Forecasting Tendency of the Transmission Line Project Cost Index Using Markov Chain

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Abstract: The transmission line project cost index, which reflects price changes of transmission line project components affecting project cost, is an integrated indicator. Based on the constitution of the transmission line project cost index, 324 transmission line project cost index during 2002 and 2010 were selected, in order to describe variation tendency of the transmission line project cost index in recent years. The results of Markov chains as a proper model were created for forecasting the transmission line project cost index. The primary contribution of this research is the creation of Markov chain forecasting model that reflects the variation of transmission line project cost index more objective and quickly. It is shown that the method applied to the overall cost evaluation and analysis of factors which influence cost in the estimating stage. It is expected that this work will contribute to the dynamic management of the transmission line project cost index.

Keywords: Markov chain, the transmission line project cost index, trend prediction.

1. INTRODUCTION

With the rapid growth of investment in power construction, the original market balance of supply and demand was broken by a substantial increase in demand for power equipment and material. In addition, all kinds of higher material prices in international and domestic market [1] caused the current price of land, equipment and material of electricity infrastructure investment to rise. Thus, investment control of power construction projects has a greater challenge. The transmission line project cost index, which is defined as an important parameter of researching and calculating investment planning and engineering economic work of overhead line and cable projects, can truly reflect price change factors in transmission line project investment indicators. The prediction of cost index can help related construction unit to estimate investment at the early phase and provide the basis for the owner investment decisions. The power transmission line structure was simplified by some new patents so as to greatly reduce construction investment cost of a power transmission project [2]. However, it is limited to rely on technical progress, technological level and management efficiency to offset cost growth of construction land, equipment and material purely. Therefore it is necessary to establish a quantitative model to forecast the trend of transmission line project cost index which adapts to the dynamic management of the project cost [3].

Because of the transmission line project cost index system's complexity and diversity, it is more difficult to determine the comprehensive cost index trend [4], particularly, to predict the short-term one by analysis of the main factors of price index. Quantitative methods and computer system [5] have been proposed to forecast transmission line project cost index. A computer implemented method and model to perform project cost prediction associated with various factors such as project schedules and volatility in the design requirements [6]. These methods can be classified into two major categories: time series model and fuzzy analogy method. Time series forecasting method includes moving average method, exponential smoothing method and BP neural network model [7], these methods apply to predict object presenting a trend of rising or falling over time, but not applying to fluctuate within a certain range. Fuzzy analogy method uses basic principles of fuzzy reasoning and fuzzy relationship to build a quantitative comparison of the proposed projects and existent projects of similar structural system. It is adequate for the prediction of similar projects which needs a lot of engineering feature data.

Probability has been used to accurately evaluate a schedule for attaining a project uncertain about success and failure [8]. Markov forecasting method applies the principles of Markov chain and transition probability matrix to predict trend of random events, which is applicable to the predicted object remaining basically unchanged. The research objective of this paper is to create Markov forecasting models for predicting ransmission line project comprehensive cost index based on a group of transmission line project cost indexes from 2002 to 2010, including labor, wire, tower and other materials cost index. The predictability of the Markov forecasting models is assessed before conclusions are presented.

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2. MARKOV CHAIN MODEL

2.1. Model Description

Markov analysis method is mainly used for analyzing the future development trend of random events [9]. Moreover, it uses the current state and trend of a variable to predict its future state and changes in a particular period for taking appropriate countermeasures. Markov analysis is carried out using Markov chain [10].

A Markov chain is a random process, that is to say, what happens next depending rarely on the current state of the system. Usually, a Markov chain is reserved for a process with discrete time and states.

2.2. Properties of Markov Chain

1. Markov property

When the process state in t_m is known, the probability characteristics after tm depends only in the state in t_m, but not in states before t_m.

2. Stationary distribution [11]

We assume that Markov chain probability distribution is{η(i), i∈I}, where I is the state space of the chain. Matrix P = (P_{ij}) is the transition matrix, where i∈I, j∈I and I is the state space. Thus, probability distribution and transfer matrix must be satisfied the formula: $\eta(i)=\sum_{j=1}^{\infty}\eta(j)P_{ij}$, and this property of Markov chain is called a stationary distribution.

3. Ergodicity

Ergodicity is defined as the state that tends in probability to a limiting form that is independent of the initial conditions. The mathematical formula is $\lim_{n\to\infty} p_{ij}=\eta(j)$. In other words, a state j is ergodic if it starts from any state and the probability of the state j is close to a fixed constant with enough transitions.

