Research on risk assessment of underground logistics system project based on Grey Analytic Hierarchy Process

Yanhong Qin *, Wentao Yan **
*(Department of Management, Chongqing Jiaotong University, China)
** (Department of Management, Chongqing Jiaotong University, China)

ABSTRACT

The reasons of the risk of city underground logistics system are discribed from three aspects of technology, careerman and environment,the risk evaluation index system is constructed based on the method of analytic hierarchy process,the Grey Analytic Hierarchy model is established and the feasibility and validity of this evaluation model is verified by using it in the risk assessment of a underground logistics system project.

Keywords - *Grey Analytic Hierarchy Process, risk assessment,underground logistics system*

1. Introduction

According to the estimation of the relevant departments of the United Nations, half global population is living in the city in 2008 and the mankind is entering into the "Century City"; but the rapid development of the city also brings to the city a series of economic, social and environmental problems[1].Among them, the city traffic congestion as an important factor which affects thousands of households' daily travel , has restricted the city operation efficiency and the raise of city's competitiveness has become an important problem which is urgent to be solved in the world big cities.In order to solve this problem, the United States, Japan, Holland and other countries have turned their eyes to underground, hoping to reduce the ground traffic pressure through the development of underground logistics system and effectively solve the problem of traffic jams.But so far, there is not a complete underground logistics system in the world , so risk evaluation becomes a necessary method before the construction of underground logistics project.Zheng Liqun,Wu Yuhua and so on(1999)[2] used the artificial intelligence method to solve the problem of investment risk management, studied the feasibility of using artificial neural network method to do the risk evaluation,determined the risk investment evaluation neural network structure and algorithm model , calculated the weights between nodes.Dong Xianzhou,Xu Peide(2001)[3] discussed the feasibility of risk analysis based on Probabililistic Risk Assessment(PRA) method in the engineering project and designed a risk analysis system based on PRA.Sun Shusheng,Liu Xiaokang(2009)[4] took the major tasks of each stage of a logistics park project into account and analyzed the various risks existing in each stage and offered risk-hedging strategies and preventive measures.

This paper expounds the reasons for underground logistics system risk from three aspects of technology, talent and environment, creates the risk evaluation index system on the basis of the reasons, and then constructs the grey hierarchy evaluation model and case analysis, provides the basis for the risk level of project risk management, proves this model's effectiveness and feasibility in risk assessment.

2. The risk cause of underground logistics system

From the view point of system, underground logistics system is a new concept of logistics system.In the full life cycle of investment, there will be all kinds of uncertainty, each kind of uncertainty will have an impact on the project and the final result also depends on the influence of interaction of the uncertainty.

2.1The technique is not mature

Underground logistics system as a new concept has gained worldwide attention, but the research is still in the feasibility study and risk analysis phase.There is not a complete transportation pattern, operation mechanism and technical specifications for reference in the world. These technical factors directly restrict the development of underground logistics system and become the key factor of underground logistics system risks.

2.2The lack of professionals

In 2013 China's dozens of universities in China added the city underground space engineering major, which marks the cultivation of underground space engineering talents in China has just started, so the talents of underground logistic system are much rare. The lack of talents will affect the construction of the project, the operation of the system and the system of management, so the lack of professionals is one of the important reasons for underground logistics system risks.

2.3The uncertainty of the environment

The uncertainty of the environment includes system internal environment uncertainty and the uncertainty of external environment. The internal environment refers to update equipment, technology development and system improvement. The external environment includes political environment, financial environment and natural environment. When project's environment and conditions change, the project needs to change in order to adapt to the new changes, this consequence of change is unpredictable.This uncertainty of environment is also one important reason for the underground logistics system risks.

3. The establishment of evaluation index system of risk

According to the reason of underground logistics system risks, combined with the current situation of the development of underground logistics in China, the risk analysis of underground logistics system project are made according to scientific, systematic, operational and forward-looking principles. The risk evaluation index system is set up as shown in Figure 1[5].The index system has three levels: the goal layer, the factor layer and the index layer. The target layer is comprehensive risk of underground logistics system, the factor layer refers to all aspects of the impact and the index layer contains the refined indicators which react each risk factor.

