Correlation Analysis between the Control Degree of the Construction Project Department to the Labor Subcontracting Team and the Construction Quality

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Abstract: As the labor subcontracting team is the most basic organizational unit on the construction site, which can have an impact on quality, safety, construction period and cost, the management of the labor subcontracting team by the construction project department is a very important part of the project management. The construction quality of construction engineering is also a hot issue studied by many scholars. From the existing research results, we can know that there are many factors that affect the construction quality. This paper sets up the concept of control degree, which indicates the comprehensive management level of the construction project department to the labor subcontracting team, establishes the control degree and construction quality evaluation system, and calculates the weight and comprehensive score of each evaluation index of the control degree and construction quality evaluation system by using entropy weight method. The correlation between control degree and construction quality is analyzed by using SPSS software, which provides reference for construction project management.

1. Introduction

In the wake of the continuous development and improvement of China's construction market and the continuous improvement of the degree of specialization, professional engineering subcontracting and labor subcontracting have become the needs of the healthy development of the construction industry. At present, the construction industry in China has formed a three-level construction market of construction general contracting, professional subcontracting and labor subcontracting. The labor subcontracting team is the most basic organization unit in the construction site management, while the project department is the highest management organization on the construction site. The control degree of the project department to the labor subcontracting team reflects the control degree of the project department to the whole project to a certain extent. Construction quality is an important criterion to measure the success of an engineering project, and construction quality has always been a hot issue studied by many scholars. There are many factors that affecting the construction quality. However, few people have studied whether the control degree of the construction project department over the labor subcontracting team is related to the construction quality. Therefore, the study on the correlation between the control degree and the construction quality in this paper has strong theoretical and practical significance and is of great research value.
2. Theory of Entropy Weight Method (EWM) and Control Degree

2.1. Theory of Entropy Weight Method (EWM)

2.1.1. Brief introduction of EWM

Information entropy is a concept in information theory. A smaller amount of information will reflect a larger entropy and greater uncertainty. On the contrary, a larger amount of information will reflect less entropy and less uncertainty\(^1\).

From this, EWM is derived as a method of index weight distribution calculation. It is an extremely objective method of index weight distribution, which is not affected by subjective consciousness or personal preference, and obtains the index weight through simple calculation according to the acquired data set. However, the index weight calculated by EWM is affected by the basic data set, the richer the basic data set, the wider the scope, the more reasonable and true the calculated index weight is.

2.1.2. Calculation steps of EWM

1. Design sample data. For \(n\) samples and \(m\) indexes in the basic data set, let \(X_{ij}\) be the value corresponding to the \(j\) index of the \(i\) sample, where \(1 \leq i \leq n, 1 \leq j \leq m\).

2. Data standardization. Standardize the collected basic data as the units of the index data are not uniform. In addition, these indexes are divided into positive indexes and negative indexes. For positive indexes, the bigger the better; while for negative indexes, the smaller the better. Therefore, for the positive index and negative index, further data standardization is needed to obtain the processed data set. The algorithm of positive index and negative index is shown as follows:

Positive index:

\[
X_{ij} = \frac{X_{ij} - \min \{X_{1j}, \ldots, X_{nj}\}}{\max \{X_{1j}, \ldots, X_{nj}\} - \min \{X_{1j}, \ldots, X_{nj}\}}
\]

Negative index:

\[
X_{ij} = \frac{\max \{X_{1j}, \ldots, X_{nj}\} - X_{ij}}{\max \{X_{1j}, \ldots, X_{nj}\} - \min \{X_{1j}, \ldots, X_{nj}\}}
\]

3. Calculate the weight of the \(i\) sample data in item \(j\) of the index

\[
P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \quad \text{where} \ 1 \leq i \leq n, 1 \leq j \leq m.
\]

4. Calculate the entropy value of item \(j\) index.

\[
e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \quad \text{where} \ k \text{satisfies the condition of } c_j > 0 \ 1 \leq j \leq m. \quad k = \frac{1}{\ln(n)} \quad 0
\]

