Knowledge Diffusion on Community Network

−the Angle of Absorptive Ability and Diffused Ability

Qingjun Li
Institute of Science and Technology for Development of Shandong; Soft Science Research Base of Shandong Province and Technology Innovation
Jinan, 250014, China
33104731@qq.com

Fanping Kong, Yongfei Jia, Quanmin Bai
Institute of Science and Technology for Development of Shandong; Soft Science Research Base of Shandong Province and Technology Innovation
Jinan, 250014, China
davidleo.1982@stu.xjtu.edu.cn

***Abstract*—This article summarized the performance of knowledge diffusion on community network by looking level of final knowledge as an evaluation index of the whole knowledge network based on agent's absorptive ability and diffused ability. We construct a knowledge diffusion model and simulate the process of knowledge diffusion, theoretic analyses and simulation results indicate that the average knowledge level increases as the enhance of absorptive ability when keeping community connections constant. The experimental outcomes told us low diffused ability will depress the final research level.**

Keywords- Knowledge Diffusion; Community Network; Absorptive Ability; Diffused Ability

I. INTRODUCTION

Review of papers on knowledge transfer, which had a lot of literature emphasized the importance of knowledge diffusion [1-3]. Many scholars found that it was a very difficult task to improve knowledge diffusion effectively and how to evaluate the performance of knowledge diffusion [4].

The knowledge diffusion model that proposed by Cowan [5] studied the exchange and diffusion of knowledge among different types, which attracted wide attention of researchers. In Cowan's model, there were small amount of direct connections among agents, knowledge diffusion occurred when knowledge exchange existed among agents that were linked each other by direct connections. The knowledge diffusion model proposed by Cowan researched how different network structures (i.e. small world network, regular network, and random network, etc.) affected the performance of knowledge diffusion. His study found that the knowledge diffusion system on these network structures had all shown "a significant feature with 'Small World', and in which the steady-state level of average knowledge is maximal when the network structure is a small world" [5]. The other scholars explored knowledge diffusion on several other classical network structures (i.e. hierarchical network and scale-free network etc.) based on Cowan's model. For example, Lin [6] extended Cowan's model to scale-free network, and explored knowledge diffusion on small world network, regular network, random network and scale-free network, his research set the average knowledge stock level as a function of time, and calculated the diffusion time when knowledge stock level arrived stead on these four types of network structures. Lin's research results showed that scale-free network's final average knowledge level was maximal and the growth and diffusion of knowledge was fastest in small world network and so on four kinds of network structures. Tang [7] described knowledge diffusion as an repeating process between knowledge origin and end. He thought that the diffused ability of knowledge senders was as important as the absorptive ability of knowledge receivers during knowledge diffusion process. He used a neural network model-SLPM testing the effect of knowledge senders' diffused ability and knowledge receiver's absorptive ability on average knowledge level in hierarchical network and scale-free network. Li [8] studied the knowledge dissemination on community networks (only considered absorptive ability); the experimental results indicate that the more inner-community and inter-community connections were, the higher average knowledge level was. Most of the existing literature studied the knowledge diffusion on network structures based on absorptive ability except for diffused ability which was regarded as an important factor during knowledge transfer process [7]. Therefore, this paper focuses on the performance of knowledge diffusion not only considering absorptive ability but also diffused ability. The rest content of this article is following. In the second part, we introduce the model of knowledge diffusion process and community network. In the third part, the experimental outcomes are given. In the last part but two, this article closes with a discussion and summary of this article.

II. THE MODEL

This paper uses network to describe the relationship of knowledge diffusion among agents. The nodes on network represent agents who participate in knowledge diffusion, the links denote that the agents can transfer knowledge each other. Based on Li's paper [8] for depicting network, we can denote network G as follows:

(1) Set $S=\{1,...,N\}$ denote a finite aggregate of units, and a aggregate of links, $\delta \subseteq S\times S$; and

(2) $\delta \to \{a,b\}$ is a sign function, where $a=1$ and $b=0$. No matter what $i, j \in S$, set the variable $\delta(i,j)=a$ if has a link between i and j , and $\delta(i,j)=b$, otherwise. Equivalently, $\delta(i,j)\to\{1,0\}$.

$G = \{\delta(i,j); i,j \in S\}$ denotes that links among units that exist on the network, it is an finite aggregate. The units on the network if and only if have links can transfer knowledge each other. The aggregate $\Psi_i = \{j \in S : \delta(i,j) = 1\}$ denotes i's all neighborhood.