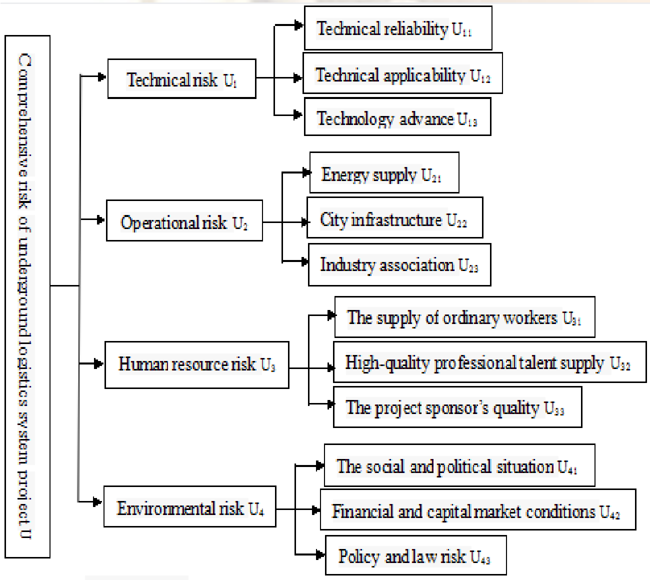

figure1 the index system of risk assessment of underground logistics system

4. Grey hierarchy evaluation model

4.1Determine the weight of evaluation index

In the established index system , the important degree of each index to the target is different.The indexs should be given different weights when measuring the effect of each index on the object. The more important the index is,the greater the weight value should be.There are a lot of methods to determine the weight , such as AHP (analytic hierarchy process), entropy method and factor analysis method.The weights of the first level indicators are:$A=\{a_i\}(i=1,2,3,4)a_i\geq0$,and they meet $\sum_{i=1}^{4} a_i = 1$.The weights of the second level indicator are:$A_i=\{a_{ij}\}(i=1,2,3,4),j=1,2\cdots m,a_{ij}\geq0$,and they meet $\sum_{j=1}^{m} a_{ij} = 1$,when i=1,2,3,4 then j=3,3,3,3.

4.2Determine the rank of evaluation and evaluation index of sample matrix

The evaluation index of U_{ij} is qualitative indicator. In order to simplify calculation, the qualitative indexes often are turned into quantitative indexes when the risk evaluation index system is established.Because of many kinds of risk factors of underground logistics system project and they have different effects on the target, so the risk level is divided into five dregees [6] (low risk, fairly low risk, normal risk, fairly hign risk, high risk).The 1,3,5,7,9 are used to assign the five dregees, when the risk index dregee is between two corresponding levels, corresponding points are the average score of two adjacent assignment value, named: 2,4,6,8.

According to the formulated risk rating standard, n experts are organized to fill in the point table and give a score on the level of risk evaluation. So the sample evaluation matrix of the project'construction risk can be got as D (assuming the project evaluation risk has P factors, and the final evaluation factor has Q evaluation index):

$$D = \begin{bmatrix} d_{111} & d_{112} & \cdots & d_{11n} \\ d_{121} & d_{122} & \cdots & d_{12n} \\ & & \vdots & \\ d_{211} & d_{212} & \cdots & d_{21n} \\ & & \vdots & \\ d_{pq1} & d_{pq2} & \cdots & d_{pqn} \end{bmatrix}$$

figure2 the sample matrix of score

d_{pqn}— score which the n expert gives based on the P risk factor's Q risk index

4.3Determine the evaluation of grey and grey evaluation coefficient

In order to objectively reflect the influence degree of risk,the evaluation of engineering project risk grey need to be determined.That is the evaluation grey level, grey number and the whitenization weight function need to be determined[7]. The evaluation grey is divided into low, fairly low, average, fairly high and high five dregees in this paper, the order is expressed by e (e=1,2,3,4,5).The whitenization weight function is selected linear in this paper, the whitenization weight function which corresponds grey number is shown as follows[8]: set $X_1=1$, $X_2=2$, $X_3=3$, $X_4=4$, $X_5=5$.

