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A Study on Quality Factors of Web Enabled Collective Intelligence as a Donor for Business Success

Normatov, R. Ismatilla* · Joo, Jae-Hun**

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Ⅰ. Introduction

As Information Technology (IT) has been rapidly developing and globalization also has been taking place in each and every corner business throughout the world (주재훈, 2009; Joo and Normatov, 2010, Park and Moon, 2007), collective intelligence (CI) has already become one of the determinants of successful competitive strategy of companies such as Threadless, InnoCentive, iStockphoto, Panda Security, and Wikipedia. There is no doubt that the emergence of the Internet, social networks, and other CI tools enabled collective intelligence and contributed heavily to its development. Organizations that realize the importance of CI in knowledge management and develop appropriate systems to adopt it in their service and product development are withholding their strong competitive advantage in the market. Individuals from all over the world are now participating in the process of creating valuable knowledge in social networks and bookmarks, blogs and wikis. However, it is important for organizations that are eager to apply CI in their businesses to consider what really motivates and drives individuals to participate in the CI process.

Therefore, it is necessary to identify the main

* Master course of Cooperative Department of Electronic Commerce, Dongguk University.
** Professor of Department of Information Management(Corresponding author), College of Business and Tourism, Dongguk University at Gyeongju.

factors that determine the quality of CI and build a comprehensive research model. Our main research question is: "*What are the factors that affect the quality of CI?*" Hence, in this study we are going to explore what CI is, what CI tools are, and why people participate in web enabled CI. Finally, our study investigates factors affecting the quality of web enabled CI by analyzing the case studies of our interest.

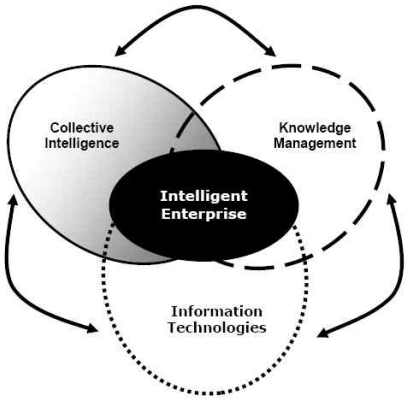
In this study, we investigate and present the nature of CI in a clear and understandable format. Many studies regarding CI are carefully examined, summarized, and presented in a logical sequence. Five cases of companies are analyzed and discussed to draw the main propositions regarding the quality of CI. Finally, we conclude and suggest the implications of the findings. It is worth noting that this study reveals important aspects and areas of CI to be utilized in further empirical studies. We believe that this study will be beneficial to both researchers and practitioners interested in the field.

Ⅱ. Literature Review

The concept of CI has been increasingly used among scholars. CI is relevant to sociology, business, computer science, and communications. The word "Collective intelligence" was widely used in ant-based research, which later developed as "Swarm Intelligence" (Bonabeu et al., 1999; Kennedy and Eberhart, 2001).

CI occurs only when there is an interaction or cross-fertilization between those participating in the task, generally more innovative than the intellectual capability of individuals working alone or in tandem (Weschsler, 1971). Russell (1995) and other scholars defined CI as an intelligence that emerges from the collaboration of many individuals and it has a mind of its own. Heylighen (1999) highlighted that the basic idea of CI is that a group of individuals (e.g., people, insects, robots, or software agents) can be smart in a way that none of its members is. Complex, apparently intelligent behavior may emerge from the synergy created by simple interactions between individuals. As such, CI can be defined as the ability of a group to solve more problems than its individual members.

CI is the capacity of human collectives to engage in intellectual cooperation in order to create, innovate, and invent (Surowiecki, 2004; Tovey, 2008). Zara (2004) suggested that to be competitive, firms should be "intelligent enterprises" who stand on three pillars CI, knowledge management, information, and collaboration technologies that are in turn continuously interacting, they are inseparable and complementary (Figure 1). The premise of CI is that collective performance surpasses the sum of individual performances and it is the capacity of an organization, or community, to ask questions and seek answers together (Zara, 2004).



<Fig. 1> The Three Pillars of Intelligent Enterprises (Zara, 2001)

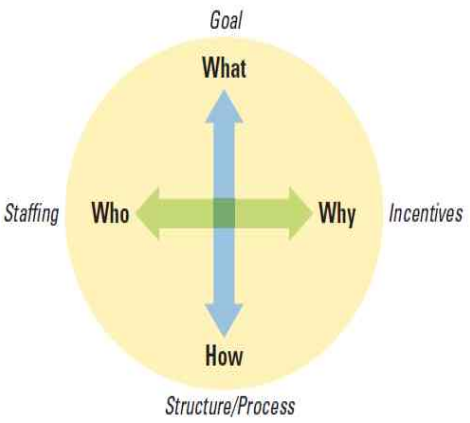
Yuan et al. (2007) defined the CI phenomenon as the capacity of communities to evolve toward higher order complexity thought, problem solving, and integration through collaboration and innovation. Through the study of animal behaviour, Pratt (2010) referred CI to a group of agents acting as a single cognitive unit to solve problems, make decisions, and carry out other complex tasks. He notes that CI emerges from local interactions among a large number of individuals, none of whom acts as a leader or central controller.

Nowadays, many scholars agree that never before have so many creative and knowledgeable people been connected by such efficient, universal networks (e.g., social web) and resulted in incredible breadth of information and diversity of perspectives. Also, Gruber (2007) referred to CI as a grand vision and defined the current state of the Social Web as collective intelligence: the value of user contributions is in their being collected together and aggregated into community- or domain specific sites (e.g., Flickr for photos, YouTube for videos, etc.) and allowing new companies with very modest budgets to provide innovative new services to millions of on-line participants. Narasimhan (2007) refers to the CI phenomenon as the property of a complex system consisting of many individual agents collaborating and competing with each other.

