ICIC Express Letters ICIC International ©2018 ISSN 1881-803X
Volume 12, Number 5, May 2018 pp. 465–471

SYSTEM SIMULATION RESEARCH ON THE DYNAMIC GOVERNANCE RELATIONSHIPS OF WATER CONSERVANCY PROJECT STAKEHOLDERS

Fang Liu[1] and Wang Miao[2,*]

[1]School of Public Administration
Shandong Normal University
No. 88, East Wenhua Road, Lixia Dist., Jinan 250014, P. R. China
liufang7698@126.com

[2]School of Business Administration
Qilu University of Technology
No. 3501, Daxue Road, Changqing Dist., Jinan 250353, P. R. China
*Corresponding author: miao2011sd@163.com

Received November 2017; accepted February 2018

Abstract. *The tools and methods provided by system simulation can effectively express and analyze several individual elements, as well as the dynamic relationships between those elements. This paper attempts to build a system simulation model of the dynamic changes in the social network of water conservancy project stakeholder governance relationships. We analyze the key variables and their associations, design parameters and perform validation, thus giving a representational form and the analytic methods of water conservancy project governance activities. Thereby, our study will reveal the dynamism within the social networks of stakeholder governance relationships based on information and cooperation. The aim of our study is to avoid the harm currently being caused by sub-optimization, and, at least to some extent, we hope to contribute to the existing theoretical research on water conservancy project governance.*
Keywords: Water conservancy project, Stakeholder, Dynamic governance relationship, System simulation

1. **Introduction.** A system simulation of water conservancy project stakeholder dynamic governance relationships is founded on the goal of conducting a system analysis of stakeholder dynamic governance relationships [1,2]. Our study is conducted under the condition of analyzing the various natures of system elements, as well as their mutual relationships. Building a system simulation model can describe a system's structure or the behavioral processes of stakeholder dynamic governance relationships and processes [3]. In view of the importance of simulation design principles, some domestic and foreign experts and scholars have elaborated on this subject [4]. However, until present, no set of uniform and complete simulation design principles has been established. Through a thorough analysis of existing literature, this paper has found several similarities in terms of simulation design. It must be stated, however, that the contents and aims of system simulation are very different [5]. The simulation design is mainly based on case studies, existing experiment data, experience and the research of theoretical hypotheses. When the rules are complicated, the decision-maker's explanation of the model result becomes difficult. A simulation design should fully reflect a realistic situation. The design should be corrected and adjusted continuously under conditions of a thorough examination of the overall effectiveness of the model [6]. The platform like Vensim was used to simulate the specific formation process of an innovation system network. Some work was based on the innovation system state of China and a compound triple helix model [7]. They concluded that the essence of subject behavioral rule is a kind of objective reflection of reality. Some

researchers built quantitative models to calculate the influence of agent behavior on society. They indicate that the fusion and innovation of cultural systems and science and technology are constituted by a complicated feedback mechanism of mutual actions [8]. In addition, the feedback mechanism loop built into the system simulation indicates a realization path of the fusion and innovation of culture, science and technology. Researchers put forward the "Belief Desire Intention Theory" model, which uses three basic concepts (belief, desire and intention) to describe the features of a simulation subject.

In a relevant system simulation of stakeholder dynamic governance relationships, the water conservancy project stakeholders' desires, capabilities, intentions, obligations and other features of their mental states can also be input variables in the system simulation. Stakeholder behavior rules are a series of basic action rules that all stakeholders must follow. Based on these rules, there are various interactions among stakeholders and social networks [9]. Because these behavior rules exist, in the process of system evolution, stakeholders will continue to change their own behavior to adapt to external network environments. In these circumstances, stakeholders then present complicated dynamic phenomena. Based on the theoretical analysis of dynamic governance relationship simulation, two types of simulations are studied. First, we study the simulation of governance relationship of stakeholders based on governance information. The second is to examine the system simulation model based on governance cooperation. Through the construction of the model, the paper discusses the intrinsic motivation and potential project risk of the project stakeholders' governance behaviors. And finally get the relevant conclusions and future research prospects.