① low risk（e=1）,grey number $\otimes_1 \in [0,1,2]$,the whitenization weight function f_1 is:

$$f_1(d_{pqn})=\begin{cases}1 & d_{pqn}\in[0,1]\\ 2-d_{pqn} & d_{pqn}\in[1,2]\\ 0 & d_{pqn}\notin[0,2]\end{cases} \quad (1)$$

② fairly low risk(e=2),grey number $\otimes_2 \in [0,2,4]$,the Whitenization weight function f_2 is:

$$f_2(d_{pqn})=\begin{cases}d_{pqn}/2 & d_{pqn}\in[0,2]\\ (d_{pqn}-4)/(-2) & d_{pqn}\in[2,4]\\ 0 & d_{pqn}\notin[0,4]\end{cases} \quad (2)$$

③ normal risk (e=3) ,grey number $\otimes_3 \in [0,3,6]$,the Whitenization weight function f_3 is:

$$f_3(d_{pqn})=\begin{cases}d_{pqn}/3 & d_{pqn}\in[0,3]\\ (d_{pqn}-6)/(-3) & d_{pqn}\in[3,6]\\ 0 & d_{pqn}\notin[0,6]\end{cases} \quad (3)$$

④ fairly high risk (e=4,grey number $\otimes_4 \in [0,4,8]$,the Whitenization weight function f_4 is:

$$f_4(d_{pqn})=\begin{cases}d_{pqn}/4 & d_{pqn}\in[0,4]\\ (d_{pqn}-8)/(-4) & d_{pqn}\in[4,8]\\ 0 & d_{pqn}\notin[0,8]\end{cases} \quad (4)$$

⑤ high risk,grey number $\otimes_5 \in [0,5,10]$,the Whitenization weight function f_5 is:

$$f_5(d_{pqn})=\begin{cases}d_{pqn}/5 & d_{pqn}\in[0,5]\\ 1 & d_{pqn}\in[5,10]\\ 0 & d_{pqn}\notin[0,10]\end{cases} \quad (5)$$

For the index of project risk evaluation U_{ij} , the grey evaluation coefficient of the assessed risk factor which belongs to the e evaluation grey is M_{ije}:

$$M_{ije}=\sum_{k=1}^{m} f_e(d_{pqn}) \quad (6)$$

Then the grey evaluation coefficients of various other evaluation grays which belong to the category of the project are recorded as M_{ij} :

$$M_{ij}=\sum_{e=1}^{5} M_{ije} \quad (7)$$

4.4 Calculate the grey evaluation weight vector and weight matrix

For the evaluation index U_{ij} , all of the evaluators' grey evaluation weight of project's the e grey evaluation is r_{ije} ,and:

$$r_{ije}=M_{ije}/M_{ij} \quad (8)$$

For the evaluation project's five grey's grey evaluation weight vector r_{ij} , $r_{ij}=|r_{ij1},r_{ij2},r_{ij3},r_{ij4}|$, then get the gray evaluation weight matrix R_i of risk evaluation index U_{ij} :

$$R_i=\begin{bmatrix}r_{i1}\\ r_{i2}\\ r_{i3}\\ \vdots\\ r_{ij}\end{bmatrix}=\begin{bmatrix}r_{i11} & r_{i12} & r_{i13} & \cdots r_{i1m}\\ r_{i21} & r_{i22} & r_{i23} & \cdots r_{i2m}\\ r_{i31} & r_{i32} & r_{i33} & \cdots r_{i3m}\\ \vdots & \vdots & \vdots & \ddots \vdots\\ r_{ij1} & r_{ij2} & r_{ij3} & \cdots r_{ijm}\end{bmatrix} \quad (9)$$

4.5comprehensive evaluation

① The calculation results of the comprehensive evaluation of the second dregee risk factors U_{ij} are recorded as B_i , it can be got by the following formula:

$$B_i=A_i\cdot R_i \quad (10)$$

② The calculation results of the comprehensive evaluation of the first dregee risk factors U_i are recorded as B , it can be got by the following formula:

$$B=A\cdot B_i \quad (11)$$

③ The overall goal evaluation of the project risk

This paper uses 5 levels of gray value, the first gray class is 1, second gray class is 3, third gray class is 5, fourth gray class is 7, fifth gray class is 9, so the evaluation of grey level value vector C = (1,3,5,7,9), the evaluation value of the project's general objective is:

$$Z=B\cdot C^T \quad (12)$$

According to the value of Z to determine the level of risk and take appropriate measures to process and control of risk scientifically[9].