CI can be defined as the dynamic aggregation of cognitive, reasoning, and knowledge resources of humans supported by intelligent and networked information systems (Maio, 2009). CI is construed in terms of a) activity and b) outcome, rather than in terms of the supporting technology: CI is a) the generation, apprehension, and use of distributed information through collaborative processes and b) the knowledge or products resulting from such activity (Billman et al., 2010). Their perspective on CI concerns planning within an organization: "planning" —the process, we mean identifying events and scheduling them in time, with the intent to guide or anticipate future actions; "plan" —the product, we mean an externally represented specification of a (partially) ordered set of activities. In organizations, planning depends on CI and plans in turn provide input to CI (Billman et al., 2010). Gholami and Safavi (2010) closely relate CI to the popular open and participatory paradigms and have proven that a group of people having the same interests are smarter than even the smartest

of its members. They further continue that knowledge management as a recent attractive phenomenon in organizations depends on CI processes which enable knowledge to be externalized and made explicit.

There are several researches that have considered CI from various perspectives. Particularly, Malone et al. (2010) at MIT's Center for CI classifies collective intelligence in accordance with four questions: Who is performing the task? Why they are doing it? What is being accomplished? How is it being done? (Figure 2).The working definition of CI used in the ongoing study of CI by Malone et al. (2010) is that *CI is groups of individuals doing things collectively that seem intelligent*. That is, CI is the combination of individual intelligence, but as one Complex Adaptive System, it is more than the addition of individual intelligence.



<Fig. 2> Elements of CI "Genes" (Malone et al., 2010)

As the adaptive agents (individual intelligence) acted individually and mutually. CI is a shared or group intelligence that emerges from the collaboration and competition of many individuals and appears in consensus decision making in animals, humans, and computer networks.

Finally, Levy (2010) suggested that the best use of new technologies is not artificial intelligence (AI), but CI: not getting computers to imitate humans, but helping humans to think and develop their ideas collectively. He states that CI is a determining factor in competitiveness, creativity, and human development in a knowledge based economy, or in an economy. Taking into consideration previous explanations and various perspectives, web enabled CI can be defined as:

"Composed ability of individuals who are acting as a single cognitive unit to achieve common goals, think reasonably, solve problems, make decisions, carry out complex tasks, and develop creative ideas collectively through participation and collaboration on the Web".

Literature on the subject clearly shows the importance of CI in knowledge management and its role in intelligent enterprises. Web enabled CI is a fundamental new approach to problem solving in the new century of mass collaboration facilitated by rapidly developing technologies. The phenomenon is still in the process of early development and not fully researched. Table 1 summarizes the previous studies.

<Table 1> Literature review

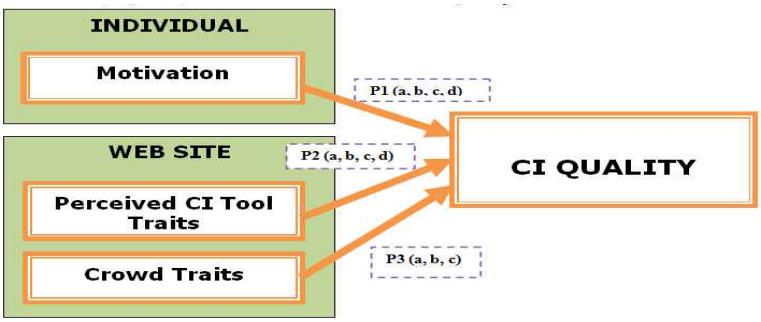
Study	Reference	Focus of Study	Field of Concern
Grounded Theory Study	Wechsler (1971)	The concept of CI: what is collective intelligence?	CI Concept
	Yuan et al. (2007)	Technologies related to CI on the Internet and CI mechanism analysis	CI Tools
	Gruber (2007)	How the integration of social web and semantic web can be used to create new value (rich of human participation and powered by well structured information)	CI Tools, CI Application CI Concept
	Marsden (2009)	Concepts of crowdsourcing and its application in creating marketing strategy and potential opportunities it creates	CI Application
	Bons et al. (2010)	Exploring the concept of CI (open innovation and crowdsourcing)	CI Concept CI Tools CI Benefits
	Malone et al. (2010)	Differentiate genes of Web enabled CI and analyze them to build up appropriate framework and genome of CI	CI Concept Crowd Motivation in CI CI Tools,
	Convertino et al. (2010)	Discussing CI tools, refining problems, develop research agenda for the problem of supporting CI among organization employees	CI Tools
	Lane (2010)	Focuses on the use of CI forms (crowdsourcing and open innovation) for achieving competitive advantage (CA): How should organizations apply CI to maintain or create CA	Crowd in CI CI Application
	Leimeister (2010)	Explores the CI phenomenon, recent areas of interest on CI, and areas of application for CI via Social Web as well as studies success factors	CI Concept CI Application CI Success Factors
Case Study	Narasimhan et al. (2007)	Application of CI principles into Knowledge Management in organizations	CI Principles Crowd Motivation in CI CI Application
	Lakhani and Kanji (2008)	Focuses on the strategy and business processes of Threadless and explains how Threadless becomes popular through the application of CI concepts	CI Application CI Tools
	Colombino et al. (2010)	Proposes various ways of producing more precise news based on CI concepts and technologies and notes technological challenges that must be solved to apply CI in journalism	CI Tools CI Application
	Billman and Feary (2010)	Application of CI concepts into organizational planning process via NASA case study analysis	CI Application CI Tools

Study	Reference	Focus of Study	Field of Concern
Empirical Study	Berquist and Ljungberg (2001)	Discusses theories of gift giving and its application in open source communities and how it is done via peer review	CI Tools Crowd Motivation in CI
	Rubio et al. (2007)	Focuses on Web 2.0 technologies (Wikis and Blogs) and their impact on education as well as awareness of CI tools.	CI Tools CI Application
	Brabham (2008)	Discusses the demographics of iStockphoto CI community members and what motivates them to participate	CI Tools CI Crowd Crowd Motivation in CI
	Javanmardi et al. (2009)	Studies WIKI users contribution to CI	CI Crowd CI Tools
	Gholami and Safavi (2010)	Studies CI technology traits (Wiki and Social Network) and their contribution to CI	CI Tools
	Brabham (2010)	Discusses why people participate in CI, crowdsourcing, particularly, and presents the study of Threadless community members	Crowd Motivation in CI CI Tools

It indicates that there are many studies regarding the motivation of the crowd participating in CI processes and studies carried out to investigate CI tools used in the process. There are also studies that cover the traits of the crowd linked with the quality of CI solutions and outcomes. However, there have not been any investigations concerning the quality factors of CI. Although there are empirical and conceptual studies carried out, there are no researches that would consider them in a single context.