5. Calculate the redundancy of information entropy of item \(j\) index. \(d_j = 1 - e_j\) where \(1 \leq j \leq m\).

6. Calculate the weight of each index.

\[
W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad \text{where} \ 1 \leq j \leq m.
\]

7. Calculate the comprehensive score of each sample.

\[
S_i = \sum_{j=1}^{m} w_j X_{ij} \quad \text{where} \ 1 \leq i \leq n, \text{and } X_{ij} \text{is the standardized data} \quad [2].
\]
2.2. Theory of Control Degree

2.2.1. Concept of control degree.
The control degree in this paper is a concept set up to represent the management effect of the construction project department on the labor subcontracting team. The control degree of the construction project department over the labor subcontracting team is a quantitative index of the comprehensive evaluation effect of the project department on the management of the labor subcontracting team from the aspects of system, economy, quality, materials, site, safety, environment, etc.

2.2.2. Characteristics of control degree.
1. Different from the previous single index, the control degree is multi-dimensional. The control degree is the comprehensive evaluation index of the construction project department to the management of labor subcontracting team in terms of system, economy, quality, material, safety, environment, etc., which shows the inclusiveness of control degree.

2. Different from the previous purely conceptual indexes, the control degree is a quantitative index. The control degree is the comprehensive score of the project department's control over the labor subcontracting team calculated by professionals according to the control degree evaluation system as well as integrating the on-site management practice data of the evaluation project.

3. Different from the general directivity index in the past, the control degree is a highly targeted index. The control degree set up in this paper refers to the comprehensive management level of the labor subcontracting team by the construction project department. The labor subcontracting team involved is in the construction phase of the project, which has clear purpose and directionality.

3. Evaluation System Construction for the Control degree of the Construction Project Department to the Labor Subcontracting Team and the Construction Quality

3.1. Initial Evaluation System Construction of Control Degree and Construction Quality
Since the control degree is a multi-dimensional quantitative index of comprehensive evaluation, the selection of control degree evaluation index in this paper should follow the principles of objectivity, representativeness, comprehensiveness and maneuverability. On the basis of combining practical experience, referring to existing literature research and consulting experts, this paper summarizes the initial index of control degree (Table 1) and the initial index of construction quality (Table 2). However, these initial indexes are too subjective to be used directly as a research. In this study, the Delphi method and mathematical statistics are used to screen the initial index of the control degree in Table 1 and Table 2, so as to further narrow the scope of the index in order to select a more real, effective and reasonable evaluation index. The expert information used in the Delphi method has been listed in Table 3.
Table 1 Initial evaluation index of control degree.

| No. | Index                                                                 |
|-----|-----------------------------------------------------------------------|
| 1   | Number of times of labor personnel late arrivals for meetings         |
| 2   | Number of rectification notices                                       |
| 3   | Number of safety penalties                                            |
| 4   | Number of safety and quality accidents                                |
| 5   | Days of construction delay caused by labor party                      |
| 6   | Number of notified awards                                             |
| 7   | Material cost saving rate                                              |
| 8   | Number of contract breaches by the labor party                        |
| 9   | Number of legal disputes by the labor party                           |
| 10  | Certified employment rate of labor personnel                          |
| 11  | Number of times the labor party has defaulted on the wages of migrant workers in this project. Attendance rate of technical personnel = (attendance number of technical personnel from labor party / number of technical personnel specified in the contract) * 100% |
| 12  | Implementation rate of rectification notice                            |
| 13  | Completion rate of construction data of labor party                   |
| 14  | Qualified rate of labor employment (age, health, etc.)                |
| 15  | Signing rate of labor employment contract                             |
| 16  | Number of complaints from Party A and supervising company             |
| 17  | Coverage rate of safety education                                     |
| 18  | Number of claims initiated by labor party                             |

Table 2 Initial evaluation index of construction quality.

