inform its application in the corporate context.

The study might provide valuable information to support effective decision making and various organization strategies from the results. The results confirmed that collective intelligence is derived from the activities of internal and external participants who cooperate and compete in the process of finding solutions to difficult problems that typically cannot be solved by a specialized pool of professionals within a corporate organization. The study suggests that collective intelligence is one of the critical tools for developing work processes, operation, and service sector in organizations.

From a corporate standpoint, for the purposes of establishing an active online community that creates collective intelligence and for the purposes of improving levels of participation, openness, sharing, and collaboration, continual and systematic efforts are required. More references or external links that support the knowledge contributed by knowledge or information providers must be created. In addition, the pursuit of active participation by knowledge contributors and encouragement of greater collaboration were implicitly found by this study to contribute to the improvement of the quality and credibility of knowledge or information. For the purposes of having corporate employees create products or ideas, the belief that new

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knowledge can be created during the process of fine-tuning the various knowledge bases must be strengthened while pursuing the act of creating new knowledge itself.

Collective intelligence was found to affect work processes, operation, and service innovations. This suggests that during the process of making work processes more innovative, the more actively collective intelligence is pursued, the greater the improvement in the performance of work processes, work procedures, work efficiency, customer satisfaction, and services. This seems to point to a need to develop collective intelligence services that will raise levels of participation, sharing, and collaboration while also inspiring contribution motivations of collective intelligence. In other words, the introduction of a system such as Smartwork as the only focus will inevitably lead to difficulty in achieving even inconsequential outcomes and will counter expectations that the Smartwork system will contribute to enhancing work performance and job satisfaction.

Regarding the result indicating that collective intelligence is associated with incremental innovation, if corporations pursue active participation, sharing, and collaboration for the purposes of using collective intelligence services, then from an organizational or corporate management standpoint, the effects of decision-making processes as well as product and service development efforts will be improved.

From the study, it can be indicated that collective intelligence involves a process in which an individual's idea is combined with and evolves with other ideas to produce a force greater than can be expected from simply including the intellectual capabilities of each individual. In other words, a synergy effect is produced. When corporate employees work in an environment where collective intelligence is highly developed, work processing procedures or efficiency may differ depending on the onset of collective intelligence. This raises the importance of collective intelligence within an organization and implies the importance of finding means to vitalize collective intelligence.

By utilizing collective intelligence, for example, Procter & Gamble is reducing its share of research and development costs while continuing to post good performance. On the other hand, Monsanto is spending immense sums of money on research and development without producing any major products and is facing a crisis. Smooth mutual engagement, feedback, and active participation are methods that can raise collective intelligence. Additionally, corporate cultures must find efficient space in which employees can communicate.

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