Ⅲ. Resarch Model and Propositions

Taking into consideration the literature review



<Fig. 3 > Research Model

of previous studies regarding CI, we have put forward a model (Figure 3) in order to reflect the quality factors of CI.

Three independent variables and one dependent variable (CI Quality) were considered in this study. Perceived CI tool traits (navigating, usefulness, agility, and user preference) and crowd traits (expertise, size, and diversity) were clustered into Web site factors, whereas motivation factors (love, money, glory, and professional development) were regarded as individual factors. It was assumed that these independent variables have strong positive relationships with CI quality. Table 2 provides a more detailed representation of the quality factors of web enabled CI.

<Table 2 > Model constructs and items

Factor		Variable	Items	Reference
Individual	Motivation	Love	Enjoyment of activity	Brabham (2010) Cheng et al. (2009) Convertino et al. (2010) Malone et al. (2010) Narasimhan et al. (2007) Prasarnpanich and Wagner (2009) Tan et al. (2010)
			Altruism	
			Socialize with others	
		Money	Monetary reward	
		Glory	Respect by Peer Recognition	
			Self Marketing	
		Professional Development	Improving Professional skills	
			Freelance work opportunity	
Web-Site	Perceived CI Tool Traits	Navigating	Ease of Use	Gholami and Safavi (2010) Hars and Ou (2002)
			Layout Consistency	
			Feedback	
		Usefulness	Communication Facility	
			Empowerment capability	
			Content	
		Agility	Speed	
		User Preference	Personalization	
			Customization	
	Crowd Traits	Expertise	Level of education and experience of community members	Bons et al. (2010) Brabham (2010) Javanmardi et al. (2009) Lane (2010)
		Diversity	Level of heterogeneity of the crowd	
		Size	The number of participants in the community	
CI Quality		Accuracy	Accuracy, objectivity, believability of information, knowledge contributed	Kulkarni et al. (2007) Lee et al. (2002) Wang and Strong (1996)
		Relevancy	Relevancy, timeliness and completeness of information and knowledge contributed	
		Understandability	Interpretability, ease of understanding, representational consistency of information, knowledge, and solutions shared	

3.1. Collective Intelligence Quality (CIQ)

Generally, it is hard to measure the quality of CI by its nature in other words, there is no exact set of attributes to calculate the quality of CI. So instead, we focus on the measuring the quality of the final outcomes of CI, such as innovative solutions provided by CI community members of *InnoCentive* or articles contributed by wikipedians. A literature review revealed that the subject has not been well researched, yet it has provided us with clues to understanding the main attributes of CI outcomes.

According to Lee (2003), depending on the degree of quality and quantity of information related to the task as well as whether or not information is directly utilized in business, there are five possible attributes of quality such as timeliness, proper quantity, relevance, flexibility, and diversity. Also, based on the research of Wang and Strong (1996) it can be interpreted that the quality of CI outcome is possible to be measured by its appropriateness, timeliness, completeness, and proper quantity. Additionally, referring to the study of Lee et al. (2002) the quality of CI outcome can be calculated by its proper quantity, relevance, understandability, interpretability, objectivity, and reliability. So in conclusion, based on the previous findings, the following quality attributes of CI can be used:

- *Reliable CIQ includes accuracy and objectivity.*
- *Relevant CIQ includes completeness and timeliness.*
- *Understandability CIQ includes aspects related to the format of CI such as consistent representation as well as ease of understanding.*

3.2. Motivations

The Internet, specifically the recent Web 2.0 trend toward massive user-generated online content, is the vehicle for distributed, large-scale, and enjoyable collective production (Convertino et al., 2010). In such environment, it is a set of incentives that drives crowds to participate in web enabled CI. Motivation to participate is a major, if not the most crucial, factor contributing to the success of CI (Bonabeau, 2009; Malone et al.,2009). Furthermore, incentive systems and personal expectation are the key factors driving academics to engage in knowledge sharing activities (Cheng et al., 2009).

In addition, Linus Torvalds, the founder of Linux, predicted the pleasure found in doing hobbies is a primary motivator, and recent findings on the subject of motivation in open source projects support such prediction (Bonaccorsi and Rossi, 2004 Hars and Ou, 2002). He also stated that most good software developers do programming because it is fun (Brabham, 2010). The findings of Brabham (2008, 2010) indicate the following 5 themes that motivate CI community members:

- *The opportunity to make money*
- *The opportunity to improve one's creative skills*
- *The opportunity for eventual freelance design work*
- *The love of community*

• *Addiction to the community*

Moreover, studies on Wikipedia found that altruism is a prevalent driver for participation in CI, particularly, where participants have both individualistic and collaborative motives, collaborative (altruistic) motives dominate (Prasarnphanich and Wagner, 2009). Melone et al. (2010) derived the following three basic "why" genes of motivation of people who participate in CI:

- ***Money.*** *The promise of financial gain is an important motivator for most actors in markets and traditional organizations.*
- ***Love.*** *The Love gene can take several forms: people can be motivated by their intrinsic enjoyment of an activity, by the opportunities it provides to socialize with others, or because it makes them feel they are contributing to a cause larger than themselves.*
- ***Glory.*** *Glory or recognition is another important motivator.*

Concluding their preliminary studies, Melone et al. (2010) highlight that CI relies heavily on the Love and Glory motivation "genes", in contrast with traditional organizations, which rely more heavily on Money as a motivating force.

Finally, motivation factors are clustered into four main dimensions based on previous findings: 1. Love (enjoyment of activity, altruism, and socializing with others); 2. Glory (respect/peer recognition and self marketing); 3. Money; 4. Professional Development (improving professional skills and freelance work opportunity). So to summarize, the motivation of users is essential to ensure sufficient participation in CI, which in turn influences the quality of CI; therefore, we hypothesize the following propositions:

P1: Crowd motivation has positive effect on quality of CI.
P1a: Love motivation has positive effect on quality of CI.
P1b: Glory motivation has positive effect on quality of CI.
P1c: Money motivation has positive effect on quality of CI.
P1d: Professional development motivation has positive effect on quality of CI.