5. The example analysis

According to the calculation method of grey analytic hierarchy process, taking Beijing city as an example.Beijing is a big city with a population of more than 10 million and is facing serious problem of traffic congestion. Suppose Beijing is to build a city underground logistics system and the risk assessment is to be done.First invite 5 experts to give scores to grade one and grade two judgment matrix , after processing the data, the comprehensive judgment matrix is obtained, and then use the AHP to determine the weight vector of grade one evaluation index: A =（0.51,0.08,0.26,0.15）; the weight vectors of grade two evaluation index are A_1 =（0.13,0.59,0.28）, A_2 =（0.18,0.71,0.11）, A_3 =（0.09,0.29,0.62）, A_4 =（0.11,0.31,0.58）.Invite 5 underground space development experts to give scores to the 12 grade two indexes in the index system and get the evaluation of sample matrix:

$$D^T = \begin{bmatrix} 7 & 5 & 7 & 1 & 5 & 5 & 1 & 5 & 7 & 7 & 5 & 5 \\ 9 & 5 & 1 & 5 & 5 & 1 & 3 & 3 & 7 & 3 & 5 & 3 \\ 3 & 7 & 5 & 2 & 9 & 3 & 1 & 5 & 8 & 3 & 6 & 7 \\ 6 & 1 & 8 & 7 & 2 & 4 & 5 & 5 & 9 & 8 & 3 & 3 \\ 4 & 8 & 6 & 6 & 3 & 3 & 3 & 6 & 8 & 2 & 7 & 5 \end{bmatrix}$$

For the first evaluation index reliability of technology U_{11}, the calculation processes of its evaluation coefficient are as follows: first calculate the risk coefficients M_{ije} by the e evaluation gray class.

$$e=1: M_{111} = f_1(d_{111}) + f_1(d_{112}) + f_1(d_{113}) + f_1(d_{114}) + f_1(d_{115})$$
$$= f_1(7) + f_1(9) + f_1(3) + f_1(6) + f_1(4) = 0$$
$$e=2: M_{112} = f_2(d_{111}) + f_2(d_{112}) + f_2(d_{113}) + f_2(d_{114}) + f_2(d_{115}) = 0.5$$
$$e=3: M_{113} = f_3(d_{111}) + f_3(d_{112}) + f_3(d_{113}) + f_3(d_{114}) + f_3(d_{115}) = 5/3$$
$$e=4: M_{114} = f_4(d_{111}) + f_4(d_{112}) + f_4(d_{113}) + f_4(d_{114}) + f_4(d_{115}) = 2.5$$
$$e=5: M_{115} = f_5(d_{111}) + f_5(d_{112}) + f_5(d_{113}) + f_5(d_{114}) + f_5(d_{115}) = 4.6$$

Therefore, the general evaluation coefficient M_{11} of the risk : $M_{11} = M_{111} + M_{112} + M_{113} + M_{114} + M_{115} = 9.2$

The gray evaluation weight is recorded as r_{ije} :

$$e=1: r_{111} = M_{111} / M_{11} = 0$$
$$e=2: r_{112} = M_{112} / M_{11} = 0.0543$$
$$e=3: r_{113} = M_{113} / M_{11} = 0.1811$$
$$e=4: r_{114} = M_{114} / M_{11} = 0.2717$$
$$e=4: r_{115} = M_{115} / M_{11} = 0.5$$

The grey evaluation weight vector of this risk is r_{11}:

$r_{11} = (r_{111} + r_{112} + r_{113} + r_{114} + r_{115})$ =（0，0.0543，0.1811，0.2717，0.5）