Thus, we get a conclusion: with a stochastic process{X(t), t∈T} of Markov property, the transition probability is the unique solution of the equations where η (j) ≥0.

4. State to connectivity

No matter which state the system starts from, it must achieve the same state within certain finite transitions.

2.3. Adaptability Analysis of Markov Chain Model to Transmission Line Project Cost Index Forecasting

The change of the transmission line project cost index is subject to the impact of the previous period, while the Markov chain model can describe the variation of each period and point out the various results and its probability of cost index changes. Not only does it avoid inaccurate prediction caused by stability ineffectiveness of labor and equipment cost change, but takes advantage of the mathematical model to estimate the probability distribution. Therefore, the model is one of the effective ways to solve the problem under market environment of asymmetric information between the owner and contractors.

Before using Markov chain model, the Markov chain must be examined as following steps [12]:

i) Dividing state and determining the corresponding state probability

We assume that the probability of state $E_1E_2\ldots E_n$ in t_k is $P_1P_2\ldots P_n$ in the Markov chain, where $0\leq P_i\leq 1$, and the vector $P_1P_2\ldots P_n$ is called the state probability vector in t_k.

ii) Establishment of transition probability matrix

The system may appear N status, namely $E_1E_2\ldots E_n$, and the probability of the system transferring from E_i in t_k to E_j in t_{k+1} is called the transition probability from i to j, denoted as $P_{ij}=P(E_i\rightarrow E_j)$.

Under certain conditions, the system may have transition in possible state $E_1E_2\ldots E_n$, and the possibility of transitions between all system states is represented by matrix P, which is defined as the state transition probability matrix:

$$p=\begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{n1} & p_{n2} & \cdots & p_{nn} \end{pmatrix}$$

iii) Using the transition matrix for an initial cost index forecasting and decision analysis.

If the probability vector of the initial state is P (0), through k steps, the process being in state j can be solved by the following formula: $P(k) = P(0) \bullet P^{(k)}$.

Where,

P (k): the probability of the process in state j after k steps;

P (0): the initial state probability vector;

$P^{(k)}$: k steps transition probability matrix.

3. APPLICATION OF MARKOV CHAIN MODEL IN THE TRANSMISSION LINE PROJECT COST INDEX FORECASTING

3.1. The Transmission Line Project Cost Index

The transmission line project cost index includes single price index and comprehensive cost index.

Single price index reflects the change extent of the base labor, material, plant and equipment cost during report period, such as labor price index, material price index and so on [13]. Comprehensive cost index is a comprehensive reflection of labor, material, plant and equipment cost change in the whole transmission line project or parts of the project. It intends to study the overall cost trend and change extent, including the construction cost index, the installation cost index, the equipment cost index and other expense index.

Single price index may reflect cost changes of certain kind of projects [14]. However separate consideration is required when there is a different voltage level or a different construction scale. For instance, the new 220 kV transmission line project cost was a decline over the previous year,

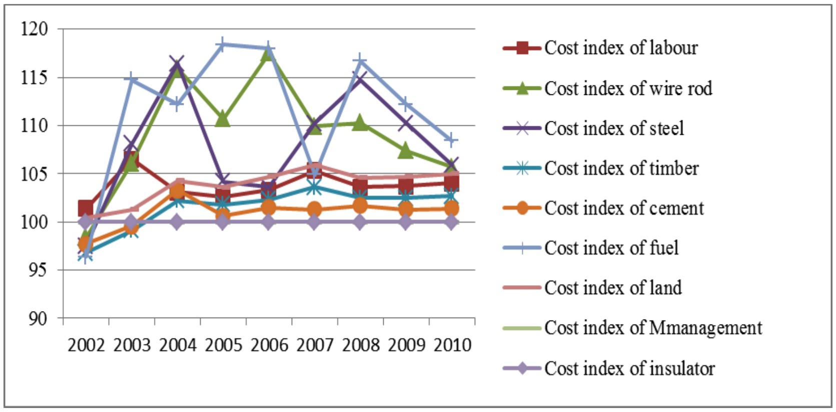

Fig. (1). 2002-2010 transmission line project cost index trend.

while the new 110kV project cost increased in the same area, but the new transmission line project cost of different voltage level cannot be taken into account by using single price index. But by calculating comprehensive cost index, the horizontal contrast of transmission line project cost level in different years can be achieved; what's more, the problem of the poor comparability of transmission line project cost index differing from construction condition and scale can be solved.