3.3. CI Tools

CI tools are ventures that harness and aggregate the wisdom of the crowd through the Web to produce solutions and products superior to those of collaborative groups or solo geniuses (Brabham, 2010). Especially, the Web has been widely adopted with the improvement of computing and collaborative tools (e.g., Web 2.0). Basically, these tools have created an easier and faster way for people to create, share, and edit online content.

Yuan et al. (2007) highlighted the key CI tools such as blogs, social bookmarks, social networking services, and Wiki. Papadopoulos et al. (2009) mentioned web applications that incorporate social tagging systems, particularly CI tool archetype. These systems enable their users to upload digital resources (e.g., bookmarks, pictures, blog posts, etc.) and

annotate them with tags (i.e., freely chosen keywords). For instance, "del.icio.us" employs social tagging systems, where people share their bookmarks, and categorize them with user-defined tags, collectively creating a shared resource about relevant information (Convertino et al., 2010).

In general, new web technologies and the growing role of users have led to the appearance of innovative web applications based on CI (Rubio et al., 2010). Scholars state that users play a crucial role in emerging CI tools: they, as members of a community, give their opinions, create, access, edit, and participate in online contents.

Most popularly, CI tools are used by organizations to support their business performance. Based on the findings of Gholami and Savafi (2010), the following perceived traits of web enabled CI tools are clustered in Table 3.

<Table 3> Perceived CI tool traits and definitions

Trait	Definition	
Navigating	Ease of Use	Degree to which a CI tool is user friendly
	Layout Consistency	A flat hierarchy of information is important for a successful web enabled CI design. The hierarchy of information should be apparent at a glance so that the user easily understands the information available.
Usefulness	Communication Facility	Leveraging communication and collaboration as well as serving as a knowledge platform for a community where they can share their knowledge with the group, put up interesting pieces of information, work together, discuss and etc.
	Empowerment capability	Increasing computer power, broadband Internet, and ever easier Web 2.0 services give users unprecedented power to do many things themselves without much difficulty, and CI tools can be referred as creating new forms of collaboration and knowledge sharing on the Web and empowering the crowd to contribute.
Agility	Speed	CI tools make inserting, updating and providing information more quickly as before. The simple structure of the tools, make them more quick and responsive.
User Preference	Customization	Customization is the ability of the tool to be customized by the user. CI technology offers an opportunity to provide more in-depth information to the user.

When people communicate effectively with one another as well as share information and feedback with the help of CI tools, they can increase the accuracy and quality of CI outcome while reducing the average individual error. Hence, the following propositions are hypothesized:

P2: Perceived CI tool traits have positive effect on CI quality

P2a: Perceived navigating of CI tool has positive effect on CI quality

P2b: Perceived usefulness of CI tool has positive effect on CI quality

P2c: Perceived agility of CI tool has positive effect on CI quality

P2d: Perceived user preference of CI tool has positive effect on CI quality

3.4. Crowd

Several studies showed that diversity, size, and expertise of the crowd play a crucial role in web enabled CI (Brabham, 2010; Brabham, 2008; Convertino et al., 2010; Gruber, 2008; Narasimhan et al., 2007).

The general perspective is that it is often better to have a group of cognitively diverse people than a group of very smart people who think alike. The reason behind is that a diverse (heterogeneous) group of problem solvers can outperform an identical (homogenous) group of highly skilled problem solvers, perhaps, because they possess a more varied portfolio of talents (Juho, 2009; Leimeister, 2010; Page, 2007). Moreover, adding new perspectives to a matter is valuable as it brings in new ideas and viewpoints that would otherwise remain absent in a group (Bonabeau, 2009; Surowiecki, 2004). Surowiecki (2004) stated that diversity expands a group's set of possible solutions and allows problem conceptualizations in novel ways.

The main ingredient in diversity is cognitive diversity that can be defined as the difference in the way people approach a problem or a question (Bonabeau, 2009; Landemore, 2008; Page, 2007; Surowiecki, 2004). Specifically, diversity denotes the following (Page, 2007):

1. *Diversity of perspectives (the way of representing situations and problems)*
2. *Diversity of interpretations (the way of categorizing or partitioning perspectives)*
3. *Diversity of heuristics (the way of generating solutions to problems)*
4. *Diversity of predictive models (the way of inferring cause and effect)*

Researchers agree upon the fact that cultural diversity; social diversity (race, gender, class, etc.), personality types; cognitive styles training and experience differences are the main sources of diversity (Leimeister, 2010; Page, 2007). These differences shape diversity and help reduce the negative effects of individual and group level biases. It is done so by adding distinct viewpoints and making it easier for people to voice their opinions (Juho, 2009).

The number of community members and their expertise are vital traits of the crowd affecting the quality of CI. Particularly, a large number of diverse crowds always predicts more accurately other than an average individual (Surowiecki, 2004). A popular example used in many studies is the "ask the audience" joker in the TV show "who wants to be a millionaire", which leads to a correct answer in 91% of the cases. Large groups of

ordinary people may do just as well as small groups of experts. Similarly, Surowiecki (2004) states: *"We should recognize that a talented `I' and a talented `they' can become even more talented "we""*. The study of Steinbock et al. (2000) showed that a large group of average persons can outperform an expert individual on a given task, especially where the degree of complexity is high. So, to improve and leverage the best CI quality, it is better to form a large community of people who must be individually smart and collectively diverse. Hence, the following propositions are hypothesized:

P3: Crowd traits have positive effect on CI quality
P3a: Crowd size has positive effect on CI quality
P3b: Crowd diversity has positive effect on CI quality
P3c: Crowd expertise has positive effect on CI quality

Ⅳ. Analysis of Case Studies

4.1 Overview

4.1.1. Threadless

Based in Chicago, Illinois, USA, *Threadless* is an online t-shirt founded by Jake Nickell and Jacob Dehart in 2000. *Threadless* uses crowdsourcing for the design process of shirts via online competition. Each week, *Threadless* relies on the crowd to *create* a group of new T-shirt designs, and then *decides* which ones to produce through a combination of voting (Malone et al., 2010).