| No. | Index                                                                 |
|-----|-----------------------------------------------------------------------|
| 1   | Number of penalties for quality issues                               |
| 2   | Number of repair and rework for quality issues                       |
| 3   | Qualified rate of primary acceptance for inspection batch            |
| 4   | Number of quality awards                                             |
| 5   | Number of penalties for civilized construction                       |
| 6   | Certified rate of primary acceptance for materials                   |
| 7   | Certified employment rate of labor managers and special types of work |
| 8   | Qualified rate of primary inspection of construction machinery and equipment |
| 9   | Qualified rate of technical disclosure materials                     |
| 10  | Primary audit pass rate of construction organization design and construction scheme |
| 11  | Correct rate of engineering survey setting-out                       |
| 12  | Primary qualified rate of test block, specimen and construction test |
| 13  | Qualified rate of primary repair and rework for quality issues       |
| 14  | Implementation rate of construction proposal and technical disclosure |
| 15  | Number of times for illegal construction                             |
| 16  | Fulfillment rate of quality objective                                |
| 17  | Completion rate of quality record data                               |
| 18  | Completion rate of construction data of labor party                   |
| 19  | Qualified rate of position and size of main structure                |
| 20  | Qualified rate of primary acceptance of concealed engineering        |

Table 3 Basic information of consulting experts.

| Category | Junior Professional Title | Medium-grade Professional Title | Senior Professional Title | Engaged in the construction industry for more than 5 years |
|----------|---------------------------|---------------------------------|---------------------------|----------------------------------------------------------|
| Proportion| 25%                       | 37.5%                           | 37.5%                     | 85%                                                      |

3.2. Data Investigation and Analysis of Evaluation System for Control Degree and Construction Quality

3.2.1. Brief introduction to statistical analysis software of SPSS.
SPSS is short for Statistical Product and Service Solutions, which is the solution of statistical products and services. The software was released in its first version in 1984, after 24 versions of continuous development and improvement, it has been powerful statistical analysis software and widely used in natural science, technical science and social sciences fields. The software has many powerful functions, such as editing, statistical analysis, mapping, programming, etc. Its native functions include more than 100 functions in 11 categories. SPSS software possesses a variety of functions from statistical description to multi-factor statistical analysis.[3]

3.2.2. Analysis of investigation data.
This study adopts the way of issuing questionnaire to experts and professionals, and uses 5-point Likert scale method to evaluate each initial evaluation index of control degree and construction quality, namely, experts and professionals will score and evaluate the importance of the initial index one by one. 5 points, 4 points, 3 points, 2 points and 1 point respectively corresponding to the five evaluation criteria of very important, important, generally important, less important and unimportant. The experts in Table 2 were investigated through questionnaires, of which 50 questionnaires were issued, 44 questionnaires were recovered and 40 valid questionnaires were collected. Next, SPSS software is used to analyze the valid data and calculate the average value, standard deviation, discrete coefficient and confidence interval of each index score.

3.3. Screening and Determination of Control Degree and Construction Quality Evaluation Index.
Through consulting with mathematical statistics experts, the selection standard of the index is obtained, i.e. when the required average value is more than 3.5, indicating that the index is of strong importance; when the discrete coefficient is less than 0.25, indicating that the expert opinion of the index is concentrated; when the lower limit of the confidence interval is more than 3.3, indicating that the data of the index is compact. Table 1 is screened with this standard, among which the average value, discrete coefficient and lower limit of confidence interval of the number of notified rewards for the 6th index are not satisfied, so the index is excluded. The 9th, 17th, 18th and 20th indexes in the discrete coefficient standard are not up to standard, so these indexes are eliminated. As a result, a new evaluation index system of the control degree of labor subcontracting team by the construction project department is obtained.

Then screen the data on Table 2 with this standard, in which the average values of the 4th index and the 10th index are less than 3.5, so these two indexes are eliminated; the discrete coefficient of the 15th index is more than 0.25, so it is excluded; the lower limit of the confidence interval of the 18th index does not meet the requirements, so it is eliminated. Finally, a new evaluation index system of construction quality is obtained.