The total investment of transmission line project mainly consists of four parts, the construction cost, the installation cost, the equipment cost and other expense. When establishing the transmission line project investment cost index model, considering difference in the cost structure and matching requirement of the transmission line project cost structure with the national corresponding price indexes, we first choose typical projects of different regions, different unit capacities and different voltage levels. By estimating and summary analysis., the main elements of four costs were assembled into labour cost, wire (cable) cost, steel cost, timber cost, cement cost, equipment cost (insulator cost for line engineering), fuel cost, land cost and management cost. At last, we measure the weight of nine components and get the transmission line project cost index, whose formula is:

$$I = \sum I_i W_i$$

Where

I: the transmission line project comprehensive cost index;

I_i: the classified cost index;

W_i: the weight, that the proportion of a certain element.

Table **1** summarizes 2002-2010 Transmission Line Project Main Element Cost Indexes, and the sources from which the date can be retrieved in the China Electricity Council. These variables represent the China electric power market and macroeconomic conditions, and may be useful to predict the tendency of Transmission Line Project Main Element Cost Indexes more objective.

According to the China Electricity Council announced 2002-2010 Transmission Line Project main factor price index, we drew out Transmission Line Project Main Element Cost Index Trend Chart and found that each index fluctuates smoothly from 95 to120, matching with the stationary distribution test. It is suitable for Markov chain trend analysis. Details are in the following figure:

3.2. Establishment of Markov Chain Forecasting Model

Based on 2002-2010 Transmission Line Project Main Element Cost Indexes, this article use Markov chain trend forecasting model to predict the transmission line project main element cost index trend. Steps are as follows:

3.2.1. Recording Transition States

In the transmission line project cost index, X (n) indicates the cost index of a certain main element in the nth year, which apparently is a random variable and $\{X(n), n \geq 0\}$ is a random process. This paper assumes that the main element cost index of the transmission line project with the stability ineffectiveness and homogeneity.

The quarterly cost index changes between ± 5% in 2002-2010. To simplify the problem, only three states are considered. The transmission line project cost index changing between ± 1.5% is recorded as state "1 ", the cost index increasing between 1.5 % and 5 % is recorded as state "2" and cost index falling by 1.5% to 5% is state "3". From Table **1**, we can see that management cost index and insulator cost index remain unchanged in the past nine years, so this section does not involved in their quantitative trend analysis. As the wire cost is the main material of the transmission line project [15], the degree of it affecting cost index reaches 20.4%. Thus we take the wire cost index as the example to build the transition probability matrix, and other main elements' cost index is calculated with reference to the example.

Wire cost index of the fourth quarter in 2010 is 105.1, a 1.35% increase over the third quarter, which is recorded as state "1" without a state transition. State"1" appears 23 times, state"2" is 7 times, and state"3" is 4 times. The times of 36 data's transition is 34, as shown in the following table.

3.2.2. Getting the State Transition Probability Matrix by Statistics

From the above table, we get the transition state of the transmission line project wire cost index, as the following table:

Table 1. 2002-2010 transmission line project wire cost index transition state division.

Quarter	2002			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	98.4	97.3	99.2	98.1
Year-on-year rate of change		2.07%	1.06%	2.20%
status		1	2	1
Quarter	**2003**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	102.9	107.8	110.3	112.4
Year-on-year rate of change	-0.37%	-2.07%	0.86%	-2.19%
status	2	2	2	2
Quarter	**2004**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	115.9	114.9	116.2	112.6
Year-on-year rate of change	0.19%	1.75%	-3.24%	-0.39%
status	2	1	1	3
Quarter	**2005**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	111.7	115.4	116.7	117.3
Year-on-year rate of change	1.48%	0.29%	1.65%	-1.05%
status	1	2	1	1
Quarter	**2006**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	117.5	115.4	116.3	114.9
Year-on-year rate of change	-0.19%	0.39%	0.58%	0.58%
status	1	3	1	1
Quarter	**2007**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	109.9	109.6	110.3	108.9
Year-on-year rate of change	0.38%	-0.47%	-0.86%	-0.48%
status	3	1	1	1
Quarter	**2008**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	110.3	109.6	108.4	107.3
Year-on-year rate of change	0.19%	0.10%	1.83%	-0.85%
status	1	1	1	1

