

Analysis on Infectious Risk Stress in the Supply Chain of Mega Infrastructure Project

Na Zhao*

School of Finance, Harbin University of Commerce, Harbin 150001, China

Abstract. In the implementation process of great infrastructure engineering, the structural safety of supply chain in coping with infectious risks (IR) is of important significance to operation of the whole project. Moreover, infectious risk can influence safety of supply chain of mega project (MP). Therefore, this study constructed a function of infectious risk stress, calculated the infectious risk stress value of supply chain of mega infrastructure project (MPSC), and analysed influences of random variables on infectious risk. Results demonstrate that the maximum infectious risk stress is at the end of supply chain of mega infrastructure project. Research conclusions provide references to anti-risk integrated design of supply chain of mega infrastructure project.

Keywords: Supply Chain, Infectious Risk, Mega Infrastructure Project

1 Introduction

The global economy is facing with great challenges due to influences of epidemics. Accelerating infrastructure layout and construction is the key to promote economic recovery. Due to the adding of new infrastructure project (NIP), infrastructure project is vested with more connotations and covers a wider scope at present. NIP mainly focuses on 7 fields, including 5G infrastructure construction, extra-high voltage and intercity high-speed railways, intercity rail traffic, charging piles for new energy automobiles, big data centre, artificial intelligence (AI) and industrial Internet. NIP involves additional economic digital characteristics compared to traditional infrastructure project centred at steel and cement. As an integrated management idea and method, supply chain management of mega projects is a management process that integrates planning, organization, coordination and control over logistics, information flow, capital flow, value-added flow, business flow and relations of other subjects in the supply chain [1]. In this environment, it requires not only coordination of internal links like planning, purchasing, manufacturing and marketing, but also close cooperation between upstream and downstream subjects including suppliers and distributors [2-4].

Supply chain of mega projects has real-time impacts on construction practices of mega infrastructure project and structural safety of the supply chain has important impacts on safe operation of the whole project, while some certain and uncertain infectious risks influence safety of supply chain of mega infrastructure project [5]. The infectious risk of mega

* Corresponding author: zhaona@hit.edu.cn

infrastructure project refers to the risk posed by the anti-social behaviour, counterproductive behaviour, altruistic behaviour, and conflicts of a certain group or individuals or other stakeholders of the supply chain of MP of the impacts of external and internal factors [6-8]. Researches on infectious risk stress of supply chain mainly concentrate on risk recognition, assessment and combined strategy. Nevertheless, specific calculation of infectious risk stress in a supply chain of mega projects have to be supplemented and perfected urgently [9,10]. Based on review of Chinese and foreign researches, this study attempted to calculate infectious risk stress of supply chain of mega projects, and quantized the infectious risk stress value by combining risk certainty. Additionally, the action mechanism of infectious risk pressure was disclosed by analysing influences of random variables on infectious risks. Research conclusions provide references to anti-risk integrated design of supply chain of mega infrastructure project and to improve reliability as well as security [11].

2 Calculation methods and procedures

Supply chain of mega projects is a system composed of many subjects, including investors, builders, contractors, suppliers, forwarders, etc. Supply chain management is to plan, coordinate, operate, control and optimize various activities and processes in the whole supply chain system and it is to assure completion of mega projects on schedule according to accurate specification, quality and state at the lowest total cost. Obviously, MP supply chain (MPSC) management is a management mode which reflects the idea of integration and coordination. It requires cooperation of members in the MPSC system in coping with complicated and changing external environment [12].

To address this problem, the infectious risk stress of supply chain of mega infrastructure project was calculated by random sampling method. The calculated results approached to accurate solutions gradually with the increase of simulation times. The basic method is to generate a group of special random variable values artificially in the corresponding probability distribution by using an algorithm, and then implement abundant simulations, and finally estimate risks by testing simulation results. Accuracy of random sampling method is determined by simulation times. The key of random sampling method is to generate a lot of random numbers in known distribution and then implement many simulations based on random numbers in a short period. Specific steps are introduced as follows: (1) Setting up the function D and analysing probability distribution of various random variables. (2) Bringing random numbers which obey to probability distribution into the function D . (3) Making statistics on times t with $D < 0$. (4) Calculating the risk rate $Q_t = \frac{t}{T}$, where T is the total number of simulations.

