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Linking Social Media with Open Innovation: An Intelligent Model

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Abstract: - A hybrid intelligent model for linking social media with open innovation strategies, processes and diffusion is proposed and discussed in this paper. In order to deal with the various facets or properties of the open innovation problem, we recommend and present a new paradigm and framework for integrating the strengths or advantages of intelligent software agents, fuzzy logic, expert systems, complex adaptive system theory, the analytic hierarchy process, simulation technique, and hybrid intelligent system method. The theoretical underpinning and rationale for the hybrid framework are provided. In addition, the effectiveness and efficiency of using social media, artificial intelligence, groupware and group decision support systems, and other decision support techniques and technologies in open innovation management are explored. Furthermore, research hypotheses on this topic are formulated.

Key-Words: - Social media; open innovation management; hybrid intelligent model; intelligent software agent; fuzzy logic; expert system; complex adaptive system; analytic hierarchy process; simulation; intelligent decision support system

I. INTRODUCTION

Chesbrough defines open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation" [1]

In this digital age, innovation and open innovation management present significant challenges to managers due to dynamically changing customer demands, individualized consumer requirements, market uncertainties and fierce competition in the global markets. This is particularly true in the computer hardware, software and mobile phone industries.

The second-named author of this paper acquired knowledge in innovation management from Imperial College London in 2010.

The first-named author of this paper proposed and initiated a research project on the use of a hybrid approach, linking and integrating intelligent software agents, expert systems (ESs), decision support systems (DSSs) and social media with innovation and open innovation management in April 2012 at the University of Westminster. The main aims of

the study are to develop and establish a hybrid model and framework, and to explore the overall value, usefulness, effectiveness and efficiency of the hybrid approach and associated software tools in supporting innovation and open innovation strategy formulation, processes and diffusion. Part of the research output has been published in the proceedings of an international conference [10]

This paper focuses on the use of social media, artificial intelligence (AI), and DSSs in support of open innovation management. It is organized as follows. The nature of open innovation management in the digital age is analyzed in Section II. The hybrid framework is proposed and presented in Section III. The effectiveness and efficiency of the use of social media, artificial intelligence and decision support systems in open innovation are discussed in Section IV. Research hypotheses are formulated in Section V. Concluding remarks are given in the final section.

II. THE NATURE OF OPEN INNOVATION MANAGEMENT

According to Chesbrough [2], a project on product or service innovation can be introduced and initiated from either internal, external or both of the sources of technology. He also points out that innovation projects can enter a market by the company's own marketing and sales channels, via outlicensing or through spin-off venture companies or agents.

There are various channels for innovation ideas to flow into the process, and many ways for them to flow out into the existing or new markets regionally or internationally in a traditional way or over the Internet across the World Wide Web.

In this section, we analyze the nature of open innovation and the needs for computerized and Internet-enabled support for open innovation management, on the basis of the previous work conducted by Li et al. [15] in the strategic marketing field.

Open innovation involves interactions amongst internal and external contributors in dynamically changing environments. Dealing with uncertainties on factors or criteria affecting innovation strategies and other decision making is another issue. Strategic thinking is important.

Open innovation requires the analysis of the consumer preferences, likes, market trends, and competitors' maneuver. It requires synthesis of useful information, and internal and external knowledge. It is knowledge intensive. Creativity and new idea generation is essential.

In addition, diffusion of innovation, making the consumers to be aware of, interested in, and to adopt new technology, novel products and services is also pivotal to the success of innovation management.

Furthermore, many managers have difficulties in managing innovation. These include lacking knowledge and skills, lacking time, having no access to effective supporting methods and tools, lacking resources, lacking useful information and ideas, lacking capacity in dealing with market changes, trends, and competitors' moves.

III. THE HYBRID FRAMEWORK

Due to bounded rationality of human being [24] and the lack of knowledge and skills [15], managers need computer-based support for open innovation management. Various methods, technologies, techniques and tools, including social media, complex adaptive system (CAS) theory, ESs, fuzzy logic (FL), abductive reasoning, analytic hierarchy process (AHP), simulation (SIM), intelligent agents (IA), and hybrid systems (HS) are available for these purposes. The concept and salient features of social media and complex adaptive system theory (CAS) have been discussed in [5, 6, 12]. The powers of simulation have been analyzed in [10, 26]. The advantages of other supporting techniques and technologies have been analyzed in [26].

A hybrid paradigm for matching the properties of open innovation management with the strengths of diverse AI and decision support methods and techniques and technologies is given in Table 1. A hybrid framework for the use of social media, AI and DSSs in open innovation is illustrated in Fig.1.

