A NEW RISK MANAGEMENT FRAMEWORK FOR COLLABORATIVE INNOVATION PROJECTS BASED ON NETWORK DYNAMIC ANALYSIS

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ABSTRACT

It is necessary to correlate the organization dimension and task dimension in the risk management for collaborative innovation projects. However, the existing analysis methods are restricted to one of the two dimensions, which also reduce the result of risk management. Social Network Analysis (SNA), which is the representative method in organization dimension, quantitatively evaluates the governance network formed by stakeholders and their relationships statically, but doesn't meet the dynamic characteristic of the network which caused by the risk factors. At the same time, System Dynamics (SD), which is the representative method in task dimension, can analyse the variational risk factors in project lifecycle and present risk mitigation actions. But it does not match the risk control responsibilities with the corresponding stakeholders properly, which generate inadequate organization fundamental for the actions. Therefore, this paper put forward a new method named Network Dynamic Analysis (NDA) by integrating SNA and SD and designed a framework of risk management based on the new method. In the framework, NDA changes the style of design and test of risk mitigation action as it connects the risk factor and risk responsibility by considering the governance network in organization dimension and project risk factors in task dimension together. More specifically, the adjustment of governance network was regard as risk mitigation action and its effect is text by a dynamic simulation model. NDA integrates organization dimension and task dimension by considering the project governance network and risk factors together, so it can improve the accuracy of risk analysis and the effectiveness of risk control.

Key words: Dynamic Network; Project Governance; Risk Management; Social Network Analysis; System Dynamics

I. INTRODUCTION

In the collaborative innovation projects, the stakeholders come from different industries and have different corporate systems and cultures (Bowers & Khorakian, 2014). So it is difficult to build the relationships spontaneously between them after proposing the risk mitigation actions. To the governance body, it is necessary to consider the organization foundation of the risk mitigation actions in the risk management process, which is represented by the project governance network. On the

other hand, it is important to take the risk mitigation actions at the appropriate time, which is hard to be judged by the state of the governance network, but the state of variables that influenced by the network in the task demission (Slovic et al., 2004), such as the level of risk factors, project period and the project work need to be done. What's more, the network in the organization demission will influence the risk factors in the task demission and the risk factors will influence the network as the network should in order with the new risk mitigation actions. So the two dimensions will influence each other in the project lifecycle. It is necessary to analyse the risk factors in the task demission and governance network in the organization demission together and dynamically, which is the special request of risk management in the collaborative innovation projects.

However, the existing analysis methods for project risk management are restricted to one of the two dimensions. SNA (Social Network Analysis), which is the representative method in organization dimension, describes the relationships between nodes through constructing conceptual network structural model (Zheng et al., 2016). SNA quantitatively evaluates the network statically, and then raises risk mitigation actions according to the evaluation results. But the governance network in organization dimension is dynamic due to the risk factor in task dimension as the project forward (Zhang et al., 2014). SNA which evaluates statically doesn't meet the dynamic characteristic of project governance network, and couldn't analyse the variational risk factors in task dimension (Ding et al., 2016). At the same time, SD (System Dynamics), which is the representative method in task dimension and is able to explore the causality and evolution process of factors in system, can analyse the variational risk factors in project lifecycle and present risk mitigation actions according to the Sensitivity Analysis about risk factors (Nasirzadeh et al., 2014). While, SD can't construct the project governance network efficiently, so it can't match the risk control roles with the corresponding stakeholders (Ding et al., 2016). As a result, the implement of risk mitigation actions are not based on an effective organization fundamental. It is visible that the existing analysis methods for project governance risk mainly put particular emphasis on organization dimension or task dimension, which is not meet the special request of risk management in the collaborative innovation projects. So, there is a need to put forward a new method to synthesize the two dimensions.

We proposed the Network Dynamic Analysis (NDA) by combining SNA and SD and then designed the framework of risk management for collaborative innovation projects based on the new method. Compared with classical risk management, the new one that we proposed in this paper is quite different in steps of analysis and response planning as NDA analysis the network dynamically and takes into account the organization fundamental of risk mitigation actions by integrating organization dimension and task dimension as a whole.