3 Function for infectious risk stress calculation of MPSC

Basic variables which influence the structural state of MPSC are a_1, a_2, \dots, a_t , and they can be classified into two basic variables according to attributes, namely random variable P and random variable W of risk stress strength. Therefore, it can get:

$$\begin{aligned} P &= P(a_{P_1}, a_{P_2}, \dots, a_{P_i}) \\ W &= W(a_{W_1}, a_{W_2}, \dots, a_{W_j}) \end{aligned} \quad (1)$$

where a_{P_i} is a variable related with structural intensity of MPSC. a_{W_j} is the variable related with risks, including investors, builders, contractors, suppliers and forwarders. Based on such processing, the problem of multiple random variables is transformed into a problem of two random variables. For the convenience of analysis, the function of MPSC structure can be simplified as:

$$D = g (P, W) \tag{2}$$

For Eq. (2), different forms can be chosen according to different situations. The function of infectious risk stress of MPSC is determined:

$$D = P - W \tag{3}$$

Here, the random variable P of infectious risk stress of MPSC is composed of $P = P (\mu_W, \gamma)$, where μ_W is the compromise strength of suppliers and γ is the collaborative coefficient. For the random variable W of infectious risk stress of MPSC, there's $W = \mu_p$ since the MPSC is in the multiple influence state. According to characteristics of infectious risk of MPSC structure, the function is designed as follows:

$$D = P - W = \gamma\mu_W - \mu_p \tag{4}$$

where μ_p is the internal risk of supply chain of MPSC.

The random variable of infectious risk stress of MPSC structure is $W = W (\mu_a, \mu_p)$ and the relevant function is built up:

$$D = -\sqrt{\mu_p^2 + \mu_a^2 - \mu_p\mu_a} + \gamma\mu_W \tag{5}$$

where μ_a is an external risk.

4 Distribution characteristics and statistical eigenvalues of random variables

In addition to major random variables that influence structural safety of MPSC, this study also viewed some parameters as random variables. Among them, statistical eigenvalues of planning coefficient γ , collaboration L_j and operation L_k can be gained through relative quantity:

$$\begin{cases} \vartheta_j = L_{\max}/L_d \\ \vartheta_k = L_k/L_{wl} \\ \vartheta_\gamma = \gamma_W/\gamma_g \end{cases} \tag{6}$$

where L_{\max} is the maximum risk of MPSC, L_d is the design risks, L_k is the central operation condition of MPSC, L_{wl} refers to control, and γ_W and γ_g are coefficients.

There are many influencing factors of MPSC risks and there's no relevant data for mathematical statistical analysis. According to error theory and central-limit theorem, these influencing factors were viewed belonging to normal distribution.

5 Conclusions

Based on function calculation, the maximum infectious risk stress is observed at the end of supply chain of MPSC structure. Therefore, the end of infectious risk stress of MPSC is used as the marking point in risk calculation and analysis. With references to probability distribution and statistical eigenvalues of different simulation variables, it can be seen from random sampling method that selection of standard deviations for different simulation variables can influence calculation of infectious risk stress of MPSC structure significantly.

To disclose influences of a simulation variable on comprehensive infectious risk stress of MPSC structure, the standard deviation of one variable is changed independently and uncertainty of infectious risk stress is the primary influencing factors of risks. To sum up, risk rate increases with the increase of the ratio between practical value and design value, indicating that uncertainties of investors, builders, contractors, suppliers and forwarders can improve stress resistance of MPSC structure slightly. Moreover, inherent feature parameters of mega projects can be viewed as certainty variables. Key attentions shall be paid to

improvement of stress resistance of the MPSC under infectious risks through planning, coordination, operation, control and optimization.

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