2. Construction of a Simulation Model of Water Conservancy Project Dynamic Governance Relationships.

2.1. Simulation of governance relationship of stakeholders based on governance information. In the social networks of stakeholder governance relationships, water conservancy project stakeholders adapt to the system's environment changes mainly by means of sole or cooperative governance (i.e., they can establish or remove linkages), to survive and develop. Through the acquisition of information, water conservancy project stakeholders can continuously accumulate and update their knowledge base [10], thus improving their governance capabilities. The process of stakeholder information and knowledge accumulation can be shown as Formula (1):

$$d_{k_i}/d_t = B_i(k_i, t) + E_i(g, k) - D_i(k_i) - C_i(g, k) \tag{1}$$

$B_i(k_i, t)$ represents the information and knowledge application capability of stakeholder i at time t; $E_i(g, k)$ represents the overflow of information and knowledge obtained from the established stakeholder governance relationship social network g by water conservancy project stakeholder i; $D_i(k_i)$ represents the attenuation degree of the information and knowledge of stakeholder i; $C_i(g, k)$ represents the costs which stakeholder i spent in obtaining information and knowledge from g. The probability of success has a very close association with the adopted water conservancy project governance mode (single or cooperative), as well as the individual information and knowledge level of the stakeholders. Thus, this paper puts forward Hypothesis 1 to validate.

Hypothesis 1: The more information and knowledge water conservancy project stakeholders obtain, the more probable the success of the water conservancy project governance will be.

In order to validate this hypothesis, we selected 108 persons with water conservancy project governance experience. The quantity of information and knowledge relevant to the project governance activities obtained by water conservancy project stakeholders can be expressed as one of three levels, namely less (expressed as 1), middle (expressed as 2) and more (expressed as 3). For given cases of different quantities of information and knowledge and project governance modes (single or cooperative governance), the respondents select the predicted value of the probability of the success of governance activities. The probability of success, from small to large, is expressed in a range from 1 to 7 (1 = "extremely probable failure" and 7 = "extremely probable success"). This paper employs a water conservancy project governance mode (single or cooperative governance) as the co-variant. Excluding the influence of the co-variant on the observed variable, we analyze the action and influence of the controlling variables on the observed variables. The results of inter-subject influences are shown in Table 1.

Table 1. Examination of inter-subject influences of Hypothesis 1

Source	III type square sum	df	Mean square	F	Sig.
Corrected model	172.923[a]	3	57.641	103.367	.000
Intercept	186.524	1	186.524	334.492	.000
Project governance mode	24.756	1	24.756	44.395	.000
Information and knowledge level	101.240	2	50.620	90.777	.000
Error	57.994	104	.558		
Sum	2901.000	108			
Corrected sum	230.917	107			

Dependent variable: success probability of water conservancy project governance activities
a. R square = .749 (Adjusted R square = .742)

The results indicate that, excluding the influence of the governance modes of the water conservancy project, the level of information and knowledge related to water conservancy project governance activities (obtained by different water conservancy project stakeholders) exhibit significantly different influences on the probability of the success of water conservancy project governance activities. As seen from the goodness of fit of the model to the observed data, the value of R^2 is 0.749.

Furthermore, the specific differences in the degree of influence of the three previously-mentioned information and knowledge levels on the probability of the success of water conservancy project governance activities can be analyzed and compared (Tables 2 and 3).