II. THE FRAMEWORK OF RISK MANAGEMENT BASED ON NDA METHOD

Our framework is a risk management process with five phases based on the classical risk management (Fang & Marle, 2012; Taroun, 2014): (1) governance network identification; (2) governance network assessment; (3) governance network analysis; (4) risk response planning by adjusting governance network; and (5) risk monitoring and control. Figure 1 illustrates this framework. The innovative steps based on the classical risk management process and the new generated outcomes are highlighted in the Figure 1.
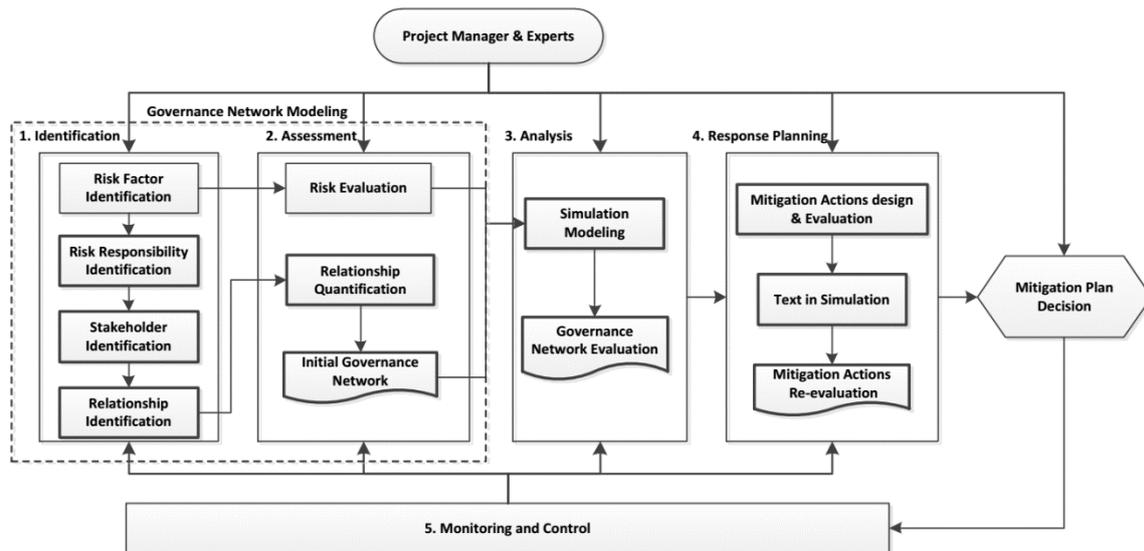
Figure 1. Framework of Risk Management Based on NDA Method

In the phase1 named governance network identification, we add the identification of network nodes (stakeholders) and network lines (relationships between the stakeholders) after the classical step that recognizing the risk factors. We propose the way of stakeholder identification based on the risk responsibilities and risk factors, and then recognize the relationships among the stakeholders (Wang, 2016).

In the phase2 named governance network assessment, we add the relationship quantification whose result is the governance network with weight. The governance network is the initial network of the simulation model in the next phase.

In the phase3 named governance network analysis, we use a simulation model to judge whether the governance network is robust enough for risk management process, which means that the project result at least is acceptable to the project governance body or not. We will introduce the simulation modelling process detailedly in the below.

In the phase4 named risk response planning, we regard the adjustment of governance network as the risk mitigation action and text the effect of the action by the simulation model build in the phase3. Specifically speaking, the potential mitigation actions are identified according to the analytical results from the previous phase or the text result of the last action, and they are preliminarily evaluated by experts. The mitigation action changes the initial governance network and then the project result will make a difference which may satisfy the risk management needs of the project governance body. Then, the project governance body makes decisions about the practical strategies suggested by simulation model in NDA.

In the phase5 named risk monitoring and control provides feedback for the previous phases, which take the simulation process as standard, such as the value of network indexes, the level of risk factors and the amount of the work to be done. When the real state of the project and the standard are quite different, it is the right time to finish the phase 1 to 4 in risk management again. Finally, the evolution of the risk factors, project governance network is monitored and the effectiveness of the actions is evaluated to keep the project under control.

Decision-makers (usually the project governance body and team of experts) are allowed to modify, complete, and refine the managerial suggestions proposed by NDA method. As mentioned by Fang, "It is also necessary for them to participate in each phase of risk management to provide their knowledge, expertise and experience" (Fang & Marle, 2012), so it is the foundation of risk management that getting accurate data for NDA method.

