ISSN : 0974 - 7435 Volume 10 Issue 9

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(9), 2014 [3955-3960]

Research on the relation between postdoctoral system and the growth process of post-doctoral fellows based on GERT model

Gao Hong*,Wang Jigan

Business School,Hohai University,Nanjing,(CHINA)

ABSTRACT

This paper describes the dynamic growth process of post-doctoral fellows and establishes a kind of GERT network model based on the “life cycle”theory. It collects data from Nanjing as an example to give the specific solution and the analysis process. The results show that the value of the natural probability that an undergraduate student growning to be a postdoctoral fellow is just 1.9684%,while if the postdoctoral system will have been improved,the probability will increase to 2.7808%.

KEYWORDS

GERT network model; Postdoctoral system; The growth process of post-doctoral fellows.

INTRODUCTION

Our country has implemented postdoctoral system since 1985 and the system has used the experience of American postdoctoral system for reference in order to train young researchers and advance scientific research. Postdoctoral system is crucial to post-doctoral fellows because it can promote talent flow and improve the quality of talent cultivation. However,the quantity and quality of post-doctoral fellow cultivation in our country are much lower compared with the United States.

In an attempt to remedy the problem,this paper proposes to study the relation between postdoctoral system and the growth process of post-doctoral fellows based on GERT network model. According to the "life cycle"theory,the growth process of post-doctoral fellows is a dynamic process of objective system,it will be transferred from one state to another. Meanwhile, it is random and can be reflected by a certain probability. GERT can give the static and dynamic characteristics and also the probability distribution of the system[1],so the present study tries to use GERT to establish a dynamic GERT net model which takes the natural and hypothetical growth process of post-doctoral fellows.

GERT NETWORK AND ITS APPLICATION TO TALENTS

Graphical Evaluation and Review Technique (GERT) is one of the important branches of system engineering and a generalized kind of random network analysis method which combines network,probability theory,signal flow diagrams and simulation technology. This network can be used in modeling and analyzing different systems in engineering,manufacturing,finance and other areas of society because it describes systems under joint action of environmental conditions which changes randomly and includes the random factors in system.

The steps to compute the GERT network which contains mutex nodes only are as follows:a)build a GERT network model according to the research problem;b)collect the basic parameters of each activity and describe the transfer relation;c)use mason formula to calculate the equivalent function and equivalent probability;d)transfer the equivalent transfer function to equivalent moment generating function;e)calculate all parameters and give the solution.

In paper[2],a hi-tech product development process and a project analysis method based on GERT were studied. Documentary[3] used Grey GERT to describe the process of formation and development of regional industry cluster. Based on the S-GERT model,paper[4] used a relative algorithm to diagnose quality fluctuations on the supplier side and detected critical quality resources in a complex supply chain. GERT network also can be used to study the growth of innovation talents,paper[5] constructed the life GERT model of the military commander learning and working by applying the thoughts of system science and random net theories. A GERT model was also built up in paper[6] to describe the growth of regional technology innovation talents and design some government support programs in variety of the growth.

THE CONSTRUCTION OF THE BENCHMARK MODEL OF POST-DOCTORAL FELLOWS'S GROWTH PROCESS

According to the "life cycle"theory,the growth process of post-doctoral fellows will be transferred from one state to another while it is random and can be reflected by a certain probability. Based on the "life cycle"theory and looking back to the features and procedures of post-doctoral fellows' growth process,through abstraction and generalization,this paper comes up with eight main stages of the growth process. The above situations taken into consideration,the dynamic diagram of GERT network which concers the natural growth process of post-doctoral fellows is thus established,as is shown in Figure 1. This paper sets the natural probability model as a benchmark model.