Table 1. contd…

Quarter	2009			
	The First Quarter	The Second Quarter	The Third Quarter	The Fourth Quarter
Cost index of wire rod	107.4	107.4	106.9	106.7
Year-on-year rate of change	-0.96%	-1.06%	1.66%	0.00%
status	1	1	1	1
Quarter	**2010**			
	The First Quarter	**The Second Quarter**	**The Third Quarter**	**The Fourth Quarter**
Cost index of wire rod	105.7	106.9	103.7	105.1
Year-on-year rate of change	-0.29%	0.58%	0.00%	-1.43%
status	1	1	3	1

Table 2. 2002-2010 transmission line project wire cost index transition states.

1→1	12 Times	1→2	6 Times	1→3	2 Times	total	20 Times
2→1	6 times	2→2	1 times	2→3	2 times	total	9 times
1→3	2 times	2→3	2 times	3→3	1 times	total	5 times

Table 3. Transmission line project cost index predicting results.

Index Categories		$P^{(1)}$		
The index of major elements	Cost index of labour	0.720	0.200	0.080
	Cost index of wire rod	0.696	0.130	0.174
	Cost index of steel	0.737	0.158	0.105
	Cost index of timber	0.400	0.333	0.267
	Cost index of cement	0.600	0.300	0.100
	Cost index of fuel	0.438	0.250	0.312
	Cost index of land	0.308	0.231	0.461
Composite index		0.969	0.031	0.000
Index Categories		$P^{(2)}$		
The index of major elements	Cost index of labour	0.765	0.144	0.091
	Cost index of wire rod	0.714	0.165	0.121
	Cost index of steel	0.632	0.232	0.136
	Cost index of timber	0.442	0.330	0.228
	Cost index of cement	0.600	0.253	0.147
	Cost index of fuel	0.483	0.255	0.262
	Cost index of land	0.405	0.369	0.226
Composite index		0.954	0.046	0.000

Table 3. contd…

Index Categories		$P^{(n)}$		
The index of major elements	Cost index of labour	0.774	0.132	0.094
	Cost index of wire rod	0.812	0.169	0.019
	Cost index of steel	0.484	0.374	0.142
	Cost index of timber	0.473	0.312	0.215
	Cost index of cement	0.600	0.219	0.181
	Cost index of fuel	0.503	0.261	0.236
	Cost index of land	0.605	0.381	0.014
Composite index		0.823	0.177	0.000

Furthermore, the transition probability matrix can be worked out:

$$p=\begin{pmatrix}\frac{12}{20} & \frac{6}{20} & \frac{2}{20}\\ \frac{6}{9} & \frac{1}{9} & \frac{2}{9}\\ \frac{2}{5} & \frac{2}{5} & \frac{1}{5}\end{pmatrix}$$

3.2.3. Predicting Index State Probability Vector

According to Markov chain process, the state vector can be represented as S (k) in different periods, then S (k) =S (0) $\cdot P^k$. Taking the fourth quarter of 2010 as the base, we predict the future two quarters' transmission line project wire cost index. The initial state vector is:

S(0)= (1 , 0 , 0)

The transmission line project wire cost index after k quarters can be predicted by using Markov chain, according to the formula S (k) =S (0) P^k, then

$$S^{(1)}=\begin{pmatrix}1 & 0 & 0\end{pmatrix}\begin{pmatrix}\frac{12}{20} & \frac{6}{20} & \frac{2}{20}\\ \frac{6}{9} & \frac{1}{9} & \frac{2}{9}\\ \frac{2}{5} & \frac{2}{5} & \frac{1}{5}\end{pmatrix}=\begin{pmatrix}\frac{2}{5} & \frac{3}{10} & \frac{1}{10}\end{pmatrix}$$

$$S^{(2)}=S^{(1)}\cdot P=\begin{pmatrix}\frac{2}{5} & \frac{3}{10} & \frac{1}{10}\end{pmatrix}\begin{pmatrix}\frac{12}{20} & \frac{6}{20} & \frac{2}{20}\\ \frac{6}{9} & \frac{1}{9} & \frac{2}{9}\\ \frac{2}{5} & \frac{2}{5} & \frac{1}{5}\end{pmatrix}=(0.6 \quad 0.253 \quad 0.147)$$

$S^{(3)}S^{(4)}\ldots S^{(n)}$ all can be obtained, and $S^{(n)}=S^{(0)}\cdot P^n=(0.812 \quad 0.169 \quad 0.019)$, n→∞

It is visible that in the short term, there is 81.2% probability of the wire cost index fluctuating within the range of ± 1.5%, 16.9% probability increasing by 1.5% to 5% and 12.1% probability decreasing by 1.5% to 5%.