The corresponding probability of the success of water conservancy project governance activities at Level 3 is the highest. The second highest is at Level 2, and the minimum degree of probability is found at Level 1. Therefore, Hypothesis 1 is acceptable.

k_i^t represents the level of information and knowledge of water conservancy project stakeholder i at time t. According to research conducted by Carayol and Roux [11], when the information and knowledge level (as related to water conservancy project governance) of stakeholder i in an organizational cooperative network reaches k at some time, the probability density function can be expressed as: $P(k_i = k) = \lambda e^{-\lambda k}$. Under conditions of no engagement in water conservancy project governance behavior at the moment, the conditional probability of engagement in water conservancy project governance activities of stakeholder i can, from the perspective of a change in the stakeholder's information and knowledge level, be expressed as:

$$q_i = \frac{P\left\{k_i \in [k, k+dk], k_i > k\right\}}{P(k_i > k)} = \lambda \tag{2}$$

TABLE 2. First comparison result of Hypothesis 1 (K matrix)

Brief comparison between information and knowledge level[a]			Dependent variable Success probability of water conservancy project governance
Level 1 and Level 3	Comparison estimated value		−2.447
	Hypothetical value		0
	Difference (Estimated – Hypothetical)		−2.447
	Standard error		.182
	Sig.		.000
	95% confidence interval of difference	Min.	−2.808
		Max.	−2.087
Level 2 and Level 3	Comparison estimated value		−1.048
	Hypothetical value		0
	Difference (Estimated – Hypothetical)		−1.048
	Standard error		.185
	Sig.		.000
	95% confidence interval of difference	Min.	−1.415
		Max.	−.681

a. reference category = 3

TABLE 3. Second comparison result of Hypothesis 1 (K matrix)

Brief comparison between information and knowledge level[a]			Dependent variable Success probability of water conservancy project governance
Level 2 and Level 1	Comparison estimated value		1.399
	Hypothetical value		0
	Difference (Estimated – Hypothetical)		1.399
	Standard error		.204
	Sig.		.000
	95% confidence interval of difference	Min.	.995
		Max.	1.803
Level 3 and Level 1	Comparison estimated value		2.447
	Hypothetical value		0
	Difference (Estimated – Hypothetical)		2.447
	Standard error		.182
	Sig.		.000
	95% confidence interval of difference	Min.	2.087
		Max.	2.808

a. reference category = 1

Therefore, this paper can conclude the success probability of carrying out water conservancy project governance within one cycle $[t, t+1]$ of stakeholder i:

$$P_i^t = \int_t^{t+1} q_i k_i^t dt \tag{3}$$

If $\Delta k_i^t = \int_t^{t+1} k_i^t dt$ represents a change in the information and knowledge level within $[t, t+1]$ of stakeholder i, the above formula can be simplified as:

$$P_i^t = \lambda \Delta k_i^t \tag{4}$$

2.2. **Simulation of governance relationship of stakeholders based on governance cooperation.** According to real-life experiences, the probability of success when water conservancy project stakeholders cooperate in performing water conservancy project governance is higher than the success rate of single governance. One of the most important reasons for this finding is, in the process of cooperation in governance, more information and knowledge regarding the water conservancy project will be transmitted between stakeholders. Therefore, the degree of increase in the transfer and speed of information and knowledge will also be higher. However, it must be noted that this kind of cooperation effect cannot be enlarged without limits. Thus, this paper brings forward Hypothesis 2 to validate.

Hypothesis 2: The probability of success of water conservancy project stakeholders' cooperation in performing water conservancy project governance is higher than that of single governance.

This paper analyzes investigation data from 108 persons with water conservancy project governance experience. The cooperation levels of water conservancy project stakeholders who are conducting project governance activities can be expressed as one of three levels: low (expressed as 1), middle (expressed as 2) and high (expressed as 3). For given cases with different quantities of information and knowledge and project governance modes (single or cooperative governance), the respondents gave their predicted values of the probability of the success of governance activities. The probability of success, from small to large, is expressed within the range from 1 to 7 (1 = "extremely probable failure" and 7 = "extremely probable success"). This paper analyzes the relationships between stakeholder acquisition of information, as well as the knowledge related to water conservancy project governance activities and the probability of the success of water conservancy project governance. In order to more accurately assess the controlling factors, this paper employs the water conservancy project governance mode (single or cooperative governance) as the co-variant. The results of our examination and analysis of inter-subject influences are shown in Table 4.