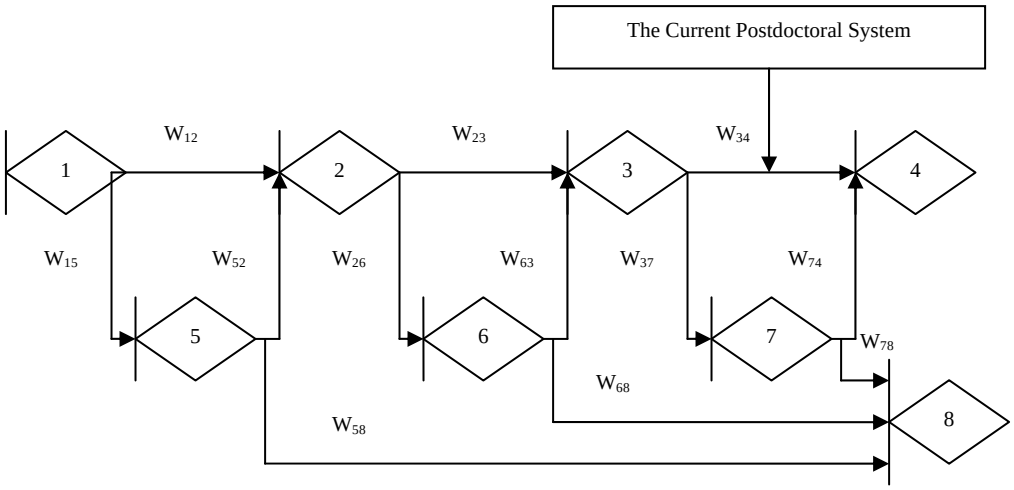

Figure 1 : The benchmark GERT model of post-doctoral fellows' growth process

Figure 1 shows that there are 8 paths from node1 to node 4,which means there are 8 paths in order to foster an undergraduate student to be a postdoctoral fellow. The paths are as shown in TABLE 1.

TABLE 1 : paths from node 1 to node 4

Path	Passing Nodes
1	1-2-3-4
2	1-5-2-3-4
3	1-5-2-6-3-7-4
4	1-2-6-3-4
5	1-2-6-3-7-4
6	1-2-3-7-4
7	1-5-2-6-3-4
8	1-5-2-3-7-4

Description of the nodes and activities

Different nodes indicate different states of the system. In Figure 1, Node 1 refers to the state where the person is studying for a bachelor's degree, Node 2 refers to the state where the person is studying for a master's degree, Node 3 refers to the state where the person is studying for a doctor's degree. Node 5,node 6 and node 7 refer to the state where the person is in a short period of working and node 8 refers to the state where the person is in a long-term employment. Node 4 is the goal node of this paper,it refers to the state where the person is doing the postdoctoral research. By the model in Figure 1,it can obtain the probability of the transfer value from node 1 to node 4 and it means the natural probability which makes an undergraduate student become a postdoctoral fellow.

Activity(1,2) refers to the person who gets the bachelor's degree wants to study for a master's degree directly;Activity(1,5)refers to the person who gets the bachelor's degree is going to get a job;Activity(5,2)refers to the person wants to study for a master's degree for some reason while he/she has already got a job,and activity(5,8) refers to the person who is willing to be in a long-term employment and does not want to pursue advanced studies.

Activity(2,3) refers to the person who gets the master's degree wants to study for a doctor's degree directly;Activity(2,6)refers to the person who gets the master's degree is going to get a job;Activity(6,3) refers to the person wants to study for a doctor's degree for some reason while he/she has already got a job,and activity(6,8) refers to the person who is willing to be in a long-term employment and does not want to pursue advanced studies.

Activity(3,4) refers to the person who gets the doctor's degree wants to do the postdoctoral research directly;Activity(3,7)refers to the person who gets the doctor's degree is going to get a job;Activity(7,4) refers to the person who wants to do the postdoctoral research for some reason while he/she already got a job,and activity(7,8) refers to the person who is willing to be in a long-term employment and does not want to pursue advanced studies.