Similarly, the general evaluation coefficient of other indexs can be calculated , and the following grey evaluation weight vectors r_{12}，r_{13}，r_{21}，r_{22}，r_{23}，r_{31}，r_{32}，r_{33}，r_{41}，r_{42}，r_{43} can be determined,so the grey evaluation matrixs can be established as follows:

$$R_1 = \begin{bmatrix} 0 & 0.0543 & 0.1811 & 0.2717 & 0.5 \\ 0.1149 & 0.0575 & 0.1149 & 0.2299 & 0.4828 \\ 0.1232 & 0.0616 & 0.0825 & 0.2155 & 0.5172 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.1033 & 0.155 & 0.1343 & 0.2324 & 0.3719 \\ 0 & 0.1418 & 0.2212 & 0.2599 & 0.3781 \\ 0.0798 & 0.1197 & 0.2658 & 0.2793 & 0.2554 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.1619 & 0.1619 & 0.2429 & 0.2227 & 0.2105 \\ 0 & 0.0472 & 0.1887 & 0.3302 & 0.434 \\ 0 & 0 & 0 & 0.0909 & 0.9091 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0 & 0.1901 & 0.2538 & 0.2139 & 0.3422 \\ 0 & 0.0899 & 0.2401 & 0.2923 & 0.3777 \\ 0 & 0.0512 & 0.1709 & 0.3071 & 0.4708 \end{bmatrix}$$

According to formulas (10)and (11)

B =（0.0582,0.0602,0.1146,0.2271,0.5297）

The overall goal Z of the project risk evaluation can be got according formula (12)

Z =(0.0582,0.0602,0.1146,0.2271,0.5297)·(1,3,5,7,9)^T =7.1688

The comprehensive evaluation of the underground logistics system project risk value can be calculated as 7.1688 by the grey analytic hierarchy process.It belongs to high risk according to the risk evaluation grade. Risk manager should do further analysis on the project risk combined with the actual engineering project risk level, find out the high risk source and control it to ensure that the project is in a low risk level.

6. Conclusion

City underground logistics system construction requires a large amount of money, as a new logistics system, it is very difficult to win the enterprise's favor if without scientific and reasonable risk analysis of investment.And this will make the underground logistics project which has potential development ability lose opportunities for development in the early construction period because of a shortage of funds.If people can predict the risk level more accurately and control of it effectively in construction project before investment then the enterprise and government will put more money into the underground logistics project, which is conducive to the rapid development of underground logistics system.This paper uses the grey analytic hierarchy process, combined with the advantages of analytic hierarchy process and grey system, integrated of the qualitative and quantitative analysis, greatly reduce the influence of subjective factors in risk analysis and improve the assessment accuracy and effectiveness.In addition, the underground logistic system project's internal and external environment are changing all time.Improving and perfecting the evaluation index system and evaluation method according to the actual situation of project and making the risk evaluation results more practical is the research direction in the future.

References

[1] Sun Bindong, *Study on the spatial strategy of big city's traffic development in our country -taking Shanghai as an example(*Nanjing:Nanjing University press,2009).
[2] Zheng Liqun,Wu Yuhua,Zhou Bokang,Xia Qing,The application of artificial neural network(ANN) on investment risk evalucation,*Journal of Management Science in China,2(4),*1999:93-95.
[3] Dong Xianzhou,Xu Peide,Design of Risk Analysis System Based on Probabilistic Risk Assessment,*JOURNAL OF SYSTEM SIMULATION,13(6),*2001:756-758.
[4] Sun Shusheng,Liu Xiaokang,Risk Analysis and Control of Losgistic Park Projects Based on Life-cycle Management,*Logistics technology,28(12),*2009.
[5] Qian Qihu,Guo Dongjun,*An introduction to the city underground logistics system*(Beijing:China Communications Press,2007).
[6] Zhong Caigen,Liu Huixia,Deep foundation pit engineering risk source analysis and countermeasures,*Construction supervision,(6),*2009:64-66.
[7] Cai Jianchun,Wang Yong,Li Hanling,Grey Hierarchy Evaluation for Investment Risk of Venture Capitial,*Journal of Industrial Engineering/Engineering Management,(2),*2003:94-97.
[8] JamesH.BoykinA.Ring,The Valuation of Real Estate.Rogenss PrentieeHall.Ine.1993.
[9] Duan Jinli,Zhang Qishan,Liu Weijia,Risk assessment model of information system based on AHP method and Grey Theory,*Journal of Guangdong University of Technology,23(4),*2006:12-14.