Social Risk Assessment of Engineering Project Based on Ordered Voting Model

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Abstract. In the process of urban construction, the implementation of various engineering projects will lead to a series of social problems. If these problems are not effectively resolved, they will be further upgraded into social risks and have a negative impact on social order. At present, China's social risk assessment methods mainly include expert scoring and expert sorting. The paper takes the method of expert sorting as the main research object. Based on the ordered voting model, this paper further analyses the scientific nature of the ranking method from the aspects of single index evaluation and multi-index evaluation.

1. Introduction
With the acceleration of urbanization and the increasing construction of engineering projects, the mass incidents have also increased. How to resolve the social risks accompanying engineering projects and maintain social order has become an urgent problem to be solved. The research on social risk assessment of engineering projects in China has just begun in recent years. In 2002, social risk assessment was formally included as an important part of projects evaluation by the National Development and Reform Commission. In 2005, Suining in Sichuan province took the lead in conducting social stability risk assessment of major engineering projects, which was recognized by the state.

At present, scholars have carried out a series of studies from the theoretical basis, evaluation methods and index systems of social risk assessment. Hu et al. analyzed the psychological and cultural aspects of public risk perception and constructed a framework for social risk assessment analysis [1]. Zhou started with citizen participation and studied the mechanism of citizen participation in social stability risk assessment from four aspects: evaluation subject, evaluation object, evaluation method and risk response [2]. Huang et al. commented on the models, characteristics and objects of social risk assessment from the perspective of state governance [3]. In the indicator system of social risk assessment, many scholars have carried out the research. Yang et al. constructed the social risk assessment index system of the project from four aspects of economic, ecological, social and institutional factors [4]. The research team of the Jiangxi Provincial Development and Reform Commission proposed an evaluation system that included four indicators of the first level, and established 17 secondary indicators [5]. Gao et al. proposed a risk assessment system including project legal and policy, social and environmental, construction and operation [6]. In terms of evaluation methods, many scholars have emphasized economic and environmental evaluation methods such as cost-benefit analysis and environmental risk analysis [1].

In summary, the research on social risk assessment of engineering projects in China is diversified. At the same time, it is still simple in the evaluation index system and evaluation method. The evaluation of each risk index is mainly based on the expert's rating or ranking. This article only considers the form of sorting by experts, which is different from other articles.
2. Social Risk Evolution Index of engineering Project

2.1. The connotation of social risk of engineering projects

2.1.1. Social risk
Social risk mainly refers to the possibility of triggering social contradictions and conflicts, which in turn endangers social order and social stability [7]. Once this risk is accumulated to a certain extent, it will be transformed into a social crisis, posing a threat to social and economic development and social stability. Social risks generally have the following three characteristics. First, social risks will always be hidden in all aspects of social operations. Second, we cannot accurately predict the time and consequences of future social mass incidents, and it is difficult to take targeted interventions in advance. Third, once social stability risks become social crises, the losses they bring include political and economic aspects.

2.1.2. Social risk of engineering project
The social risk of an engineering project refers to the risk of uncertainty in the implementation and operation of major engineering projects due to conflicts of interest of different stakeholders, resulting in certain individuals or groups achieving their own interests in extreme behavior. On the one hand, social risks will hinder the implementation progress of the project, and on the other hand, it will bring a large-scale and long-lasting negative impact on the public. The social risks of engineering projects are mostly in the projects of demolition and traditional cultural destruction [8].

2.2. Index system of social risk assessment
Various types of engineering projects will involve economic, cultural, ecological and other aspects of problems in the implementation process. Due to the large scope of influence, it is particularly important to design a reasonable social risk rating indicator system. If there are too many rating indicators, it will not only increase the workload of the assessment process, but also cover up the differences between various social risks. On the contrary, if the evaluation indicators are too small, it is difficult to objectively reflect the social risks faced by the project [9]. In the engineering project, there are mainly the following social risks. First, economic factors. If the economic compensation for the affected subjects is not handled properly, there will be social risks that cause public protest or conflict. Second, social factors. Some engineering projects will cause damage to the traditional culture of the region, which may lead to conflicts such as cultural incompatibility. Third, institutional factors. The system of information disclosure and the accountability mechanism for accidents are not perfect. Fourth, ecological environment factors. Construction usually has problems such as noise pollution, water pollution, dust, etc. Environmental damage will lead to protests from surrounding people. Specific indicators are shown in Table 1.