Definition of the parameters

Due to the diversity and complexity of the growth process of post-doctoral fellows[7],it can't find a commom parameter for all scenarios. Therefore,this paper surveys and collects data from Nanjing province as an example to give the specific solution and analysis process. Thus,the relevant parameters and probabilities of activities which make the growth process transferred from one state to another are shown in TABLE 2.

TABLE 2 : Parameters in the benchmark GERT model

Acativity	Probability	Distribution	Parameters（year）	Moment generating function	Transfer function
(1, 2)	0.3	Normal distribution	$\overline{t}=4,\sigma=1$	$e^{4s+0.5s^2}$	$0.3e^{4s+0.5s^2}$
(1, 5)	0.7	Constant distribution	$t=4$	e^{4s}	$0.7e^{4s}$
(5, 2)	0.1	Constant distribution	$t=3$	e^{3s}	$0.1e^{3s}$
(5, 8)	0.9	Constant distribution	$t=30$	e^{30s}	$0.9e^{30s}$
(2, 3)	0.2	Normal distribution	$\overline{t}=3,\sigma=1$	$e^{3s+0.5s^2}$	$0.2e^{3s+0.5s^2}$
(2, 6)	0.8	Constant distribution	$t=3$	e^{3s}	$0.8e^{3s}$
(6, 3)	0.1	Constant distribution	$t=4$	e^{4s}	$0.1e^{4s}$
(6, 8)	0.9	Constant distribution	$t=25$	e^{25s}	$0.9e^{25s}$
(3, 4)	0.1	Normal distribution	$\overline{t}=4,\sigma=1$	$e^{4s+0.5s^2}$	$0.1e^{4s+0.5s^2}$
(3, 7)	0.9	Constant distribution	$t=4$	e^{4s}	$0.9e^{4s}$
(7, 4)	0.1	Constant distribution	$t=5$	e^{5s}	$0.1e^{5s}$
(7, 8)	0.9	Constant distribution	$t=20$	e^{20s}	$0.9e^{20s}$

Model solution

According to the GERT network theory,each procedure can be defined as its W function and signal flow graph theory is used to calculate the equivalent transfer function $W_E(S)$,and all parameters can be counter-calculated by using the moment generating function's basic property[8]. The equivalent transmission function is obtained as follows:

$$\begin{aligned} W_E(S) &= \frac{1}{\Delta}\sum_{k=1}^{m} p_k\Delta_k \\ &= 0.006e^{11s+1.5s^2} + 0.0014e^{14s+s^2} + 0.000504e^{23s} + 0.0024e^{15s+s^2} \\ &\quad + 0.00216e^{20s+0.5s^2} + 0.0054e^{16s+s^2} + 0.00056e^{18s+0.5s^2} + 0.00126e^{19s+0.5s^2} \end{aligned} \quad (1)$$

According to the character of moment generating function,when $S=0$, $M_E(S)=W_E(0)=1$,the realization probability $P_E=W_{E(S)}\big|_{S=0}$.

By calculating,the result shows that the value of the natural probability that an undergraduate student growing to a postdoctoral fellow is just 1.9684%. It means that it is difficulty to foster post-doctoral fellows,most people could not do the postdoctoral research because of kinds of reasons.

THE CONSTRUCTION OF THE CONTRAST MODEL OF POST-DOCTORAL FELLOWS' GROWTH

Post-doctoral fellows are important to our country while postdoctoral system is the main system tool to foster these high-level talents. People always try to improve the quantity and quality of post-doctoral fellow cultivation through better policy.

In the following content,the paper assumes that postdoctoral system will have been improved and studies the effect of this more perfect postdoctoral system on post-doctoral fellows. According to the fact, postdoctoral system only has an effect on activity(3,4) which refers to the person who got the doctor's degree already and wants to do the postdoctoral research directly. By interviewing and discussing with scholars,post-doctoral fellows and managers from National Post-Doctor Regulatory Commission,the study makes the probability of activity(3,4) increased by 10% and the variance reduced by 50%. The relevant parameters and probabilities of activities are shown in TABLE 3 and the contrast model is shown in Figure 2.

