

Identification and Analysis of the Main Affecting Factors of Transmission and Transformation Project Cost

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Abstract—Based on the key factors that can influence the investment control of power transmission and transformation project, this study reasonable utilize the factor contribution analysis methods of ranking, grey correlation degree, nonparametric variance test to analyze different main factors that can influence the cost, such as itemized expenses, technical conditions, natural factors.

Index Terms—Transmission and transformation project, cost, factor identification and analysis.

I. INTRODUCTION

Power transmission and transformation project has the features of long construction period, huge investment and complex technology composition. Compared with the specific project, investment of these projects affected by technical conditions, and macroeconomic aspects of natural factors, present certain volatility and regularity.

According to the affecting mechanism of different factors, we can study the combining site of different analysis methods and actual situation, in order to analyze the main influencing factors. Rank all the influencing factors by the influencing degree and provide reliable theoretical basis and analysis method for cost control work, so that we can control investment effectively.

II. COST IMPACT FACTOR ANALYSIS METHOD AND THE CHOICE

According to the nature of the main influence factors and characteristics of data analysis method is as follows:

A. Use the Grey Correlation Degree Method to Identify and Analysis the Technological Factors

Since the amount of power transmission and transformation engineering samples is uncertain, so we need to priority choose the analysis method that is not affected by the amount. Grey correlation method does not need too many data and it is based on the analysis of the correlation coefficient. This method measure the correlation degree between factors according to the development trend of similar or dissimilar degree [1]-[3]. Due to technical indexes and economic indexes does not have the same dimension, gray correlation analysis can remove the influence of the dimension and calculate the relation degree among factors in the gray system

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correlation factor concentration. Considering the grey correlation model is not limited to the sample size, this method is superior to the classical mathematical methods to describe the dynamic process. It is applicable to study the correlation of the main technical conditions for the economic performance of enterprise [4]-[8].

B. Calculate the Contribution Degree to Identify and Analysis the Price Factor [9]-[11]

Static investment cost of power transmission and transformation project is mainly made up of a number of project cost, such as power transformation engineering cost, installation cost, equipment cost and other cost. When calculating the contribution degree of each cost to the static investment change rate, we need to consider the proportion that the cost components itself accounts for static investment and the normal change rate of cost components itself. So, the contribution degree method is used to calculate more effectively and clearly [12], [13] (Fig. 1).

C. Adopt the Method of Nonparametric Test to Identify and Analysis the Natural Environment Factors

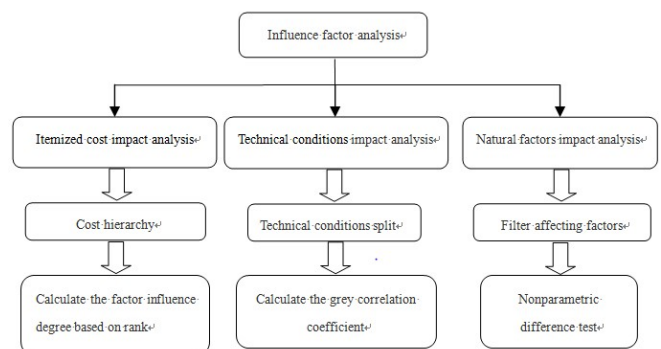


Fig. 1. Roadmap of factor analysis.

III. THE MAIN INFLUENCE FACTOR IDENTIFICATION AND ANALYSIS OF SUBSTATION PROJECT

A. Sample Situation

TABLE I: SAMPLE TABLE OF 110 KV NEW-BUILT SUBSTATION PROJECT

technical project		number of project	Capacity of the scale (MVA)	static investment(ten thousand yuan)	
substation type	High side power distribution device type				
Outdoors	GIS	1/3×50	6	300	14,497.87
		2/3×50	3	300	10,686.15
		2/3×63	1	126	3,237.94
		1/2×63	1	63	2,341.70
Total		11	789	30,763.66	

Taking the 110 kV new-built substation project of × × Company as an example, basic situation of the samples is as follow Table I.

B. Itemized Expenses Analysis Based on the Rank of Factor Contribution

- Cost hierarchy
We can make division of the cost hierarchies according to the substation project item cost containment relationship, and the main components of the static investment cost include project construction cost, equipment purchase cost, installation cost, and other cost. These four subentries should be the emphasis when doing the analysis of their contribution to the cost.
- Factor contribution analysis based on the rank

TABLE II: TABLE OF CONTRIBUTION THE CONSTITUENT ELEMENTS TO STATIC INVESTMENT ANALYSIS OF THE 110 KV NEW SUBSTATION PROJECT

Cost component factors	Cost of the unit capacity		Cost rate of the unit capacity		contribution degree (Z1×Z2)
	Cost (Yuan/kVA)	Z1	Change rate (%)	Z2	
construction cost	91.38	3	-4.204	-1	-3
equipment cost	191.86	4	9.50	2	8
installation cost	54.65	1	10.03	-3	-3
other cost	51.15	2	29.76	-4	-8
static investment	389.91		-3.53		-

The Table II shows that static investment in 2014 decreased by 3.53% compared to 2013. It is other cost that make the most contribution to the decline of the static investment, followed by installation construction cost and project construction cost. Equipment purchase expense rose slightly in 2014, but since the rising proportion is low, the static investment kept fall in 2014.