All designs submitted on *Threadless* by registered members are voted on for a 7 day period and picked by the community. Once the scoring period has ended, the design receives a score from 0 to 5 (Skinny Corp LLC, 2010). Brabham (2010) explained how *Threadless* works as follows:

T-shirts which gain the highest rate are then produced and sold online or in its stores what would be considered a low price for a designer t-shirt: around US$15–20. Shirts are shipped internationally from the Chicago warehouse. On the site, members can sign up for free with a valid e-mail address and participate in the various functions of the Threadless community –submit designs, vote on designs, and shop. Additionally, a blog forum exists for members to chat about t-shirts or any other topic, and this forum is incredibly active, with several new posts created every minute.

As of July 2009, winning designers were rewarded with US$2,000 in cash and US$500 in *Threadless*gift certificates (SkinnyCorp LLC, 2010). As of June 2006, *Threadless* was selling 60,000 t-shirts a month, with a profit margin of 35% and was on track to gross $18 million USD in 2006, with only 20 employees' (Howe, 2006). Within 5 years after its foundation, *Threadless* has acquired 500 designs on their virtual shelf and built up 350,000-strong user community (SkinnyCorp LLC, 2010).

From a problem-solving perspective of CI, *Threadless* goal is to acquire innovative,

attractive, sellable designs for its t-shirt line. In a sense, the task environment or problem space for this design process occurs in the contest on its Website (Brabham, 2010). It is very difficult for the company to be the leader in the fast changing t-shirt styles and fashion. If CI were not used in their businesses, then it would be impossible to rely on few designers for Threadless to achieve success. The company founders state that the *Threadless* growth was a community effort of increased participation and word of mouth.

4.1.2. iStockphoto

iStockphoto, an online international microstock photography provider operating with the micropayment business model (Wikipedia, 2010). It was founded in Canada by Bruce Livingstone in 2000 as a free stock imagery web-site that evolved into a successful online business using CI of its community members.

In 2000, Bruce Livingstone founded *iStockphoto* when he was seized with the belief that the old way of distributing images was not going to work anymore and put all the images online for free. Soon it became very popular for web designers who downloaded as many pictures as they could. To his surprise, visitors who had digital cameras started uploading images of their own. When the monthly bandwidth bills topped $10,000, Bruce polled the growing iStock community to find out if people would support paying for images (iStockphoto LP, 2010). Eventually, in 2002, iStock began selling credits (between 1 and 150 credits ranging from $.95 to $1.5 USD each)to support online presence, for example, a high-quality image can be downloaded for under a dollar, and the artist who contributed this image gets paid a royalty.

Since 2000, thousands of individuals have created, worked and learned together from all over the world (iStockphoto, 2010). Only in 2007, *iStockphoto*'s revenue reached $71.9 million USD of which $20.9 million (almost 30%) was paid back to contributors (Wikipedia, 2010) or in other words "iStockers" (Brabham, 2008). *iStockphoto* currently pays $1.7 million weekly in artist royalties within a decade 100 million files were downloaded and its community members reached 6 million people (iStockphoto, 2010).

At *iStockphoto*, millions of members and tens of thousands of contributing artists send photographs, illustrations, videos, sound effects and more. Even after the various changes in the management and businesses, the basic idea of *iStockphoto* instigated by Bruce Livingstone remains the same: *anyone, anywhere can join us for free, find the digital media they need and sell original content of their own* (iStockphoto, 2010).

From the perspective of CI, for *iStockphoto*, the problem is how to come up with affordable stock photography. It is the community who provides solutions by uploading their creative content and *iStockphoto* then attracts clients who select the stock they want, and users together with iStockphoto make money on it (iStockphoto, 2010). It can be clearly seen that *iStockphoto* CI

itself is a process, a model, for distributed problem solving through the Web (Brabham, 2008).

4.1.3. Panda Security

The latest example of intelligent enterprises can be referred to Panda Security (2010) which uses the CI approach to malware recognition. Panda security, based in Spain, has been using the CI approach piloted by millions of users of many Panda free products since 2007, allowing Panda to collect ten times as much malware samples as traditional antivirus vendors. Panda Security is the first security vendor that has the technology, infrastructure, knowledge, and experience to apply the CI approach, and its recent products are based on CI. The new Panda 2011 consumer products based on CI providing maximum protection with minimum impact on PC.

Panda Labs has developed a CI approach, which uses community knowledge to protect others, while automating and enhancing malware collection, classification, and elimination. CI for Panda Security (2010) is a security platform offering high-level protection in real time, exponentially increasing the detection capacity of antivirus software. It leverages the knowledge in the Panda Security user community and allows enormous quantities of malware to be processed, delivering mega-detection capacity while reducing resource consumption (Panda Security, 2010).

The new approach allows the automated collection, classification, and elimination of malware as well as gives insight to Panda engineers about new malware techniques and entry points. Applying CI dramatically increased the amount of malware collection in their malware detection system within 2 years. In turn, it might have interesting applications and useful facts for law enforcement efforts. Finally, the application of data warehousing and data mining techniques to malware detection by the community provides significant knowledge on how malware and targeted attacks are carried out (Urzayr, 2008).

4.1.4. InnoCentive

InnoCentive, based in Waltham, Massachusetts, USA, was launched in 2001 by Jill Panetta, Jeff Hensley, Darren Carroll and Alpheus Bingham (Wikipedia, 2011) with funding from pharmaceutical giant Eli Lilly. The company uses CI for scientific problem solving in various areas including chemistry, life sciences, business and entrepreneurship, computer science, and clean technology.

InnoCentive enables scientists to collect professional recognition and financial award for solving R&D challenges; at the same time,it enables companies to tap into the talents of a global scientific community for innovative solutions to tough R&D problems (InnoCentive, 2010).