3.2.4. Solving the Model Based on Steady-State Conditions

Based on Markov chain system's steady condition,

$$\begin{cases}\eta=\eta P_1, \eta=(x_1 \quad x_2 \quad x_3)\\ \sum x_i=1\end{cases}$$

So,

$$\begin{cases}(x_1 \quad x_2 \quad x_3)=(x_1 \quad x_2 \quad x_3)\begin{pmatrix}\frac{12}{20} & \frac{6}{20} & \frac{2}{20}\\ \frac{6}{9} & \frac{1}{9} & \frac{2}{9}\\ \frac{2}{5} & \frac{2}{5} & \frac{1}{5}\end{pmatrix}\\ \sum x_i=1\end{cases}$$

We get, x_1=0.812 , x_2=0.169 , x_3=0.019

Accordance with the above method, all the main element cost index of the transmission line project in the first quarter of 2011 can be predicted, and the change possibility of cost index is as shown below.

3.3. Analysis of Forecasting Results

As can be seen from the results predicted, there is 50% to 80% possibility of the main element cost index ranging between ± 1.5%, and 20% to 40 % chance of an increase of 1.5 % to 5%. The possibility of the other main element cost indexes is below 20% except timber and fuel cost index. Corresponding quarter capital plans can be made based on the probability of the main element cost index changes [16] to ensure adequate funding of main elements and the entire project. A reasonable procurement plan in accordance with changes in the main element cost index is accessible. That is to say, taking priority to purchase material which will be increasing to reserve procurement space and to avoid the procurement risk.When calculating the reserve fund for risk in price at the feasibility study stage, we can invest some

Table 4. Error analysis of predictions.

Index Categories	Cost Index of Labour	Cost Index of Wire Rod	Cost Index of Steel	Cost Index of Wood
Year-on-year rate of change	1.52%	0.08%	3.14%	0.07%
Index Categories	**Cost Index of Cement**	**Cost index of Oil**	**Cost Index of Land**	**Comprehensive Cost Index**
Year-on-year rate of change	0.24%	-0.06%	2.31%	0.15%

fund which is original for timber and fuel reserve in the unforeseen cost [17], for example, to control the risk of rising steel and land cost. And thus the total cost is controlled within a reasonable range to prevent the budget estimate from exceeding the estimate. Cement cost index and land cost index respectively have a 21.9% and 38.10% likelihood of rising up, and both are closely related to the national policy and the social environment. With the marginal improvement of supply and demand and deep haze governance, intelligence and low-carbon becomes the subject of green building materials market. In the future, control of air pollution in some regions and cement industry's close down, limited production and reducing emission will further increase raw material prices of high-polluting industries. In China the transmission line project got land by means of land acquisition, and land acquisition cost is charged in accordance with the relevant policies and standards. The land acquisition fees are mainly for pole and tower foundation area of overhead lines, the land of corridor and underground cable tunnels area. Due to the shortage of the transmission line corridor resources and the greater pressure on the environment caused by transmission lines, the land use approval of electric power industry is increasingly difficult, along with increasing related land acquisition and compensation cost. Typically the cost of transmission line corridors could reach 5% to 10 % of total cost [18] and is showed an increasing trend, where land acquisition cost and relocation compensation cost are the main drivers. Reasonably predicting rising or falling space of land prices index is beneficial to setting guide price for power transmission line corridor costs for next year, so as to produce the budgetary estimate more accurate.

This prediction provides the opportunity to ensure that the predictions and practical results match well. Cost index for the first quarter of 2011 compared with the rate of change in the cost index for the fourth quarter of 2010 as follows:

The above table shows the cost indexes of steel and land index rise 3.14% and 2.31% respectively, which appears as slight deviation from the fact. Forecasts show steel and land price index are 48.4% and 60.5% possibilities of the variation in the range of between ± 1.5%, while 37.4% and 38.1% possibilities rising between 1.5% to 5%, other price indices are in the range between ± 1.5%. It is reasonable and valid using this method to forecast cost index of transmission Line project.