TABLE 3 : Parameters in the contrast GERT model

Case	Acativity	Probability	Distribution	Parameters（year）	Moment generating function	Transfer function
The Benchmark Model	（3，4）	0.1	Normal distribution	$\overline{t}=4,\sigma=1$	$e^{4s+0.5s^2}$	$0.1e^{4s+0.5s^2}$
	（3，7）	0.9	Constant distribution	$t=4$	e^{4s}	$0.9e^{4s}$
The Contrast Model	（3，4）	0.2	Normal distribution	$\overline{t}=4,\sigma=0.5$	$e^{4s+0.25s^2}$	$0.2e^{4s+0.25s^2}$
	（3，7）	0.8	Constant distribution	$t=4$	e^{4s}	$0.8e^{4s}$

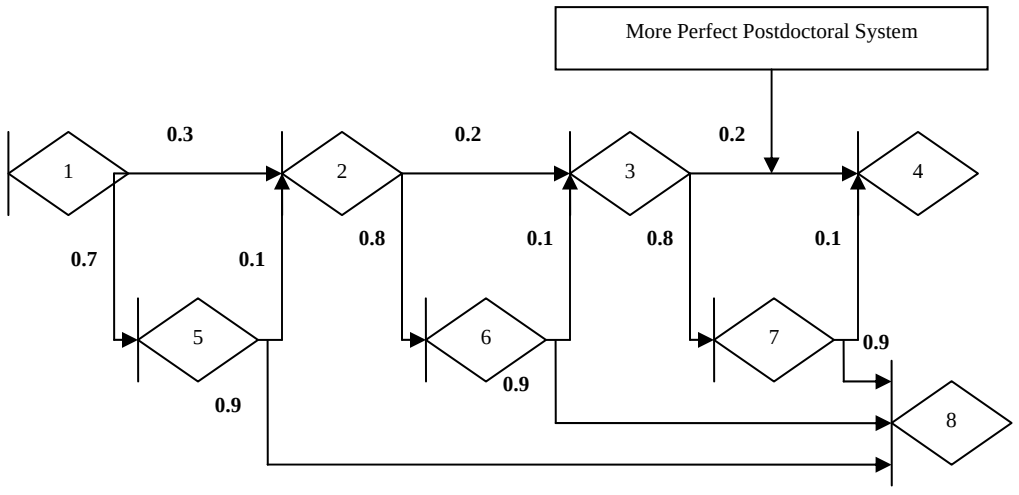

Figure 2 : The contrast GERT model of post-doctoral fellows' growth process

Figure 2 shows that the more perfect postdoctoral system can increase the probability of activity(3,4) and the probability that an undergraduate student growing to a postdoctoral fellow is 2.7808% by calculating. The increased value compared with benchmark model is 0.8123%. From this,if the government carries out more perfect postdoctoral system,it will increase the probability of postdoctoral fellows' growth and it is important to future development.

CONCLUSION

This paper establishes a kind of dynamic GERT network model which describes the dynamic growth process of post-doctoral fellows. It solves the problem of the quantitative description of post-doctoral fellows' growth process and gives a qualitative and quantitative analysis of the influence of the postdoctoral system on post-doctoral fellows' growth process. The value of the natural probability that an undergraduate student growing to a postdoctoral fellow is just 1.9684%, if the government carried out more perfect postdoctoral system,the probability can increase to 2.7808%.

However,because the modeling and solving method in this paper need the parameter data of the various activities,but the data in this paper only be attained from Nanjing,it is necessary to collect data from other areas in order to reach the conclusion.

ACKNOWLEDGEMENTS

This work was supported by the project "Research on postdoctoral system role in promoting the construction of university faculty". The authors wish to thank the National Post-Doctor Regulatory Commission in Ministry of Human Resource and Social Security of China for their help.

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