Table 1. The hybrid framework for matching the properties of OI with supporting techniques and tools

Open Innovation Management	Supporting technologies, techniques, methods and tools
OI strategies Facets or properties: The markets and consumer requirements for products and services; trends; competitors and competition; competitive advantage; strategic alternatives; plans and various criteria; uncertainty; environments; strategic thinking; vision. [1, 2, 15]	ES; social media; groupware; group DSS; group Delphi; AHP; fuzzy logic; intelligent software agents [26]; hybrid system [16, 17, 18, 19]
OI process Facets or properties: interactions with internal and external contributors; consumer preferences; information and knowledge acquisition; new idea generation; human creativity; individual and group work; dynamics [1, 2]	Complex adaptive system (CAS) theory [7, 8]; system dynamics; social media; ES; brain storming; groupware; group Delphi; group DSS; fuzzy logic; simulation; intelligent software agents [26]; context-sensitive reasoning [11, 23, 25]; hybrid system [16, 17, 18, 19]
OI diffusion Facets or properties: Spreading new ideas and technology; communication channels; awareness, interest, evaluation, trial, and adoption [3, 4]	Social media [5, 6]; CAS; system dynamics [9]; ES; computer simulation; intelligent software agents [26]; hybrid system [16, 17, 18, 19]

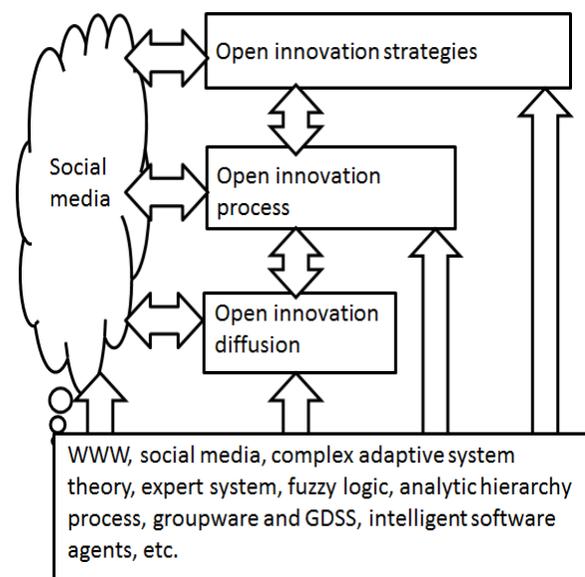


Fig.1. A hybrid intelligent model for linking social media, AI and DSS with open innovation

Within this paradigm and framework, social media tools such as Facebook, LinkedIn and Twitter, are employed to enable online interactions and collaboration, stimulate, collect and share comments and ideas about product/service innovation. Relevant Web analytics tools such as Facebook Insights and Omniture, can be employed to collect, measure and analyze the online Internet data about new products, services and innovation. Web analytics-oriented software agents can be created to watch and extract the key information such as preferences, likes, comments, new ideas, and market trends. This information can then be sent to a co-ordination software agent for open innovation.

Within this model, Peirce's abductive reasoning method [11, 23] and the inductive reasoning approach are utilized to monitor the social environments, make inference and find causes for innovation. The powers of contextual smart software agents can be utilized to detect, analyze and respond to the audience buzz, likes, trends and competitor maneuver in relation to open innovation, through inductive and abductive reasoning. The context-sensitive intelligent decision support systems method [25] can also be incorporated.

The system dynamics (SD) approach [9] is applied to represent and analyze the interactions and changes amongst online virtual social networks, the company's open innovation process and the competitors.

Computer simulation with animation and dynamic graphical displays can be used to the modeling, simulation run and analysis for open innovation strategy scenarios, dynamic process and diffusion in social networks.

CAS theory [7, 8] is employed to model and analyze the interactions amongst social media, the open innovation process and competitors at the micro level. It is also applied to simulate and estimate "emergence" such as novel ideas at the macro level [12].

The AHP method [22] is utilized to perform pair-wise comparisons, and evaluate priorities for innovation strategy alternatives by assessing them against relevant criteria.

Fuzzy logic [20, 21] is used to model and deal with uncertainty factors in relation to the criteria and variables that determining open innovation strategies and processes.

A fuzzy expert system [26] can be built to represent and store domain expert knowledge on open innovation and generate intelligent advice on innovation strategies, processes and diffusion in social media contexts.

Group decision support systems (GDSSs), groupware and group Delphi [26] can be utilized to support idea generation, differing point of view resolving, innovation priority assessment and ranking, and information sharing for open innovation management.

As shown in Table 1 and Fig.1, there are different facets and matching methods, techniques and technologies which can be considered as elements or components of the whole hybrid intelligent support system. Based up our previous work [17, 26], we recommend the use of a multi-agent coordination and integration method, called intercommunication job-sharing hybridization, for solving this complex problems that can be decomposed into smaller

separate subproblems or component, with communications/exchange identified and managerial judgement and creativity incorporated [26].

A managing software agent can be created to co-ordinate the communication and interactions amongst supporting elements, intelligent-based decision support methods and tools.

