Infrastructure construction project management whole process risk management-Building a Risk Assessment Framework Based on Meta-Network Analysis

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Abstract. China's construction industry vigorously implements the construction of infrastructure construction projects, infrastructure projects as the basic core engineering of building facilities, risk occurs in the investment decision-making stage, engineering design stage, procurement and construction stage, delivery and use stage and other whole process, the overall is a dynamic state of change. Multi-factor and multi-stage risk impact will bring diverse risk changes to the whole infrastructure project. This paper adopts the meta-network analysis method to construct the corresponding risk assessment framework by identifying and evaluating the risk factors, risk events, and risk items in the whole process of infrastructure projects. The relational influence and correlation between factors, events, and projects are derived through the analysis of each network risk superposition operation. Suggestions and strategies can be put forward in the risk prevention and risk response for the whole process of infrastructure construction project, which has certain positive significance for the construction of infrastructure projects.

Keywords: Infrastructure Engineering; Risk Analysis; Meta-Network Analysis; Risk Framework

1 Introduction

Infrastructure construction engineering is the cornerstone of economic and social development, strategic, fundamental and pioneering role[1], seize the key links to vigorously promote infrastructure construction, will help innovation-driven development strategy, accelerate the transformation of old and new kinetic energy, and play a positive role in expanding domestic demand, stabilizing investment and growth[2]. Construction of infrastructure projects for the identification of risk, risk framework construction, risk avoidance strategy is an important part of project management, throughout the process.

Infrastructure construction is the core element of the engineering field, is the infrastructure for the development of social production and people's lives to provide basic

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public services[3] 3, its key function is to safeguard and optimize the social and economic activities of the country or region, as well as a series of major areas such as political, economic, social[4], scientific and technological and environmental protection and other major areas of synergistic development, and has a far-reaching impact on the public's health and life and national security and other key issues[5]. Infrastructure construction projects generally have the following characteristics: firstly, their basic nature is remarkable, the project as the core framework of infrastructure, for the promotion of various types of infrastructure projects to provide solid support[6]; secondly, it has a comprehensive nature, the close involvement of many links, stages and events, the policy level of multi-party participation, information exchange and interactivity and the integration of resources as a whole, are all significant features; and furthermore, the project has the following characteristics Complexity, internal and external factors are intertwined, the links[7], phases of mutual feedback, as well as highly dynamic engineering risk change process, so that the entire project cycle there are diversified risks, which will lead to a variety of events on the project at different times to produce different impacts. In view of the above characteristics of infrastructure construction projects, it is necessary to establish a risk assessment framework with strong correlation of risk factors, intuitive risk assessment and reference for decision makers.

2 Whole Process Risk Analysis

In the whole-process risk analysis that needs to be established in this research, according to the analysis of the meta-network correlation relationship among the three basic elements of risk factors, risk events and risk projects, the principle of correlation will produce six kinds of correspondences[8], namely, factors and factors, factors and events, factors and projects [9](this kind of special factors have a direct impact on the project, such as policies, wars, raw material fluctuations, etc.), events and events, events and projects, projects and projects, and so on. (these are special factors that have a direct impact on the project, such as policy, war, raw material fluctuations, etc.), event to event, event to project, and project to project. The above six types of risk-related relationships in the whole process in the broad sense of the full coverage of the relationship, is that we constitute the original network of related relationships based on the contact elements. Infrastructure construction projects often involve the mutual influence of multiple factors that lead to dynamic changes in the project's own goals and expectations, the factors and the relevant relationships formed by the whole is called the engineering target network, that is, the whole process of risk assessment of the whole, that is, the project engineering target network. On the basis of the above elements that constitute the entire framework to study the dynamic changes between the elements of the link has a key entry point and the overall peripheral framework.

2.1 Risk Identification

Identifying the risk elements is the first step and the front end of the inputs that determine the risk changes, playing the role of variable x. The identification of the risk elements is the first step and the front end of the inputs that determine the risk changes. The identification of risk elements is aimed at the identification of risk factors, risk events and risk projects in infrastructure construction projects, as well as the identification of the six basic associations of the above factors and factors, factors and events, factors and projects, events and events, events and projects, and then further analyze the nodes of influence in the associations[10], so as to make the meta-network analysis throughout the whole process of infrastructure projects. According to the different purposes of the implementation of different infrastructure projects, the relevant construction policies are different. Further, this paper combines the participants and policy documents to divide the project into three aspects: pre-decision risk element screening, dynamic change of risk during the construction period, and good internal benefit during the operation period, and uses the meta-network analysis method to construct the risk framework of the whole process, and forms the corresponding evaluation statement, as shown in table 1.