- Technical condition analysis based on the grey correlation
According to the principle of the main technical condition, there are 6 main factors that influence the project static investment of the 110 kV new-built substation project: substation capacity, master complex building area, site earthwork quantity, high voltage wire count, medium voltage wire count, and low voltage wire count.

TABLE III: GREY CORRELATION COEFFICIENT MATRIX OF 110 KV NEW SUBSTATION PROJECT

influence factors	substation capacity	master complex building area	site earthwork quantity
correlation coefficient	0.848	0.836	0.683
influence factors	high voltage wire count	medium voltage wire count	low voltage wire count
correlation coefficient	0.856	0.687	0.787

The Table III shows that the high voltage wire count has the greatest influence on the project static investment, and the correlation coefficient is 0.856. The rank of main technical conditions according to the influence on the static investment is high voltage wire count, substation capacity, master complex building area, low voltage wire count, medium voltage wire count, and site earthwork quantity.

- Analysis of the natural factors based on nonparametric test
There are 6 kinds of landform in the 11 samples of 110kV new substation project, including depression/concave ground, down land, slope, high ground, mountainous region, ponds/ditches. There are 5 levels of soil bearing capacity: 95,100,110,120,130. According to calculation, the effects of two variables on static investment are both insignificant, and comparatively speaking, topography of the 110 kV new-built substation project has greater influence than the soil bearing capacity.

IV. THE MAIN INFLUENCE FACTOR IDENTIFICATION AND ANALYSIS OF ROUTE PROJECT

A. Sample Situation

Taking the 110 kV route project of × × Company as an example, basic situation of the sample is as Table IV:

TABLE IV: SAMPLE TABLE OF 110 KV ROUTE PROJECT

technical proposal		project amount		single circuit length (km)		static investment(Yuan)	
circuit number	cross-section of conductor (mm ²)	amount	proportion	length	proportion	amount of money	proportion
		single	300	2	9.09	4.77	1.26
	400	2	9.09	8.72	2.30	690.40	2.48
double	300	2	9.09	9.46	2.50	667.00	2.40
	400	6	27.27	163.19	43.11	9,901.81	35.60
single+double	240	1	4.55	25.00	6.60	2,444.24	8.79
	300	7	31.82	133.47	35.26	9,580.02	34.44
	400	2	9.09	33.90	8.96	4,033.19	14.50
Total		22	100	378.51	100	27,815.94	100

B. Itemized Expenses Analysis Based On The Rank Of Factor Contribution

- Cost hierarchy

TABLE V: TABLE OF CONTRIBUTION THE CONSTITUENT ELEMENTS TO STATIC INVESTMENT ANALYSIS OF THE 110 KV ROUTE PROJECT

first level	second level	third level
Ontology cost		
Auxiliary facilities cost		
other cost	The cost of construction site requisition and cleaning	Permanent land occupation
		cost for tower footing
		Green compensate cost
		compensate cost for trees cut down
		Housing demolition compensation cost
		Large factories demolition compensation and other large damages compensation
	The cost of the project early stage work	
	Other special cost	

- Factor contribution analysis based on the rank
The calculation and result of the contribution degree that first level itemized expenses of route project to the change of the cost per capacity length can be seen in the Table VI.
The Table VI shows that every first level cost promotes the rise of cost per capacity length. Among them, the other cost does the greatest contribution. Considering the cost proportion and growth rate, other cost has the greatest influence to the cost per capacity length.

TABLE VI: THE CONTRIBUTION DEGREE OF THE ROUTE PROJECT FIRST LEVEL ITEMIZED EXPENSES TO THE CHANGE OF THE COST PER CAPACITY LENGTH

itemized expenses [⊖]	cost per capacity length [⊖]	
	cost (Yuan/kVA·km) [⊖]	Z1 [⊖]
Ontology cost [⊖]	7.62 [⊖]	3 [⊖]
Auxiliary facilities cost [⊖]	0.038 [⊖]	1 [⊖]
other cost [⊖]	1.88 [⊖]	2 [⊖]
Total [⊖]	9.53 [⊖]	
change rate of cost per capacity length		contribution degree [⊖] (Z1×Z2) [⊖]
change rate (%) [⊖]	Z2 [⊖]	
9.93 [⊖]	1 [⊖]	3 [⊖]
146.76 [⊖]	3 [⊖]	3 [⊖]
37.52 [⊖]	2 [⊖]	4 [⊖]
14.71 [⊖]	- [⊖]	

The calculation and result of contribution degree that the third level cost to per building site cost can be seen in the Table VII. In 2013, 110kV route project does not have large factories demolition compensation and other large damages compensation, so their growth rate is +∞.