InnoCentive community involves two kinds of groups: *Seekers* and *Solvers*. "*Seekers*" are organizations who are seeking answers for their challenges and "*Solvers*" community members who are interested in solving critical and pressing

problems (InnoCentive, 2010). Seeker companies post their most difficult R&D challenges to the InnoCentive solvers and solvers can then submit solutions through the web, which go under review by the seeker (Brabham, 2008). If a solution meets the technical requirements of the challenge, then the seeker company awards a cash prize which may range from US$10,000 to $100,000 per challenge (Howe, 2006). Potential solvers need only to register for free at *InnoCentive*, providing contact information such as degrees earned, areas of research interest and more importantly solvers need not be professional scientists or scholars.

InnoCentive provides scientific challenges throughout the world and harvests CI from over 200,000 independent solvers from over 160 countries. As of 2008, *InnoCentive* already had 64 seeker companies such as Boeing, DuPont, Proctor & Gamble, and Dow Agro Sciences. The recent results (Table 4) indicate that *InnoCentive* is taking advantage of a new form of business and gaining competitive advantage.

<Table 4> InnoCentive Facts (InnoCentive, 2010)

Current as of July, 2010
Total Solvers:200,000+ from 180countries
Total Challenges Posted:1044
Project Rooms Opened to Date:294,865
Total Solution Submissions:19,346
Total Awards Given:685
Total Award Dollars Posted:$24.2 million
Range of awards:$5,000 to $1 million
Total Dollars Awarded:$5.3 million
Average Success Rate:50%

4.1.5. Wikipedia

Wikipedia is one of the best examples of Wiki technology application in harvesting CI throughout the crowd. Wikipedia is a free, web-based, collaborative, multilingual encyclopedia project supported by the non-profit Wikimedia Foundation. Its 17 million articles have been written collaboratively by volunteers around the world, and almost all of its articles can be edited by anyone with access to the site (Wikipedia, 2011). Its founders originally attempted to build online encyclopedia called "Nupedia" with the traditional editorial process of writing and without open access software, which yielded 24 completed articles during its existence (Prasarnphanich and Wagner, 2009). But with the application of Wiki technology, their new child Wikipedia became successful. The first Wiki was developed by Ward Cunningham in 1995 to communicate specifications for software design. The term Wiki (from the Hawaiian *Wikiwiki* meaning "fast") gives reference to the speed with which content can be created with a Wiki (Wagner, 2004).

Wikipedia was launched in 2001 by Jimmy Wales and Larry Sanger and has become the largest and most popular general reference work on the Internet ranking seventh among all web-sites on Alexa and having 365 million readers, 853,842 uploaded files, and 13,499,296 registered community members (Wagner, 2004; Wikipedia, 2011).

Compared to traditional encyclopedias,

Wikipedia uses "Wiki" technology where any person can edit Wikipedia to update its content (even without registration). However, only registered users may create a new article and no article is owned by its creator or any other editor, or is vetted by any recognized authority; rather, the articles are agreed on by the community (Wikipedia, 2011).

Most importantly, when changes to an article are made, they become available instantly before undergoing any review, and later, it can be reviewed and edited by the community members or so called "Wikipedians" (Prasarnphanich and Wagner, 2009). It should be noted that there are no 'bylines'in Wikipedia, no financial rewards for writing an article, no explicit benefits for casual contributors, and minimal explicit benefits even for highly active contributors (Prasarnphanich and Wagner, 2009).

Wikipedia project can be described as the most successful online encyclopedia based on size, growth, and usage. Wikipedia, during its first 12 months of existence, and drawing on largely the same contributor community, was able to create 12,000 articles (Wikipedia, 2011). Since its inception, its size has approximately doubled every year (Wagner, 2008). Wikipedia has grown exponentially in size and has became the world's largest and most widely used online encyclopedia, and within a decade only the number of articles in English reached 3.5 million (Wikipedia, 2011)

4.2 Analysis

4.2.1. Propositions on Motivation

Preliminary studies investigating the motivations of crowds paint a partial picture of how the opportunity to make money and other motivators drive the crowd's participation in iStockphoto, Threadless, InnoCentive and Wikipedia (Brabham, 2008; Brabham, 2010;

<Table 5 > Collective Intelligence Genes of Case Studies based on Melone et al. (2010) Genome

Case	What		Who	Why	How
Wikipedia	Create	New Article	Crowd	Love, Glory	Collection
		New version of Article	Crowd	Love, Glory	Collaboration
	Decide	Whether to delete	Crowd	Love, Glory	Voting
		Whether to keep current	Crowd	Love, Glory	Consensus
Threadless	Create	T-shirt designs	Crowd	Money, Love, PD	Contest
	Decide	Which designs are best	Crowd	Love, Glory	Averaging
		Which designs to produce	Management	Money	Hierarchy
InnoCentive	Create	Solutions to scientific problems	Crowd	Money, Glory, PD	Contest
	Decide	Which solution is the best	Management	Money	Hierarchy
iStockPhoto	Create	Photos	Crowd	Money, Love, PD	Contest
	Decide	Which photos displayed first	Crowd	Love	Voting

Melone et al., 2010; Prasarnphanich and Wagner, 2009). The following results shown in Table 5 were generated by employing the CI genes genome stated by Melone et al. (2010). As seen from Table 5, it can be generalized that the love gene is one of the most wide spread motivating factors driving users to contribute.

In a study of the crowd at iStockphoto, Brabham (2008) found that the opportunity to earn money and develop one's creative skills trumped the desire to network with friends and other creative people. At InnoCentive, Lakhani et al. (2007) revealed that motivators such as enjoying problem solving and cracking a tough problem, as well as financial reward, were significantly positively correlated to success.

Prasarnphanich and Wagner (2009) studied Wikipedia community members and concluded that altruism is a prevalent driver for participation, although mixed motives clearly exist. Table 6 summarizes the main motives of community members to participate in the web enabled CI. Melone et al. (2010) findings identified only love, money, and glory motivators. But, the remaining studies showed that there are more incentives for individuals to participate in CI such as professional development. Table 6 was constructed to represent the major reasons why individuals contribute to CI in four different case studies.