| Primary indicator | Secondary indicators |
|--------------------|----------------------|
| economic factors   | Degree of land acquisition and expropriation compensation |
|                    | Increase in local employment rate |
|                    | The extent of local income increase |
|                    | Change in the cost of local public service facilities |
| social factors     | Affected area and number of people |
|                    | Integration with local traditional customs and religious culture |
|                    | Local mobile population growth rate |
|                    | Integration of immigrants and residents in resettlement areas |
Acceptance of resettlement compensation policy
institutional factors
Local public participation and information disclosure
Project accident accountability mechanism
Project emergency management system
Project quality management system
ecological
Degree of change in per capita green space
environment factors
Environmental pollution (noise, water quality, dust, etc.)
Destruction of the local cultural landscape

3. Ordered voting model: single index evaluation

Foreign researchers have conducted more mature research on the ordered voting model of a single index.

Now suppose that there are multiple experts sorting n candidate projects to select t projects to support. Each expert has only t candidates listed in order of preference. Under this assumption, \( n > t \). \( y_{ij} \) is the total number of times the i-th item is ranked jth. \( j = 1 \) means the first place. As shown below, Cook et al. first proposed an ordered voting model.

\[
Z^*_p = \max \sum_{j=1}^{t} y_{pj} u_j
\]

\[
\text{s.t. } \sum_{j=1}^{t} y_{pj} u_j \leq 1, \quad i = 1, \ldots, n
\]

\[
u_j - u_{j+1} \geq d(j, \varepsilon), \quad j = 1, \ldots, t - 1
\]

\[
u_t \geq d(t, \varepsilon)
\]

(1)

In model (1), \( u_j \) is the weight corresponding to each sort order. Constraining \( u_j - u_{j+1} \geq d(j, \varepsilon) \) is to ensure that the higher the order, the greater the weight. \( d(j, \varepsilon) \) is a differential density function. For any positive number \( \varepsilon \), \( d(\cdot, \varepsilon) \) is a non-negative and non-decreasing function, and \( d(0, \varepsilon) = 0 \).

The constraint on weights in model (1) is called weak constraint. Noguchi proposed a strong constraint to replace the constraint:

\[
u_i - u_{i-1} > u_{i-2} - u_{i-1} > \ldots > u_2 - u_1 > 0 \]

(2)

Constraint (2) means that not only the corresponding weight is greater when the rank is higher, but also the weight between adjacent ranks is different. The greater the difference is greater when the rank is higher. For example, the difference between the first and second places should be greater than the difference between the second and third places. Obviously, constraint (2) is more reasonable.

On the assumption that there are 10 projects. Four projects with high social risks need to be selected from that, and the opinions of five experts are used as a reference.

The orderly voting results of the “comprehensive opinions” of the five experts on each candidate project are shown in Table 2.

| Item Number | Number of times to get the 1st place | Number of times to get the 2nd place | Number of times to get the 3rd place | Number of times to get the 4th place | Total |
|-------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------|
| 1           | 1                                   | 0                                   | 1                                   | 2                                   | 4     |
| 2           | 0                                   | 0                                   | 0                                   | 0                                   | 0     |
| 3           | 0                                   | 1                                   | 1                                   | 0                                   | 2     |
| 4           | 1                                   | 1                                   | 1                                   | 0                                   | 3     |
| 5           | 2                                   | 1                                   | 2                                   | 0                                   | 5     |
Through calculation, the optimal solution of model (1) is shown in the second column of Table 4. Project #5, #9, #1, #4 have the highest optimal solution and should be accepted for funding.

4. Ordered voting model: multi-index evaluation

For the ordered voting model of multiple indicators, no researchers have published targeted papers at home and abroad.