Table 1. Target levels and contents in infrastructure project meta network

Project Objective	Project risk events	Project risk factors
Pre-project decision-making	Poor decision-making environment	Misjudgment of the direction of economic development
		Miscalculation of the political and military situation
		Institutional and institutional weaknesses in decision-making
		Relevant legal and policy implications
	Failure of decision makers to act	Arbitrary decision-making behavior
		Irrational decision-making behavior
Decision-making during construction	Building condition deficiencies	Poor natural conditions
		Poor construction conditions
	Technical defects in the process	Basic data does not match the actual situation
		Quality defects in the main body of the building
		Unreasonable placement in rescue design
		Immature construction technology
		Unreasonable construction methods
	Project management issues	Engineering qualitative accident
		Engineering safety accidents

		Engineering progress control issues
		Engineering investment and cost control issues
Project operational benefits	External operational environment impact	Legal policy impact
		Government subsidy impact
		Market competition impact
	Internal operational environment impact	Financial unsustainability
		Infrastructure function development issues
		Problems in the operation of supporting infrastructure projects
Social risk impact	Social stability impact	Socio economic stability impact
	Ecological stability impact	The impact of causing environmental damage

2.2 Building a Risk Assessment Network for the Entire Process of Infrastructure Engineering

After identifying the risk elements, based on the various project objectives listed in the risk list involved in the basic construction project, the meta network analysis method is used to analyze the logical relationships and related relationships between risk factors, risk events, and risk projects. A project risk meta network consisting of three levels is established, and a risk assessment model with related relationships is established. Establish corresponding risk networks for the six basic associations mentioned above, including factor to factor networks (f-f), factor to event networks (f-e), event to event networks (e-e), event to project (e-p), project to project (p-p), and networks where special factors affect projects (f-p). The risk assessment network is formed by forming a mutual relationship diagram of these six related networks and establishing a mutual influence relationship model.

The f-f network constitutes the initial level of interrelated risk networks. The further relationship network is the f-e network, which is formed by the impact of risks generated by various factors under independent events on the event. It bears the heavy responsibility of connecting factors with the event, and can intuitively reflect the intuitive effect of quantitative analysis of risk factors, especially in the analysis of establishing mathematical models. As the main body supporting project operation, the event and event network e-e network mainly focuses on the mutual influence of the corresponding operational relationships of events throughout the entire process, forming a risk network. This is a dynamic risk impact mode that conforms to the project operation rules. The e-e network is driven by the project process and forms the risk impact relationship of the entire process. The relationship impact that ultimately determines the maximum risk is the e-p network, which is the risk impact on each corresponding project goal formed by the completion of each event in the entire process or through standards. This is the biggest source of risk in the entire process of basic construction engineering, because the acceptance criteria should be standardized at the end of each event, but the completion of all events corresponds to the completion of all projects, So, will each achievement or achievement after generating risks have a significant risk impact on the goals of each project. The supplementary risk network includes the f-p risk network, which mainly reflects the objective impact caused by a single major factor. It is necessary to conduct specific analysis and set up an objective risk report before project approval to effectively ensure the smooth operation of the project during the construction process. There is also a p-p risk network, which mainly emphasizes the risk impact of the acceptance of each project after reaching the standard throughout the entire process of the infrastructure engineering project on the final risk impact of the entire engineering project. This impact belongs to a small probability event and once it occurs, it belongs to irreversible or major error risk. The responsibility judgment of the final risk can be made through legal means by referring to the contract signed by both parties. In the end, these six risk networks constitute the risk network of the entire process of the infrastructure construction project, which is a progressive, interactive, and evidence-based risk assessment network, shown in the table2 and figure1 below.

Table 2. Six types of risk networks

Risk type	Risk factor	Risk events	Risk projects
Risk factor	f-f	f-e	f-p
Risk events		e-e	e-p
Risk projects			p-p