A. Knowledge Diffusion Model

Based on the model Cowan proposed [5], this paper along the Cowan's thinking proposed that one diffused knowledge to another if and only if he can acquire knowledge from the others. In this paper, each agent $i, i \in S$ is depicted through $s_{i,r}$ *that is an vector*, r is the $r-th$ kind of the knowledge vector, $r = 1,2,...,z$. We use $\mu(i,j)$ to depict the amount of kinds in which i 's knowledge level is higher than j 's. One diffuse knowledge to the others when the sign $\min\{\mu(i,j), \mu(j,i)\} > 0\}$ conforms to the condition. The final knowledge level which changes over time as agent acquires knowledge diffused by the others. We use $s_{i,r}(t)$ depict the final knowledge level of i with category r at time t.

In this paper, we define two concepts, one is absorptive ability and another is diffused ability. Cohen and Levinthal [9] described that absorptive ability is one of the abilities that enterprise can perceive and absorb new knowledge, and use these information to promote enterprise's value. We define the absorptive ability is following:

Definition 1: It is one kind of ability that agents on network can translate the newly gained and absorbed knowledge into their own knowledge.

Tang[7] proposed that diffused ability was as important as absorptive ability in the process of knowledge transfer, he thought that diffused ability made agents effectively and efficiently express knowledge. We define the diffused ability as follows:

Definition 2: It is one kind of ability that agents on network effectively express and transfer their own knowledge to others according to the comprehension of themselves in some way.

When knowledge diffusion occurs between unit i and its neighbor $j, j \in \Psi_i$, at this time j received knowledge from i, we must consider absorptive ability, diffused ability and how much knowledge i and j have, because of above factors, j can't acquire all knowledge that i transferred. Therefore, the knowledge that unit j posses changes with time moving forward, we can depict it through the following formula:

$$\begin{cases} s_{j,r}(t+1) = s_{j,r}(t) + \alpha[\beta s_{i,r}(t) - s_{j,r}(t)], & \text{if } \beta s_{i,r}(t) > s_{j,r}(t) \\ s_{j,r}(t+1) = s_{j,r}(t) & \text{otherwise} \end{cases}$$

We use $\alpha(0 \le \alpha \le 1)$ depicts absorptive ability of agent j, and $\beta(0 \le \beta \le 1)$ is the diffused ability of i. Since j can't acquire all knowledge that i transferred, $\alpha(0 \le \alpha \le 1)$ and $\beta(0 \le \beta \le 1)$ are very critical factors of knowledge diffusion [7,8].

Unit i how much knowledge have at time t is :

$$\bar{s}(t) = \frac{1}{N} \sum_{i \in S} s_i(t)$$

here, $\bar{s}(t)$ is an important diffusion factor .

B. Community Network Model

We made simulation experiment that simulate knowledge diffusion between unit i and j on community network.

Community network: In our experimental there are some communities. We proposed algorithm to form community network model is following [10, 11]:

(1) Initialization: At the beginning, we assume there are three units that are connected each other on every community; and simultaneously, every two communities exist an inter-community connection, if we give three communities, the network have three inter-community connections. The agents to which the inter-community links connect are chosen fixedly in each community. For example, Fig.1 shows an initial graph of the model with communities and.

(2) Incremental growth: At each time step, a new agent is added to a randomly selected community. The new agent will be connected to existing agents in the same community through inner-community links and to be connected to existing agents in different communities through inter-community links.

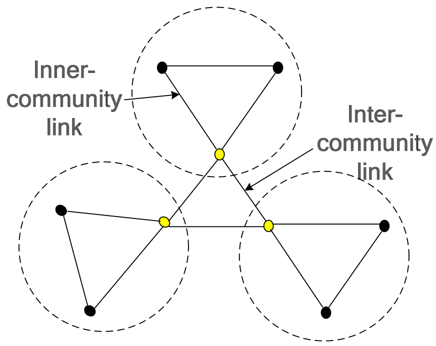

Figure.1 $M = 3$, $m_0 = 3$

(3) Attachment mechanisms: Firstly, given a probability p_{ij}, the any agents connect to another, and when the two agents are in one community, the connection is an inner-community link, the degree l_{ij} plays an important role, therefor, we can get the formula is $p_{ij} = l_{ij} / \sum_k l_{kj}$; On the other hand, also given a same probability p_{ij}, the any agents connect to another, and when the two agents are not in one

community, the connection is an inter-community link, the another degree p_{ik} also plays an important role, $p_{ik} = l_{ik} / \sum_{i,k,k \neq j} l_{ik}$.

III. Simulation Results

In this part, the experiment outcomes will be given, and the authors explain the each simulation results with every figure. In our experiment, there are total $M = 3$ communities, and have $N = 500$ units in the three communities, where the knowledge diffusion occurs. With the time changes over, we assume it is fixed that network structures are. And then, at the beginning of the simulation, each agent has a 5-category knowledge vector, we use $v_{i,r}(t=0) \sim U[0,1]$ to depict the knowledge i has. $\alpha(a \in [0.1,0.9])$ depicts absorptive capability of acquirement and $\beta(\beta \in [0.1,0.9])$ depicts diffused capability of units, and every agent has the same ability no matter what it receive or diffused knowledge. Moreover, in the first instance there are 25 'experts' every experts have high knowledge which is 10, but only one kind in our experiment. In each experiment the authors took the times are exceeding 100000 when the time are changing over, until reached the level of knowledge is not varied. And then, we took 10 experiments, get the average level as the final result, keeping the beginning requirement.