III. PROJECT GOVERNANCE NETWORK MODELING (PHASE1 & PHASE2)

Nodes and lines are the basic elements of the network. In the governance network, nodes are stakeholders and lines are the relationships among the stakeholders. Overall speaking, we should identify the risk factors and then recognize the stakeholder based on the risk responsibilities, the risk responsibilities include plan, operation, maintain and monitor (Ding et al., 2013). The identification of the network is show in Figure 2 (Wang, 2016).
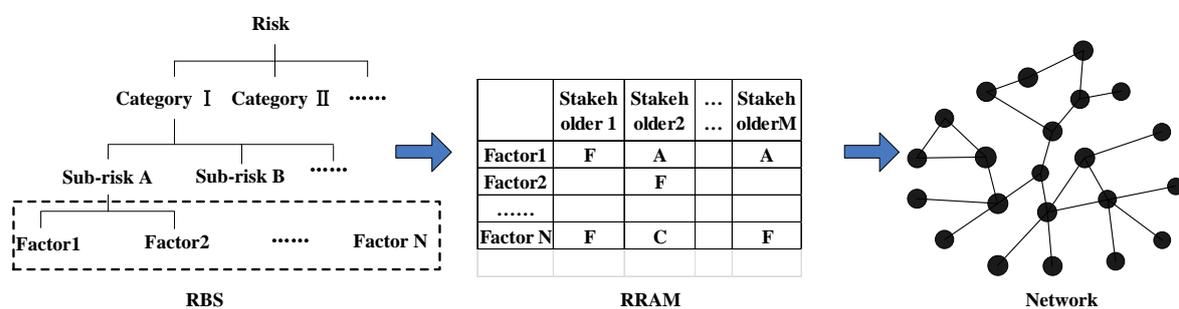

Figure 2. The Identification Process of Project Governance Network

Identify the risk factors and build the risk breakdown structure (RBS). The RBS is some like the work breakdown structure (WBS) and its building need the knowledge, experience, information of experts, project governance body and project manager. Base on the RBS and risk responsibility, it is easy to find the appropriate stakeholders for the risk factors. So every stakeholder is in charge of some risk factors and then the stakeholders, risk factors and risk responsibilities form a risk responsibility assignment matrix (RRAM) together. The RRAM also shows the relationships between the stakeholders potentially, so we can identify the governance network in the light of RRAM.

The next step is the qualification of network lines. At this moment, the experts, governance body, manager and some important stakeholders value the weight of the lines, there are some method can work as support tools in the qualification process, such as Snow Ball method (Kilkenny & Fuller-love, 2014), improved best-worst-method (BWM) (Wang, 2016), and paired Comparison method (Fang & Marle, 2012).

IV. PROJECT GOVERNANCE NETWORK ANALYSIS (PHASE3)

We consider the management degree of risk factors in the phase3 by analysing the project governance network. In the classic risk management, people usually consider the possibility and influence/loss in the risk analysis. However, it is also very important to understand the manageability of the risk factors. If the risk manageability is high, it will be very easy to reduce the possibility before the risk happens and the influence after the risk happens. The manageability can be valued by the governance network through the index of the node connected with the risk factors and the index of the whole network. The temporality and peculiarity of the project make the risk manageability analysis more important.

As previously mentioned, the governance network in the organization demission and risk factors, work to be done in the task demission will influence each other and then change in the project lifecycle, so this paper put forward a new method for the analysis of dynamic risk factors, network and other variables. We use a cause-effect feedback loops diagram to show the logic of network dynamic, as shown in the Figure 3.
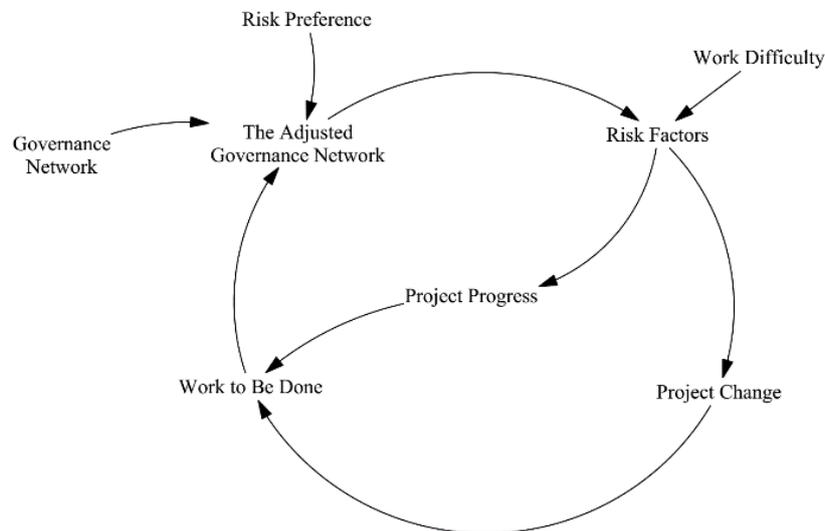

Figure 3. The Cause-Effect Feedback Loops Diagram of Network Dynamic

If the amount of work to be done is big, it is need to adjust the governance network to make the project process more reliable and rapid by reduce the level of risk factors. The adjustment is based on the initial governance network that got by the RBS and RRAM and be influenced by the risk preference of project governance body. Hereinto, if the risk preference is very high, the governance body may not adjust the network very strictly. The adjusted project governance network will affect the possibility of the risk factors and the loss of the risk factors as it will change the risk manageability. After that, the risk factors will influence the project progress which will have the direct effect on the project work, such as the decrement of the work to be done. What's more, the risk factors will also influence the project change as risk factors give raise to additional work that will expend the project scope. Here, we just consider the situation that the project change will increase the work to be done as the risk factors always lead to bad effect.