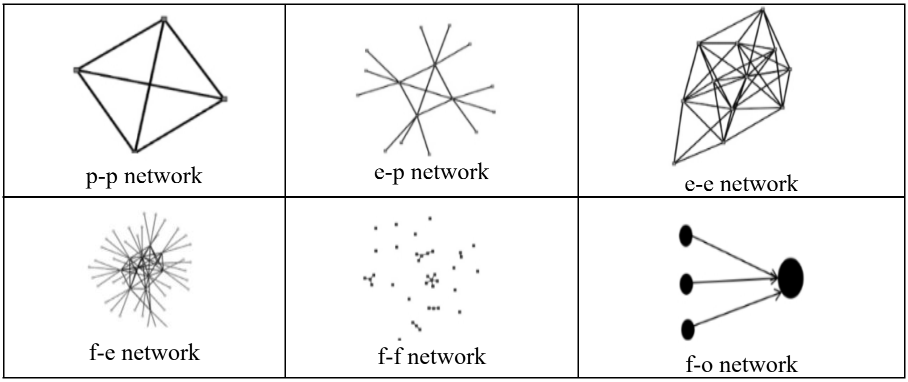

Fig. 1. Risk network diagram

3 Construction of a Risk Framework for the Entire Process of Infrastructure Engineering

After constructing a risk assessment network for the entire process of infrastructure project engineering, quantitative analysis is conducted based on the point-to-point mutual influence relationship between various elements and the time relationship between each association, as well as the face-to-face mutual influence relationship between events and projects. This enables the overall risk assessment model formed by the six risk networks to be quantified in a risk assessment framework and analyzed using algorithms. Firstly, list the risk factors and extract the special impact risk factors (f-p) influencing factors. Different risk influencing factors are assigned the intensity of their corresponding risk events. The data source here mainly comes from risk questionnaire surveys conducted on experts and engineering management personnel, and the scores given are:

$$fScores = \ (f1, f2, f3, \ldots, fn)$$

Similarly, for specific events, expert and engineering management personnel questionnaire scores are assigned for event and project risk assessment based on the review of relevant event risk and project risk：

$$eScores = \ (e1, e2, e3, \ldots, en)$$

$$pScores = \ (p1, p2, p3, \ldots, pn)$$

By combining the dynamic changes throughout the entire process of infrastructure engineering, an additional weighting is set for risk projects, in order to analyze the quantitative final scores of risk factors, risk events, and risk projects.

Firstly, determine the nature of the infrastructure project and conduct qualitative analysis of the project through the feasibility study report and the expected implementation of the construction scheme. By understanding the requirements of the project and through the project construction organization plan event table, connect the whole process of engineering events and project implementation process. Extract engineering events and projects and find corresponding scores. Then, according to the requirements of the project, the weight FN of the factors on the event is calculated, and the weight score FN of each risk factor is calculated. Then, the weight score En is given by the impact of events on the project, and the event weight score eEn is given by combining the various risk factors under the event. Similarly, the weight score of pPN can be obtained.

$$fFn\ Scores = fn * Fn$$
$$eEn\ Scores = fFn * En$$

$$pPn\ Scores = eEn * Pn$$

4 Analysis Results of Risk Factors in Meta Network Framework

After scoring the risk factors by experts and engineering management professionals, combined with the meta network framework for calculation, relevant risk results and suggestions were obtained: early project decision-making is the key to determining project direction, and the judgment of the economic, social, and political military environments in the decision-making environment is the ultimate network factor determining infrastructure construction. The second most important factor is the decision-making during construction, among which the impact of decision-makers' arbitrary decisions is the most critical, which is the most important source of management risk. The good internal efficiency during the operation period received the lowest score, among which the impact of internal operating environment and the development of infrastructure functions were the most important. The reason for this is that whether the functions of infrastructure engineering can fully serve society is an important indicator that determines the sustainable development of infrastructure engineering.

Surprisingly, in terms of social risk impact, almost all have chosen environmental impact, which should be related to the recent deepening of environmental concepts. At the same time, both managers and residents believe that the environmental impact of infrastructure projects is very important. The conclusion drawn regarding the impact of project operation efficiency on the external operating environment is that the government, policies, and market all support infrastructure construction. After infrastructure construction is approved, most of the related risks generated will be shared by the government and social organizations, thereby reducing the related risks that infrastructure construction needs to bear and providing certain support for operation efficiency.

5 Application Prospects

This risk assessment method combined with the whole process of infrastructure projects can be used in most infrastructure projects. It is not only applicable to the screening of risk factors in early decision-making, the dynamic change of risk during construction, and whether the good internal benefits during operation are controllable, but also can investigate the special impact of special factors in the whole process of the project. Link each stage with the overall project so that users can pay more attention to the risks arising from this relationship. Based on the analysis of various risk factors and the meta network analysis method, the risk assessment framework of the management process and quantitative analysis data can provide guarantee for the overall safety and better development of infrastructure projects.

6 Conclusion

This study is mainly about the risk assessment of the whole process of infrastructure construction projects. The meta network analysis method is used to build the whole process risk assessment framework, establish a dynamic risk assessment system, and integrate the three elements of risk factors, risk events and risk projects in the specific whole process of infrastructure construction projects, and dynamically analyze the impact of each factor score. Thus, in the whole dynamic process of the project, we can intuitively analyze various risk levels, and specifically collect them into the factors, events, and projects, which can also be used as a reference for the risk research of related infrastructure projects in the future.

In analyzing the important risk factors that may exist in the early decision-making risk factors screening, risk dynamic changes during the construction period, acceptance period and the impact of special factors on the project in the specific infrastructure project, we have further completed the risk dynamic analysis in the whole process, which can provide a clear and intuitive risk assessment framework for decision-makers to put forward reasonable risk countermeasures.

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