It can be observed from Table 6 that members are more motivated in cases where they are required to use more intellectual curiosity and creative thinking (e.g., finding solutions in InnoCentive; creating designs in Threadless; taking creative pictures in iStockphoto) compared to cases involving less similar effort (e.g., wikipedians). When the crowd is sufficiently well motivated, its members are eager to make accurate and objective contributions in a timely and constant manner. This in turn transforms the CI outcome into a complete and comprehensible format. It is worth noting that many individuals participating in CI might be motivated by all the factors mentioned in Table 6.

However, identifying the most crucial incentive that drives individuals from all over the world to contribute is still a challenge for

<Table 6 > Motivation of Community Members by Companies

Motivation		Case Studies			
		Wikipedia	Threadless	InnoCentive	iStockphoto
Love	Enjoyment of activity	•	•	•	•
	Altruism	•			
	Socialize with others				•
Money	Monetary reward		•	•	•
Glory	Respect peer recognition	•	•	•	•
	Self marketing		•	•	
Professional Development	Improving professional skills		•	•	•
	Freelance work opportunity		•		

organizations that use CI in their businesses. Even if a company is applying CI tools in a micro level, awareness of the most motivating factor will help develop proper incentives so that employees will contribute their best. As a result, the company will be able to leverage the utmost CI quality outcome. To summarize, the above facts support hypotheses P1 (a, b, c, and d).

4.2.2. Propositions on Perceived CI Tool Traits

The latest findings provide several supportive arguments to our proposition related to CI tools and its relationship with CI quality. First, CI tools provide the means for individuals around the world to communicate on a single platform (Brabham, 2008; Papadopoulos et al., 2009; Wagner, 2004; Yuan et al., 2007). CI tools can facilitate the exchange of diverse opinions in a decentralized way. Given that users are from different locations and cultures, they can collect and assess solutions as well as aggregate them into a meaningful form (Brabham, 2008). Further, Brabham (2008) argued that the Web is a technology that enables a certain kind of thinking, stimulates innovation, facilitates user-generated content and play, and transforms CI applications into "*pleasure domes*". In particular, Wiki technology can be referred to as one of the successful tools in harvesting CI. The success of the CI model embedded in Wikipedia appears to be related to wiki technology (Brabham, 2008).

In the case of Panda Security, CI implementation would not be possible without both a network among users and appropriate CI tools used to collect malwares and other threats. Application of CI tools such as "Wiki" technology enabled a fast and cost effective collection of knowledge from the crowd. In a true sense, it can be described as one of the best examples of web enabled CI projects. As can be seen, the CI tools play a very important role in providing better solutions and improved security.

Although CI existed for centuries, it is the technology that made the process of communication and group work considerably inexpensive. Many professionals in the area of CI mentioned that facilitating and harvesting CI of the crowd would not be possible without the new communications and Internet technologies. CI tools enable thousands of diverse people to communicate and produce high quality outcomes. Finding out the appropriate CI tools for a given problem is another challenge for organizations to think about in the first place. Thus, P2 propositions (a, b, c, and d) are supported.

4.2.3. Propositions on Crowd Traits

Further, studies of Javanmardi et al. (2009) provided an analysis of an open editing model of Wikipedia and the results showed that there is a positive correlation between user registration and the quality of contributed content. Table 7 summarizes the crowd traits of various case studies.

<Table 7 > Crowd Traits of Case Studies

Case	Crowd		
	Size	Diversity	Expertise Required
Wikipedia	14,446,030	Extremely High	Low
Threadless	Over 350,000	High	Low
iStockPhoto	6,000,000	High	Low
InnoCentive	Over 200,000	High	High
Panda Security	*	*	*

Wikipedia heavily relies on a large number of "*wikipedians*" who actively contribute in such a way as to neutralize any fraudulent poor quality content that may be inserted by a smaller number of problematic users (Javanmardi et al., 2009; Prasarnphanich and Wagner, 2009; Wikipedia, 2011). Moreover, many amateur photographers of iStockphoto who have access to high resolution digital cameras at lower costs can take professional quality pictures and later upload them on the Web. Over 350,000 members of Threadless community generate creative t-shirt design solutions in large quantities where little expertise is required, which would be very difficult to do within a regular organization.

Users of Panda Security antivirus software will benefit greatly if the size of the users grows even larger in different continents and countries. In this case, the critical role relies upon the CI technology, which automatically collects malware and viruses, and updates the main server for further cloud usage. Different from other cases, InnoCentive members have deep and diverse expertise, thus they provide distinct, creative, and effective solutions. Terwiesch and Xu's (2008) research at InnoCentive found that ideation problems are suited for broadcasting to an online base of diverse solvers.

Finally, the successful performance of Threadless in generating unique designs can be explained by a large size of diverse and wise crowd (Brabham, 2010). The analysis of the case studies revealed that the quality of the outcome in terms of accuracy, relevancy, and understandability (CI quality) improved when there was an increase in the number of users from diverse backgrounds. Hence, all of these factors support the propositions regarding the crowd P3 (a, b, and c).

Ⅴ. Conclusion

In order to enhance the quality of CI and to reduce jeopardy, organizations should ensure crowd size, encourage diversity in decision making, motivate participation, and implement appropriate CI tools. From the case studies, it can be summarized that without appropriate tools and community members (a crowd), it would be impossible to initiate CI and it would senseless to

create and run web enabled CI without motivated prospective members. Moreover, several studies provided considerable support for the propositions put forward. The most important factor is that companies and governments should be able to learn from the studies in the field of CI. Also they should acknowledge the application of CI in a way that focuses on the factors that lead to higher quality of CI. Only then the full potential of CI will be realized.

This research is not without its limitations. First, the findings come from the research of five case studies that have applied the CI phenomenon in their business models. It is believed that the analysis of wider range of organizations that are using CI would reveal deeper understanding of quality factors of CI and achieve more precise understanding. Another limitation is that, in this research, only communities that are consciously contributing to CI and respective technologies were considered, mainly focusing on both explicit and implicit CI. Hence, the study did not fully explore the quality factors of CI derived through the use of distinct techniques and technologies such as web data and text mining; clustering and predictive analysis intelligent search and recommendation engines; and the use of predictive analysis noted by Alag (2009).