Table 4. Examination of inter-subject influences of Hypothesis 2

Source	III type square sum	df	Mean square	F	Sig.
Corrected model	167.298[a]	3	55.766	102.551	.000
Intercept	23.699	1	23.699	43.582	.000
Project governance mode	38.280	1	38.280	70.395	.000
Information and knowledge level	78.457	2	39.229	72.140	.000
Error	56.554	104	.544		
Sum	2884.000	108			
Corrected sum	223.852	107			

Dependent variable: success probability of water conservancy project governance activities
a. R square = .747 (Adjusted R square = .740)

The results of the comparison indicate that, excluding the influence of the level of information and knowledge, the governance modes of different water conservancy projects (degree of cooperation in water conservancy project governance activities) impose significantly different influences on the probability of the success of water conservancy project governance activities. As can be seen from the goodness of fit of the model to the observed data, the value of R^2 is 0.747. This paper further analyzes and compares the specific differences of the influences of different governance modes of water conservancy projects on the probability of the success of water conservancy project governance activities. Also, after excluding the effect of the co-variant, we calculate the comparison results of the corrected mean of success probability of water conservancy project governance activities at each level. The corresponding probability of the success of water conservancy project governance activities at Level 3 is the highest. The second highest level is found at Level 2, and the minimum is at Level 1. Therefore, Hypothesis 2 is acceptable.

According to the above research, this paper adds coefficient α to Δk_i^t. The stronger the cooperation between stakeholders is, the closer α is to 1. We set α as $0 < \alpha < 1$. Formula (4) can thus be changed as follows:

$$P_i^t = \lambda \left[\alpha \max \Delta k_i^t + (1-\alpha) \min \Delta k_i^t\right] \tag{5}$$

In a social network of stakeholder governance relationships, the transmission of information and knowledge between stakeholders is carried out mainly through direct or indirect linkages. Then, the change in the information and knowledge level of stakeholder i at time t can be expressed as:

$$\Delta k_i^t = \Delta k_i(g_t) = u_i + \sum_{i,j \in N} \left[\beta v_{ij} + (1-\beta) w_{ij}\right] \tag{6}$$

g_t represents the current state of the stakeholder governance relationship's social network, which is a constant within $[t, t+1]$; u_i represents the quantity of information and knowledge created by stakeholder i ($i \in V$) in a period. In addition, this paper supposes that u_i is a constant within $[t, t+1]$. Parameter β is a transfer mode coefficient, which means the main mode and effectiveness of the transfer of new information and knowledge between stakeholders is $0 \leq \beta \leq 1$. The transmission of information through direct linkage is more effective than the transfer through indirect linkage. For example, stakeholders i and j are completely linked via a third stakeholder (indirect linkage), through which information or knowledge is transferred. Then, the transmission coefficient β among stakeholders is close to 0 (supposing no delay exists between the transmission of information and knowledge). If the transmission of information or knowledge is completely carried out through direct linkage, then β is equivalent to 1. At this moment, transmission efficiency is at the highest level. Also, v_{ij} means that stakeholders i and j transmit knowledge through direct linkage, and the calculating formula is: $v_{ij} = p_{ij} u_j$. In this formula, p_{ij} means the probability of establishing a linkage between stakeholders i and j; u_j means the quantity of information and knowledge created by stakeholder j ($j \in V$) in a period, and it is a constant. Furthermore, w_{ij} represents the information and knowledge transmitted by stakeholders i and j through linkage with a third stakeholder. At this moment there is $w_{ij} = \sum\limits_{l \neq i \neq j} v_{il} v_{lj}$. It is easy to see that Formula (6) means that the accumulation of information and the knowledge of stakeholder i within $[t, t+1]$ is created on his or her own, or the information and knowledge is obtained by absorbing new information or knowledge from other stakeholders (direct or indirect).