The hybrid intelligent model (HIM) can be expressed as:

$$\text{HIM} = \text{IA} \Theta \text{CAS} \Theta \text{ES} \Theta \text{FL} \Theta \text{DSS} \Theta \text{GDSS} \Theta \text{AHP} \Theta \text{SD} \Theta \text{SIM} \Theta \text{OT} \Theta \text{Web}$$

where the symbol Θ is a linkage, hybridization and interaction operator; and OT stands for other techniques and associated sub-systems.

The general specification for intelligent agents can be presented as [10]:

IA $\square\square$ (*status, timepoint, messagereceived, messagepostedout, behavior, rules & algorithms*)

The specification of fuzzy rules is similar to Li's work [27].

The output of the hybrid intelligent model can be denoted as the following equation:

OUTPUT = f_{OI} (Strategies, Process, Diffusion) \square f_T (IA, CAS, ES, FL, DSS, GDSS, AHP, SD, SIM, OT, Web) \square f_C (Human creativity)

where f_{OI} , f_T and f_C are implicit functions for the open innovation process, supporting techniques and human creativity, respectively. Here, symbol " \square " indicates logical union, integration or synergy..

IV. THE EFFECTIVENESS AND EFFICIENCY OF SOCIAL MEDIA, AI AND DSS IN OPEN INNOVATION

Based upon the authors' experience, observation and reflection on validating and evaluating the usefulness, effectiveness and efficiency of intelligent decision support systems [13, 17, 18, 26], the overall value of social media, AI and DSS in open innovation management consists of the following measures.

Effectiveness: Improved creativity, higher level of consensus, better analysis of information, better international and external interactions, improved strategic thinking, supplementing human vision, intuition and judgement, better understanding of factors influencing innovation, better performance of innovation, better quality of innovation, better outcomes of innovation, and higher degree of confidence for open innovation, and so forth.

Efficiency: Saving time, improving the speed of innovation decision making, reducing costs, saving effort, easier and faster internal and external interactions, making the innovation process easier, overcoming the time zone and geographical location barriers for open innovation and interactions.

V. RESEARCH HYPOTHESES FOR THE PROPOSED HYBRID INTELLIGENT MODEL

On the basis of the literature [13, 17, 18, 26], the authors' own reflection and synthesis of relevant research work, the following hypotheses are formulated for further research on this topic.

Hypothesis 1. The hybrid model helps stimulate creativity.

Hypothesis 2. The hybrid model helps stimulate strategic thinking

Hypothesis 3. The hybrid model with groupware and group decision support components helps generate more ideas

Hypothesis 4. The hybrid model with groupware and group decision support components helps achieve more consensus

Hypothesis 5. The hybrid model linking social media with open innovation help improve external and internal interactions

Hypothesis 6. The hybrid model linking social media with open innovation helps produce more ideas for open innovation

Hypothesis 7. Users of the hybrid model achieve better understanding of relevant factors or criteria affecting innovation decisions than non-users.

Hypothesis 8. Users of the hybrid model will attain better understanding of the interactions amongst the company, competitors and consumers in the social media contexts than non-users.

Hypothesis 9. Users of the hybrid model will obtain better insights about how a new product or service evolves, grows and adapts in social media contexts than non-users.

Hypothesis 10. Users of the hybrid model will be able to acquire more information and knowledge for their open innovation in social media contexts than non-users.

Hypothesis 11. Users of the hybrid model will know more about how social media atmosphere and buzz affect open product/service innovation than non-users

Hypothesis 12. Users of the hybrid model will have more chance to reduce the risks for open product/service innovation in social media contexts than non-users.

Hypothesis 13. Users of the hybrid model will be able to experiment and explore more strategic alternatives or options for open product innovation in social media contexts than non-users

Hypothesis 14. Users of the hybrid model will attain better coupling of analysis with human judgment, personal vision and creativity in the process of open innovation than non-users

Hypothesis 15. Users of the hybrid model will be able to yield better outcomes of open innovation than non-users

Hypothesis 16. Users of the hybrid model will attract more external contributors for open innovation than non-users

Hypothesis 17. Users of the hybrid model will be more confident (have higher level of confidence) about their innovation decisions and output than non-users

Hypothesis 18. Users of the hybrid model will be more confident (have higher level of confidence) about their innovation processes than non-users

Hypothesis 19. Users of the hybrid model will be able to accomplish better diffusion of innovation than non-users

Hypothesis 20. Users of the hybrid model will be able to save more time and effort in the process of innovation than non-users

Hypothesis 21. Users of the hybrid model will learn more about open innovation and social media than non-users

VI. CONCLUSIONS

This study has been concerned with linking social media, AI and DSS with open innovation strategy development, processes and diffusion in the digital age. A hybrid intelligent framework and model has been introduced and discussed by the author. The effectiveness and efficiency of the use of recommended methods, techniques, technologies and tools in open innovation management have been explored. Moreover, research hypotheses have been developed and stated in the paper.

Further work is being undertaken to test relevant research hypotheses, and evaluate the overall value and usefulness of the proposed hybrid model in the computer hardware, software, and mobile phone industries.

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