TABLE VII: THE CONTRIBUTION DEGREE OF TRANSMISSION LINE PROJECT THIRD LEVEL ITEMIZED EXPENSES ON PER BUILDING SITE COST

itemized expenses [⊖]	cost per kilometer [⊖]	
	cost (ten thousand Yuan/km) [⊖]	Z1 [⊖]
land occupation of tower footing	4.69 [⊖]	4 [⊖]
Green compensate cost	4.69 [⊖]	5 [⊖]
timber cutting [⊖]	2.26 [⊖]	3 [⊖]
housing demolition [⊖]	0.34 [⊖]	1 [⊖]
Factories demolition [⊖]	0.56 [⊖]	2 [⊖]
Building the field [⊖]	13.37 [⊖]	
change rate of per kilometers cost [⊖]		contribution rate [⊖] (Z1×Z2) [⊖]
change rate (%) [⊖]	Z2 [⊖]	
8.77 [⊖]	1 [⊖]	4 [⊖]
59.69 [⊖]	3 [⊖]	15 [⊖]
316.75 [⊖]	4 [⊖]	12 [⊖]
-30.11 [⊖]	-2 [⊖]	-2 [⊖]
+∞ [⊖]	5 [⊖]	10 [⊖]
53.18 [⊖]	- [⊖]	

The table above shows that green compensate cost of transmission line project has the greatest contribution to per building site cost. This means that walk path choice and local policy of the transmission line project have great influence on per building site cost.

- Technical condition analysis based on the grey correlation
According to the principle of the main technical condition, the project static investment of the route project can be divided into 6 main influence factors: route length, wire

amount, tower material amount, concrete foundation amount, earthwork volume, and fundamental steel.

TABLE VIII: GREY CORRELATION COEFFICIENT MATRIX OF 110 KV TRANSMISSION LINE PROJECT

influence factors [⊖]	route length [⊖]	wire amount [⊖]	tower material amount [⊖]
correlation coefficient [⊖]	0.855 [⊖]	0.856 [⊖]	0.845 [⊖]
influence factors [⊖]	concrete foundation amount [⊖]	earthwork volume [⊖]	fundamental steel [⊖]
correlation coefficient [⊖]	0.868 [⊖]	0.847 [⊖]	0.843 [⊖]

The Table VIII above shows that concrete foundation amount does the greatest influence on cost of the 110kV transmission line project and the correlation coefficient is 0.868. The rank of main technical conditions according to the influence on the static investment is concrete foundation amount, wire amount, route length, earthwork volume, tower material amount, and fundamental steel.

- Analysis of the natural factors based on nonparametric test
There are 4 natural factors in the samples of 110kV transmission line project, including radial thickness of ice, design wind speed, the distribution of topography (Terrain accounted for more than 50% as the main terrain), and geological conditions.

TABLE IX: DIFFERENCES TEST ANALYSIS TABLE OF THE ROUTE PROJECT COST PER CAPACITY LENGTH

influence factors [⊖]	The mean rank [⊖]			
	thin ice zone [⊖]		thick ice zone [⊖]	
radial thickness of ice [⊖]	10.50 [⊖]		21.00 [⊖]	
design wind speed [⊖]	≤23.5 [⊖]	≤27 [⊖]	≤29 [⊖]	≥33 [⊖]
distribution of topography [⊖]	flat [⊖]	hill [⊖]	river swamp [⊖]	mountainous region [⊖]
geological conditions [⊖]	ordinary soil [⊖]	pan soil [⊖]	loose sand [⊖]	Shifting sand-pit [⊖]
	10.50 [⊖]	6.00 [⊖]	7.86 [⊖]	11.75 [⊖]

test value [⊖]	rank [⊖]
Mann-Whitney-U [⊖]	2 [⊖]
0.095 [⊖]	
Kruskal-Wallis [⊖]	3 [⊖]
0.237 [⊖]	
Kruskal-Wallis [⊖]	1 [⊖]
0.039 [⊖]	
Kruskal-Wallis [⊖]	4 [⊖]
0.341 [⊖]	

The Table IX shows that the rank of main technical conditions according to the influence on the static investment is distribution of topography, radial thickness of ice, design wind speed, and geological conditions.

V. CONCLUSION

According to the different characteristics of the factors that influence the power transmission and transmission line project cost, this paper studies the different factors in classification. For cost, technology, natural these three types of influencing factors, we choose different methods to do the analyses, in order to improve the scientific nature and reliability of the conclusion. With the conclusion we can provide scientific basis of reasonable control for the power engineering construction units and engineering. We can also focus on control of the elements in the process of cost management, in order to make cost under reliable control.

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