The Simulation of Knowledge Flows on Collaboration Innovation Networks Based on Cellular Automata

Zhou Wen ,Jing Mingyang

School of Computer Engineering and Science,Shanghai University,Shanghai 200027

Abstract

A cellular automaton(CA) model of knowledge flows and innovation on collaboration innovation networks was establisted. The impact of network innovation rate to knowledge flow is studied,the changes in the amount of knowledge of the enterprise is analyzed. Simulation shows that the innovation of enterprise plays an important role in the development of the network. Further more, the change of corporate knowledge also reflects a series of rules and characteristics of the flow of knowledge in the innovation network.

Keywords: cellular automaton(CA) innovation network knowledge flow rate of innovation

1. Introduction

With the advent of the era of knowledge economy, innovation become an important manifesttation of the core competitiveness of enterprises, knowledge can effectively transfer and innovation plays an increasingly important role in the survival and development of enterprises. inter-firm knowledge flows and transfer of knowledge innovation necessary conditions[1].

In this paper, the flow of knowledge and innovation in the innovation network to establish a cellular automata model, Detailed simulation study of the rate of innovation and knowledge dissemination process of innovative network.

2. The innovation network simulation based on cellular automata

2.1. Cellular Automata

Cellular automata is a space discrete, time discrete, state values also discrete, dynamical systems to comply with the rules of the local evolution. And can be formally defined as a quintuple (cellular, cellular space, neighborhood, cellular state, state evolution rules).The cellular of hash in cellular space according to oneself and the neighbor's cellular state, in accordance with the prior-tectonic evolution of the state rules to determine the status of the Cellular next time.

2.2. Represented innovation networks based on cellular automata

According to the basic principle of cellular automata, to construct a suitable analog innovative network flow of knowledge and innovation model.

①Cellular: Enterprise innovation net works to transfer knowledge of all enterprises.

②Cellular Spaces: The organizational structure of all enterprise consists of enterprise innovation network.

③Neighborhood: A collection of all nodes connected to the enterprise node adjacent element space. So, the different nodes has a different neighborhood collection.

④Cellular states: The enterprise node has a certain knowledge.

⑤State evolution rules: Cellular evolu tion in the next time state rules.

Because knowledge flows from one to no way more to less process, so knowledge between enterprises node potential difference affect knowledge transfer probability between nodes. Hypothesis of cellular will knowledge transfer to neighborhood m will for P_{out}, cellular m accept neighborhood knowledge for probability P_{in}, then knowledge in two cellular between the probability of transmission is $\rho=|P_{out}-P_{in}|$. We assume that the enterprise has the knowledge of the same kind of comparable knowledge. Therefore, the transfer will enterprise between the enterprises themselves contain closely related to the amount of knowledge, namely $P_{i,j}$ = knowledge [i] -knowledge [j]. In this case, the enterprise mutual connection between the matrix has been generated. As shown in Figure 2.

$$\begin{bmatrix} 0 & p_{1,2} & \cdots & \cdots & p_{1,m} \\ p_{2,1} & 0 & \cdots & \cdots & p_{2,m} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \cdots & \cdots & 0 & \vdots \\ p_{m,1} & \cdots & \cdots & p_{m,m-1} & 0 \end{bmatrix} = \begin{bmatrix} 0 & \cdots & \cdots & \cdots & p_{out} \\ \vdots & 0 & \cdots & \cdots & \vdots \\ \vdots & \cdots & \ddots & \cdots & \vdots \\ \vdots & \cdots & \cdots & 0 & \vdots \\ p_{in} & \cdots & \cdots & \cdots & 0 \end{bmatrix}$$

Figure 1 Innovation network enterprise node adjacency matrix

2.3. State evolution rules

It is known that the enterprise node N cellular state $S_N(t)$ have 0 and 1 two state values:

• when $S_N(t)=0$, the said enterprise node N does not have the knowledge stock, node N will according to its neighborhood node status according to the state evolution rules perception this knowledge:

$$P_N(t+1)=\frac{\sum_{i=1}^{m} S_i(t) * \rho_{i,N}}{m} * (1+\varphi)$$

(N=1,2,3,⋯,m) (1)

$\rho_{i,N}$ the results such as for(2)

$$\rho_{i,N}=\sum_{i=1}^{m}\left|p_{i,N}-p_{N,i}\right| \text{ (N=1,2,3,⋯,m)} \quad (2)$$

From(1), the node N absorb knowledge the probability of its surrounding m the product of the probability ρ of the state of the enterprise node S with its knowledge flow averaging, and then multiplied by $(1+\varphi)$, Where φ is the innovation probability coefficient is the knowledge of the probability of the entire innovation network generated due to the flow of knowledge and innovation.

• when $S_N(t)=1$, enterprise node N is already known to the knowledge, knowledge node N according to the state of evolution rules to other the knowledge nodes pass knowledge. Constant state in the next time, the knowledge of their neighbors' perception has a positive role.

3. Simulation and results analysis

In order to demonstrate the impact of the rate of innovation in knowledge flows, we set up a special following simulation cases:

(1) The use of a random function generates a scale of 100 × 100 Innovation Network;

(2) Random function to generate the amount of knowledge contained by each of the 100 companies, on behalf of the enterprise knowledge with 2,4,6,8,10.

(3) Enterprises in the knowledge transfer process continue to absorb the knowledge, while the probability of φ to generate new knowledge and continue to pass along.

3.1. Innovation rate of flow of innovative network knowledge

To verify that the rate of innovation for innovation network formation, development, continue the great role of special to innovation rate φ = 0.1 and φ = 0.5, for

example, the flow of knowledge and innovation innovative network simulation. Figure 2 and Figure 3 shows the innovation networks to establish initial state.

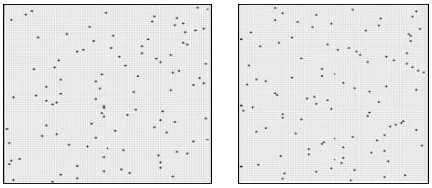

Figure 2、3 φ = 0.1 and 0.5 generates random innovation network

Different knowledge flow rate of innovation to create a random innovation network, statistical analysis of network fully iterative innovation networks included the amount of knowledge, the results shown in Figure 4.And the absolute amount of knowledge generated in each step of the iteration is shown in Figure 5.