Draw on the essential project system dynamic stock flow diagram (Cooper, 1993; Houston, 2014), this paper put forward the stock flow diagram of network dynamic based on the cause-effect feedback loops diagram, which represents the mathematical model for the network dynamic evolution, as shown in Figure 4.
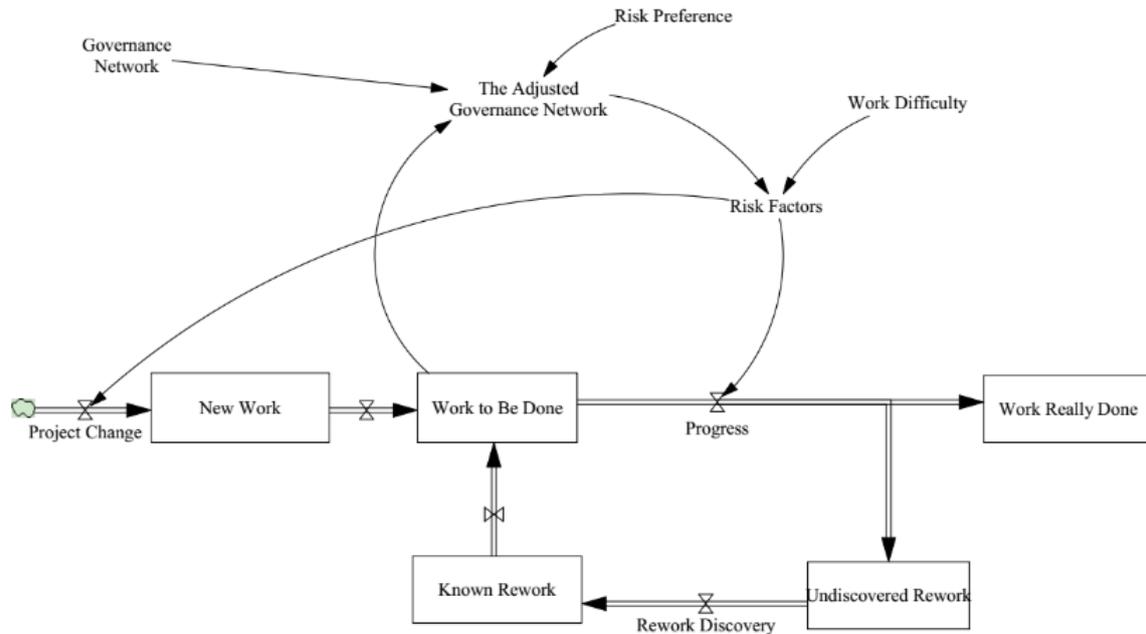
Figure 4. The Stock Flow Diagram of Network Dynamic