3. **Discussions.** In water conservancy project governance activities, there is a coordinated partnership between stakeholders. If the stakeholders wish to gain the expected level of profits, they must invest "labor" in finishing the water conservancy project governance. The aim of such water conservancy project governance tasks is to provide an effective management environment for project management (such as the assurance and management of resource supplies, and the supply of technical modes). A water conservancy project stakeholder who holds a dominant position (a lot of governance information

or intimate partners) plays an important role in the stakeholder dynamic governance relationship social network. Water conservancy project stakeholders holding dominant positions in the social network of dynamic governance relationships (in order to gain greater governance profits or to avoid governance risks), will adopt specific governance strategies. For example, they might form a group or a union. These governance strategies will have a significant impact on the whole network structure and on other stakeholders. The implementation of a joint strategy, on the one hand, is favorable in terms of the interior coordination of the stakeholder and for better interior development. On the other hand, the implementation of such a strategy can also exert great pressure on another stakeholder or stakeholders. It is certainly possible that such an opposite union may not ensure the benefits of at least some of the stakeholders. Such situations often provoke governance risks to water conservancy projects.

4. **Conclusion.** Water conservancy project governance is an extremely complicated dynamic process. The process usually needs to go through several project stages, including launching, planning, execution and close-out. During each stage, different systematic factors will affect the execution of water conservancy project governance. However, whether or not the results of water conservancy project governance can be achieved will ultimately depend on whether or not each water conservancy project stakeholder can get a lot of governance information or cooperate with the other stakeholders, both reasonably and efficiently. Future research can focus on the process of development and the evolution of a stakeholder governance relationship social network. Certain tools of social network analysis and system simulation can be comprehensively used for research.

Acknowledgment. This work was supported by the National Natural Science Foundation of China [71704097], and the Research Project of the Humanities and Social Science of the Institutions of Higher Learning of Shandong Province [J16YF13].

REFERENCES

[1] J. H. Kotir, C. Smith, G. Brown, N. Marshall and R. Johnstone, A system dynamics simulation model for sustainable water resources management and agricultural development in the Volta River Basin, Ghana, *Science of the Total Environment*, vol.573, no.12, pp.444-457, 2016.
[2] J. R. Turner, Towards a theory of project management: The nature of the project governance and project management, *International Journal of Project Management*, vol.24, pp.93-95, 2006.
[3] F. Liu and W. Miao, Multi-standard decision-making for project selection from the perspective of dynamic network governance, *Statistics & Decision*, no.2, pp.37-41, 2016.
[4] S. Karami, E. Karami, L. Buys and R. Drogemuller, System dynamic simulation: A new method in social impact assessment (SIA), *Environmental Impact Assessment Review*, vol.62, pp.25-34, 2017.
[5] J. M. Lyneis, System dynamics for market forecasting and structural analysis, *System Dynamics Review*, vol.16, no.1, pp.3-25, 2000.
[6] E. Pircalabelu and G. Claeskens, Focused model selection for social networks, *Social Networks*, vol.46, no.4, pp.76-86, 2016.
[7] R. Ding, H. Gao and N. Zhang, An analysis of the concepts of project governance, *Journal of Shandong University (Philosophy and Social Sciences)*, no.2, pp.132-142, 2013.
[8] J. D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw Hill, Boston, 2000.
[9] P. L. Freeman and A. J. Millar, Valuing the project: A knowledge-action response to network governance in collaborative research, *Public Money & Management*, vol.37, no.1, pp.23-30, 2017.
[10] S. Zhang and X. Zheng, Effects of economic development on PPP project infrastructure in developing countries, *Soft Science*, no.7, pp.25-29, 2015.
[11] N. Carayol and P. Roux, Collective innovation in a model of network formation with preferential meeting, *WEHIA Conference*, Kiel, Germany, MD, 2003.