Also, case studies discussed in this paper mainly represent North American and European countries that have distinct cultures in comparison to Asian countries. Because of the cultural differences, there might be a lack of generalizability of this study for Asian countries, especially for South Korea. Finally, we acknowledge the fact that arguments provided to support propositions may not be strong and sufficient. Interviews or field experiments should be conducted in order to suggest more robust evidence and overcome limitations.

Additional research should be undertaken on web enabled CI sites to further expand the base of knowledge about the quality factors of CI harvested from community members. It is assumed that more studies will lead to the development of relevant models that are well-suited for further empirical studies. Future studies should empirically support the findings as well as contribute towards better understanding of the quality factors of CI on all levels. Particularly, it would be of great benefit to investigate and empirically test factors affecting explicit, implicit, and derived CI. It will make it possible to capture a wide range of factors and concepts that shape the quality of web enabled CI in the recent highly volatile and ever competitive global business environment. Above all, study on social networks such as Facebook, MySpace, CyWorld in terms of CI would generate valuable knowledge and frameworks concerning the future developments in this area.

Unlocking factors of why crowds give their knowledge and creative energy to this unique process, which tools allow and contribute the most to harvesting and deriving CI from the crowd, and finally, what are the crucial attributes

of the crowd to be targeted, are vital for developing the best frameworks. These frameworks and best practices can be implemented not only by companies but also by governments eager to harvest the intelligence of the crowd to enhance the services provided to the public.

It can be concluded that CI is becoming increasingly important in the recent development of technologies that facilitate harvesting the knowledge of the crowd. Organizations achieve improved business performance due to the implementation of CI. It is strongly believed that the application of CI concepts and frameworks will play a critical role in future, intelligent organizations.

Further, it can be summarized that crowd attributes (e.g., size, expertise, and diversity) and motivations as well as relevant CI tools have a positive effect on the quality of CI harvested. The case studies strongly support the outlined propositions that a highly motivated, large, diverse crowd with both little knowledge and expertise is able to solve the problems that smaller groups cannot. They can lead to the accumulation of new ideas and approaches and bring greater benefits if appropriate CI tools are implemented. Additionally, the motivation of the crowd should be the focus of concern due to the fact that a poorly motivated crowd will not contribute their best. If the goal of using CI is to solve complex problems and require considerable exertion of members, organizations must ensure financial rewards and incentives. Specifically, South Korean companies that are willing to implement CI should cautiously consider cultural differences. Findings of this study are derived mainly from CI case studies of North America and Europe. Asian people behave differently and have different motivating factors in comparison to Europeans or Americans. Thus, South Korean companies should carefully consider the quality factors of CI more and make necessary amendments to reflect cultural difference based on the latest empirical findings. This research contributes to the body of literature analyzing the factors that have a great impact on the quality of the CI phenomenon.

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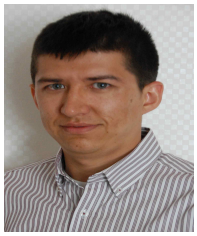

Ismatilla R. Normatov has received his bachelor of arts degree in business administration from Westminster International University in Tashkent, Uzbekistan. Recently, he is doing his Masters degree in The Cooperative Department of Electronic Commerce, Dongguk University at Gyeongju. He is interested in electronic commerce models and technologies, social commerce, knowledge management, and particularly collective intelligence.

주재훈(Joo, Jae-Hun)

현재 동국대학교(경주캠퍼스) 경영·관광대학 정보경영학과 교수로 재직 중이다. 부산대학교에서 경영학박사 학위를 취득하였다. 주요 관심분야는 전자상거래와 e-비즈니스 전략/모형/개발방법론, 시맨틱 웹, 상황인지 및 유비쿼터스 응용, 지식경영과 집단지성, 소셜 네트워크 서비스 등이다. 경영학연구, 경영정보학연구, 한국경영과학회지, 정보시스템연구, International Journal of Computer-Human Studies, Journal of Sustainable Tourism, Decision Support Systems, Information Systems Management, International Journal of Industrial Engineering, Expert Systems with Applications, Journal of Computer Information Systems 등에 다수의 논문을 게재하였다.

<초록>

기업성과 향상을 위한 웹기반 집단지성의 품질요인에 관한 연구

Normatov, R. Ismatilla · Joo, Jae-Hun

비즈니스 조직에서 집단지성을 경쟁우위의 중요한 요소로 활용하는 사례가 증가하고 있다. 인터넷과 소셜 네트워크 서비스는 물론이고 위키와 같은 편집도구 등은 집단지성을 가능하게 하는 대표적인 정보기술이다. 그러나 집단지성은 전문가 지식에서와는 다른 품질의 문제가 제기되기도 한다. 따라서 본 연구에서는 집단지성의 품질에 영향을 주는 요인을 분석하는데 그 목적이 있다. 선행연구를 통해 집단지성의 품질에 영향을 주는 개인의 동기(love, money, glory, professional development), 집단특성(expertise, diversity, size), 집단지성의 도구(navigating, usefulness, agility, user preference) 차원에서 총 11개의 영향요인을 파악하였다. 조직 경쟁우위의 핵심으로 집단지성을 활용하는 대표적인 성공사례인 Threadless, InnoCentive, iStockphoto, Panda Security, Wikipedia를 분석하여 3개 차원에서 11개의 명제를 제안하였다. 사례분석의 결과, 개인의 동기, 집단특성, 집단지성을 위한 도구는 집단지성의 품질에 긍정적 영향을 주는 것으로 나타났다. 예를 들어, 개인적 동기가 뚜렷하고 다양한 특성을 지닌 다수가 참여할수록 소집단에서보다 더 잘 문제를 해결하고 있는 것으로 분석되었다. 따라서 집단지성의 품질을 개선하고 이를 통해 혜택을 얻기 위해서 조직에서는 다양성을 지닌 대규모 커뮤니티를 구성하고, 참여에 대한 동기를 부여하고, 적절한 집단지성의 도구를 선택하여 활용하여야 한다.

Keywords: 집단지성, 집단지성 품질, 동기요인, 집단지성도구, 집단특성, 위키, 커뮤니티

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