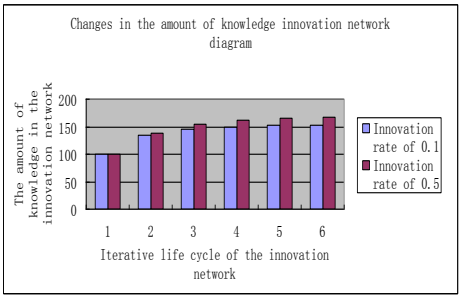

Figure 4 Changes in the amount of knowledge innovation network diagram

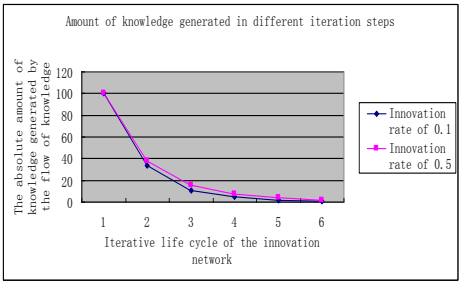

Figure 5 Amount of knowledge generated in different iteration steps

As can be seen from the comparison of Figure 4, the amount of knowledge in the innovation network have increased with the increase in the number of iterative steps, but with the increasing number of network iteration step, The innovative high network knowledge is greater than the innovative low network,and the gap is growing trend. We can see from Figure 5, in a relatively stable innovation network, with the increase in the number of iterations, the knowledge innovation throughout the innovation network will be gradually reduced, and even in the end will be attributed to 0. This is the case because when the innovation network stable, Knowledge flows alone has been unable to maintain the operation and development of the entire network. Therefore, innovation is a source of business development and growth.while we are concerned about the rate of flow of knowledge innovation should rely on their own R & D capabilities enhance. In addition,should also continue to attract more enterprises to join the Innovation Network. Only enhanced the relative novelty of the innovation network and expansion, and to continue to inject new knowledge for the network, and enhance the vitality and fluidity of the network. You can also benefit from the network of individuals.

3.2. The growth of the enterprise knowledge innovation network

In order to compare innovation networks, enterprises in the independent state of knowledge and innovation networks of knowledge dissemination and absorption of different state. Constant innovation rate φ = 0.5, a comprehensive comparison of the 100 companies of the initial amount of knowledge and iterative knowledge content, as shown in Figure 6.

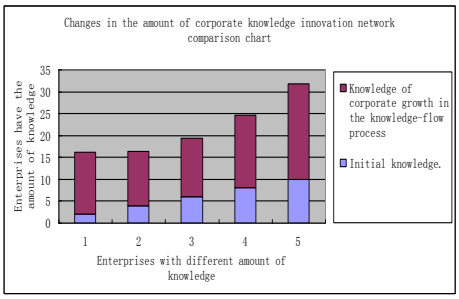

Figure 6 Changes in the amount of corporate knowledge innovation network comparison chart

Figure 6 is not difficult to find, with the knowledge flow in innovation network, the amount of knowledge of the various enterprises have an obvious growth process; However, when the initial amount of knowledge a smaller or larger, absorbed in the flow of knowledge from the Network is far greater than the amount of new knowledge and new knowledge acquired by other companies, With the increase in the number of iteration steps, the the knowledge absorption rate gradually accelerated. This also confirms the innovation network, a relatively small amount of knowledge enterprises easier access to knowledge in the network, and strong corporate mastered a lot of knowledge to better develop their own competitive advantage, and also reflects the knowledge innovation network from one sideaccumulation phenomenon.

4. Conclusion

Through the analysis of simulation results, We can know:Probability of enterprise knowledge flows is closely related to the relative amount of knowledge itself and its neighbors. Network innovation rate has a major role in the growth and development of the innovation network. Moreover, in order to maintain an network robustness, and enhance the enterprise's own independent innovation and network structure dynamic is also key. In addition, the Innovation Networks have knowledge of balance and certain knowledge agglomeration.

5. Acknowledgment

This research is supported by the Internal Natural Science Foundation of China, No. 71203135, 71003069,40976108.

6. References

[1] Zhang Bing,Wang Wenping, “A Simulation Study on Knowledge Flowing Efficiency of Informal Knowledge Networks Based on Different Interactive Policies[J]”, Chinese Journal of Management, pp: 706-713 ,2010,5.

[2] Gu Xin,Li Jiuping,Wang Weicheng, “Knowledge Flow,Knowledge Chain and Knowledge Chain Management [J]”,Soft Science, pp:10-16,2006,86.

[3] Li Jinhua,“Knowledge Flow on the Influence of the Structure of the Innovation Network - Based on Complex Network Theory Discussion [J]”,Science&Technology Progress and Policy,pp:91-94.2007,11.

[4] Wang Lubang,Qian Xingsan. “Tacit Knowledge Transfer Simulation Based on the Cellular Automata[J]”, Journal of East China Normal University,pp:123-133, 2011,5(3).

[5] Renato Guseo,Mariangela Guidolin, “Cellular Automata with network incubation in information technology diffusion”,Physica A,pp: 2422-2433, 2010,389.

[6] Jia Weifeng,Dang Xinhua,“Research on core enterprise’s knowledge flow-coupling control in technological innovation network”, Science Research Management,pp:56-63,2010.