On the assumption that there are multiple experts sorting n candidate items one by one according to m indicators to select t items to support. For each indicator, each expert has only t candidates listed in order of preference. In the above assumption, \( n > t \). \( y_{ikj} \) is the total number of times the i-th item is ranked jth for the kth indicator. \( j = 1 \) means in the first place. \( i = 1, \ldots, n \), \( k = 1, \ldots, m \), \( j = 1, \ldots, t \). Therefore, an ordered voting model for evaluating multiple indicators can be proposed as follows.

\[
Z_p^* = \max \sum_{j=1}^{t} \sum_{k=1}^{m} y_{ikj} w_k u_j \\
\text{s.t.} \sum_{j=1}^{t} \sum_{k=1}^{m} y_{ikj} w_k u_j \leq 1, \quad i = 1, \ldots, n \\
u_1 - u_2 > u_2 - u_3 > \cdots > u_{t-1} - u_t > 0 \\
\sum_{k=1}^{m} w_k = 1 
\]

(3)

In this model, \( w_k \) is the weight of the kth indicator in the overall indicator system.

For the pth candidate item, the comprehensive evaluation score is the optimal solution \( Z_p^* \) of (3). Then sort all candidate items according to \( Z_p^* \). The larger \( Z_p^* \) is, the more appropriate the corresponding project should be supported. On the contrary, the smaller \( Z_p^* \) corresponding project should be eliminated.

The defect of model (3) is that for each candidate item, the maximal \( w_k \) obtained by \( Z_p^* \) is not consistent. The result of the evaluation is not objective. In order to solve this problem, there are two ways to determine the value of \( w_k \). First, determined \( w_k \) according to experience or relevant regulations, that is, the value is preset. Second, averaging method, that is, making all \( w_k = 1/m \). This article takes the second method.

The results of the three indicators of candidate projects voted by five experts are shown in Table 3.

| Item Number | Number of times to get the 1st place | Number of times to get the 2nd place | Number of times to get the 3rd place | Number of times to get the 4th place | total |
|-------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------|
| A           | B                                   | C                                   | A                                   | B                                   |       |
| 1           | 1                                   | 1                                   | 2                                   | 0                                   | 0     |
| 2           | 0                                   | 0                                   | 0                                   | 1                                   | 2     |
| 3           | 0                                   | 0                                   | 1                                   | 2                                   | 4     |
| 4           | 1                                   | 0                                   | 1                                   | 0                                   | 4     |
Through calculation, the optimal solution of model (3) is shown in the fourth column of Table 4. It can be seen that projects #5, #9, #1, #4 have the highest optimal solution and should be accepted for funding.

| Item Number | Single indicator result | sort | multiple indicator result | sort |
|-------------|-------------------------|------|---------------------------|------|
| 1           | 0.8                     | 3    | 0.642857143              | 3    |
| 2           | 0                       | 10   | 0                         | 10   |
| 3           | 0.4                     | 5    | 0.357142857              | 5    |
| 4           | 0.6                     | 4    | 0.5                       | 4    |
| 5           | 1                       | 1    | 1                         | 1    |
| 6           | 0                       | 8    | 0.071428571              | 8    |
| 7           | 0                       | 9    | 0.071428571              | 9    |
| 8           | 0.2                     | 7    | 0.357142857              | 7    |
| 9           | 0.8                     | 2    | 0.8                       | 2    |
| 10          | 0.2                     | 6    | 0.357142857              | 6    |
| 10          | 0.2                     | 6    | 0.357142857              | 6    |

It can be seen from Table 4 that the evaluation results obtained by the two methods are highly consistent. The two methods have the same sorting result for 10 candidate items. What’s more, the results of multiple indicator evaluations are more detailed. For example, in the single-index method, items #1 and #9 are difficult to separate while multi-indicator methods show #9 better than #1. Items #2, #6, and #7 are the same in the single-index method while multi-indicator methods show #6 and #7 are better than #2.

5. Conclusion
The social risk assessment of the project can enable the government to better resolve various risks and promote the development of a harmonious society. Based on the ordered voting model, this paper conducts a preliminary study on the methods of social risk assessment of engineering projects, and proves the scientific nature of the evaluation method of expert voting. In general, it is not easy to get objective results for scoring individual indicators, while sorting is more objective. When experts use the scoring method, they are sorted according to the evaluation indicators. Then the corresponding scores are given according to the ranking results. For experts, sorting is a relatively accurate result, while scoring is more of a valuation.

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