As System Dynamics hard to express the network in the stock flow diagram and then short of the ability of network dynamic analysis, we designed an improved diagram which shown in Figure 5. Hereinto, the network is represented by an adjacency matrix, and the change of the network is expressed by the data change in the adjacency matrix.
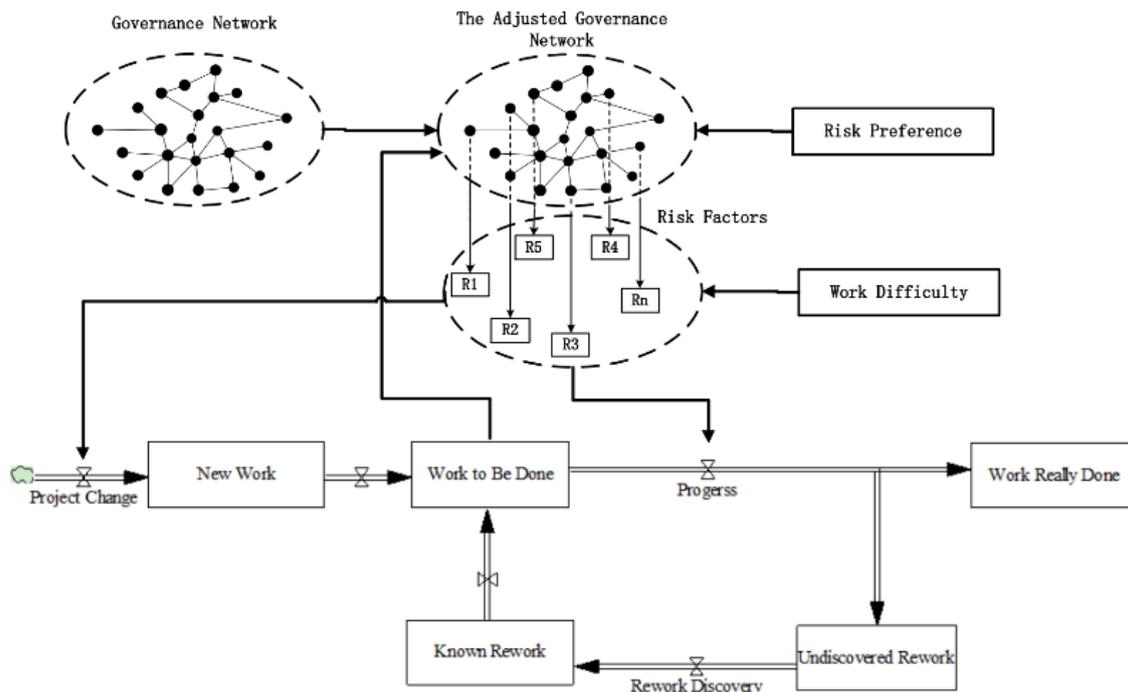

Figure 5. The Improved Stock Flow Diagram of Network Dynamic

The changes of governance network involve three aspects: the improvement for the timeliness of information communication between the maintenance nodes and operation nodes; the improvement for the timeliness of the resources supply from maintenance nodes to operation nodes; and the

improvement for the information transmission of planning nodes in the network. The changes are expressed as the change of operation nodes' ego-network and the change of planning nodes' ego-network (Ding et al., 2016).

We can evaluate the governance network from the follow aspects. Firstly, the index value of governance network, which exhibits the evaluation details of the network. Secondly, the level of risk factors, whose last result shows the effect of governance network and changing process in the lifecycle indicates that whether the governance network adjustment is seasonable or not. Thirdly, the change of the amount of project work to be done, which is very easy to understand and observed in the real word. To realize more about the work, we can analyse the amount of rework and new work, which may be more useful to propose the network adjustment.

V.MITIGATION PLANNING AND MONITORING (PHASE 4 AND PHASE 5)

We take the adjustment of the governance network as the risk mitigation action, which will change the initial project governance network, such as building the new relationships between the current stakeholders, bringing in or taking away the stakeholders, modulating the weight of the relationships and changing the direction of the relationships. The new risk mitigation action is come from experts, governance body, and project manager, and the evaluation of the mitigation action is reacted to the quantitative change of the governance network.

The adjusted governance network will affect the evolution result, such as the level of risk factors, the amount of work to be done, the project time and so on. If the decision maker (governance body) feels satisfied with the result, the next step is translating the network adjustment into real management practice and then the detailed mitigation plan is formulated.

We put forward mitigation actions based on the simulation model that also outputs the change value of risk factors, project work and governance network, which could be regard as the standard of morning and control. So it is the right time to build the initial network and use the simulation model to refresh the mitigation plan when the standard and project statues are quite different. It means that the initial network is not just the network at the beginning of the project lifecycle, but also the network at the time when the governance body wants to adjust the governance network to improve the risk manageability.

VI.CONCLUSION

It is necessary to consider the organization demission and task demission together in the risk management of the collaborative innovation projects. However, the current representative methods (SD and SNA) cannot meet the requirement. So we put forward a new method named NDA (network dynamic analysis) by combine the SD and SNA, and then designed a risk management framework based on the new method. Meanwhile, the framework also indicates the application process of NDA, so we introduced the mechanism, quantification of the new method under the framework. The new method NDA proposed in this paper associates the risk factors and the appropriate stakeholders based on risk responsibilities which materializes the risk mitigation actions and text them by network dynamic simulation model. What's more, the NDA provides standard for morning and control from three aspects that are project governance network, level of risk level and amount of work to be done.

In the future, we can realize the new method by finishing the specific quantification of the improved stock flow diagram of network dynamic, such as set the function distribution about the possibility of each risk factor and build the mathematical influence of project difficulty, which concerned with project environment and innovativeness prevailingly, to the key parameter of the function. The quantification makes the new method have the potential ability to be used in practice and then improve the significance of the risk management framework designed in this paper.

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