We selected the player i and its direct neighbors j stochastic, $i, i \in S$, $j, j \in \Psi_i$. The knowledge diffusion occurs among any agents till one of the units posses knowledge is less than another one in any kind take place, that is to say, it fit the regulation: $\frac{s_{i,r}}{s_{j,r}} \in [0.99,1.01]$.

A. Community Network and Knowledge Diffusion

The results for the knowledge transfer on community network for different values of the average degree $\bar{k} = 2(m+n)$ in Fig.2. It displays that the larger the value of the parameter $\frac{m}{n}$ is, the larger the value of average knowledge level is over the large range of absorptive ability α . According to the results we present above, we find that, for different values of the parameter $(m+n)$, the larger its value is, the average knowledge level becomes larger for the same α . We can explain this in following ways. First of all, the average degree $\bar{k}$ can affect the average knowledge level. The large value of $\bar{k}$ can improve average knowledge level. Second, because of the existence of highly knowledgeable agents, they play an important role in promoting average knowledge level.

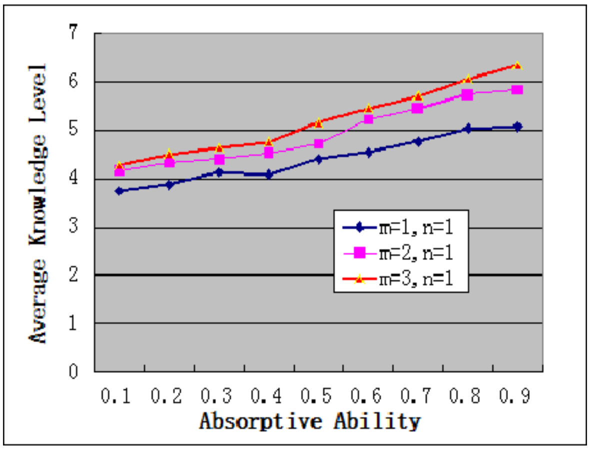

Figure 2. Different values of $\frac{m}{n}, (m+n)$, absorptive ability and different average knowledge level

B. Absorptive Ability and Knowledge Diffusion

Agents on network can translate the newly gained and absorbed knowledge into their own knowledge, however, different absorptive ability bring different average knowledge level during knowledge diffusion process. According to the results that Fig.2 presented, we find that average knowledge level is increasing as the absorptive ability becomes larger and larger for different m and n, vice versa. Therefore, from simulation results, we found that high absorptive ability can enhance average knowledge level.

C. Diffused Ability and Knowledge Diffusion

When knowledge diffusion occurs, one may only diffuses part of knowledge that another absorbs, because of his diffused ability. From Fig.4, the results presented told us that different diffused ability can produce different average knowledge level. The high diffused ability brings high average knowledge level when community structure and absorptive ability are fixed, vice versa. From the simulation results, we also conclude that high diffused ability can improve average knowledge level greatly.

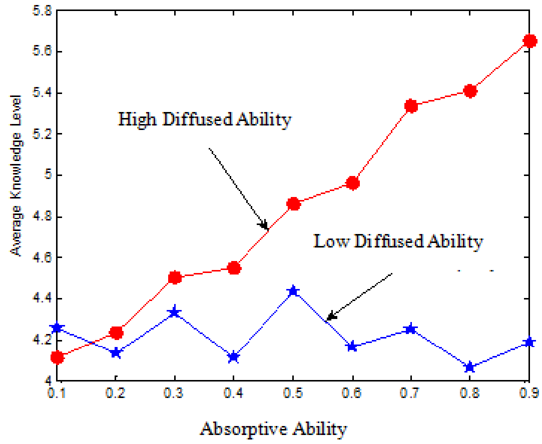

Figure3 Different disseminative ability and average knowledge level

IV. Discussion and Conclusion

In this paper, we explore the knowledge diffusion process on community networks base on absorptive ability α and diffused ability β. Our simulation results show that different and can give rise to different knowledge levels, the higher absorptive ability and diffused ability are, the higher the steady-state level of average knowledge is. In our article, though we propose a new knowledge diffusion model on community networks, only absorptive ability and diffused ability are considered, there are also other factors that can affect the knowledge transfer process. It is necessary for researchers to examine more comprehensive knowledge diffusion models for future work.

Acknowledgment

This work was supported by Soft Science of Shandong Province for Major Projects under grant No.2012RZC01001 and by Soft Science of Jinan under grant No.201302157.

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