4. Calculation on the Weight and Comprehensive Score of Each Evaluation Index for the Control degree of the Construction Project Department to the Labor Subcontracting Team and the Construction Quality

4.1. Sample Data Investigation
This study adopts the combination approach of field research and questionnaire to select 40 construction projects suitable for this study, with a distribution range of not less than 5 provinces, municipalities directly under the central government or autonomous regions, so as to ensure that the data obtained are representative to a certain extent rather than confined to a certain area. As per the distribution and collection of questionnaires, 40 questionnaires were distributed and 35 questionnaires were collected, with a recovery rate of 87.5%. Through the examination of the contents of the 35 collected questionnaires, 31 valid questionnaires were screened out, with an effective rate of 88.5%.
4.2. Calculation on the Weight and Comprehensive Score of Control degree and Construction Quality Evaluation Index

According to the entropy weight method calculation formula in 2.1.2. Section, the weight of the evaluation index of control degree and construction quality is calculated and summarized in table 4 and table 5. According to the standardized data and the weights in table 4 and table 5, the comprehensive score \( S_j \) of each sample of control degree and construction quality was calculated.

**Table 4 Weight \( W_j \) of each index of control degree.**

| Index No. | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| \( W_j \) | 215| 444| 271| 196| 220| 435| 365| 847| 243| 694| 368| 807| 376| 289| 223|

**Table 5 Weight \( W_j \) of each index of construction quality.**

| Index No. | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| \( W_j \) | 43 | 32 | 36 | 27 | 22 | 31 | 29 | 92 | 39 | 61 | 50 | 59 | 38 | 76 | 28 | 28 |

5. Correlation Analysis between Control Degree and Construction Quality

The calculated comprehensive score data of control degree and construction quality are imported into SPSS statistical analysis software for correlation analysis of control degree and construction quality. The results are shown in Table 6.

**Table 6 Correlation Analysis Results between Control Degree and Construction Quality.**

| Correlation | Score of control degree | Score of construction quality |
|-------------|-------------------------|-------------------------------|
| Pearson correlation | 1 | .561** |
| Significance (bilateral) | .001 | |
| \( N \) | 31 | 31 |
| Pearson correlation | .561** | 1 |
| Significance (bilateral) | .001 | |
| \( N \) | 31 | 31 |

**. There was a significant correlation at the level of .01 (bilateral).

1. As can be seen from Table 6, the correlation coefficient between control degree and construction quality is 0.56, and its upper right corner is marked with *, so there is a correlation between control degree and construction quality. Judging from the summary of practice, the control degree of the construction project department to the labor subcontracting team is related to the construction quality, the two are not independent existence, the relationship between them is even quite close in a certain range.

2. The correlation coefficient between the two is 0.56, more than 0, which indicates that there is a positive correlation between control degree and construction quality. In practice, it is concluded that, in general, with the continuous strengthening of the project department's control over the labor subcontracting team, the construction quality will be significantly improved; that is to say, the control degree will play a positive role in the improvement of construction quality within a certain range. The practical experience has also been confirmed from the analysis of this study.
3. Since there are 2 * in the upper right corner of the correlation coefficient of 0.56, indicating that the control degree is significantly related to the construction quality at the level of 0.01, it has passed the significance test.

4. It is generally believed that the relationship is very close if the correlation coefficient is above 0.7; the relationship is close if the data is between 0.4 and 0.7; the relationship is general in case the data is between 0.2 and 0.4; while the correlation is weak if the correlation coefficient is less than 0.2 but still significant. The correlation coefficient between control degree and construction quality is 0.56, lied between 0.4 and 0.7, which indicates that there is a close relationship between control degree and construction quality. Combined with practical analysis, whether it is positive or negative relationship, the control degree is more closely related to the construction quality than other factors such as natural factors, emergencies, construction technology, etc. Compared with other single factors, the control degree is the comprehensive evaluation index of the labor subcontracting team management by the project department, therefore, it is reasonable that the control degree is closely related to the construction quality.

6. Conclusion
In this paper, SPSS is used to analyze the correlation between control degree and construction quality, which not only enriches the theory of construction project management, but also provides a scientific basis for construction project management. Besides, the project department can manage the labor subcontracting team more scientifically, effectively and accurately according to the requirements of construction quality. From the perspective of the whole project, this can also reduce costs, risks, and the waste of resources, more effectively guarantee the success of the project. From the perspective of the whole project, this can also reduce costs, risks, and the waste of resources, more effectively guarantee the success of the project.

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