4. CONCLUSION

Markov chains widely used and publicly available variables from 2002 to 2010 were used as quarterly transmission line project main element cost indexes. Based on the results of Markov prediction model, this article classified cost index into different states and then established the cost index forecasting model of the stability ineffectiveness property. In a recent forecast, the change rate of the main elements' price is in relatively stable circumstances. The results of the forecasting model reflect that the trends of the main element cost are accordance with the electricity market economic conditions. Thus it is an effective way to apply Markov method to forecasting main element cost index trend of the transmission line project, which would avoid passivity and time-lag effects of the cost index compiling and timely grasp information of the economic changes in the market. Although the cost indexes of transmission line project has been extensively used by cost estimators, investment planners, and institutions, it does not represent all factors of transmission line project. Furthermore, the same approach can be used to test whether other macroeconomic and electric power market factors are among the explanatory indicators of transmission line project cost indexes. It is expected that this work will contribute to the management and decision-making in transmission line project preliminary estimate stage.

5. CURRENT AND FUTURE DEVELOPMENTS

Markov chain is one of the key technologies for forecast the transmission line project cost index. And the current forecasting methods mainly include three parts: The approximate deduction method, the statistical inductive method and the time series method. There are mainly two challenges for forecasting tendency of the transmission line project cost index using Markov Chain. One is the small sample that the state division standard and the prediction horizon are not unified due to the limited historical records. The other is subjectivity which has to be reduced for establishing the state transition matrix. In the future, the transmission line project cost index estimation has to be investigated according to the characteristics of transmission line project and it can also be combined with other technologies like fuzzy mathematics and artificial intelligence. It is indicated that the predictions will be more accurate based on the precision of the transfer-probability matrix.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES

[1] W. Shen, and S. Dong, "index system and calculation model on engineering cost", *Tech. Econom.*, vol 27, no. 10, pp. 62-68, 2008.

[2] Z. Song, "*Power transmission line structure of wind farm*," Chinese Patent 20,110,114,173.2, November 2012.

[3] Y. Sachiko, and C. Takahiro," *Device for calculati-ng cost Index*," Japanese Patent 3,695,152, August 2005.

[4] S.M. Shahandashti, and B. Ashuri, "Forecasting engineering news-record construction cost index using multivariate time series models", *J. Constr. Eng. M.*, vol.139, pp.1237-1243, 2013.

[5] Vyas and Bhavin J, "*Method for estimating the cost of a future project*," U.S. Patent 2007/0100775, March 2003.

[6] M.J. Campo, N.A. Mackertich, R.J. Floyd, R.E. Beitz, and P.D. Kraus, "*Method and apparatus for predicting project cost performance*," U.S. Patent 12/502,706, May 2012.

[7] J. Sun, B. Liao, and H. Li, "AdaBoost and bagging ensemble approaches with neural network as base learner for financial distress prediction of chinese construction and real estate companies", *Recent Patents Comp. Sci.*, vol. 6, no. 1, pp. 47-59, April 2013.

[8] K. Yasuhiro, K. Osamu and I. Junko, "Project Evaluation Device, Project Evaluation Method, and Storage Method," Japanese Patent 20,060,325,165 20,061,201, June 2008.

[9] M. Li, X. Ren, and L. Tong, "Application of Markov Chain in prediction of environmental quility". *Environ. Eng.*, vol. 25, no. 6, pp.78-80, 2007.

[10] S. Qin, "Markov prediction model and its applicaton based on the weighed sliding average", *J. Water Resour. Water Eng.*, vol. 24, no. 1, pp. 186-188, 2013.

[11] Zenghui Chen, "Application of markov chain in prediction of shanghai composite index", *Finan. Econ.*, vol. 14, pp. 58-59, 2008.

[12] D. Wang, Y. Lei, Y. Huang, and Q. Li, "Prediction of comprehensive cost index based on Markcov Chain", *Power Syst. Technol.*, vol. 35, no. 2, pp. 193-197, 2011.

[13] J. Li, B. Zhao, X. Shi, and Y. Zheng," Analysis methods of composite cost index for transmission projects", *Energ. Technol. Econ.*, vol. 22, no. 11, pp. 36-39, 2010.

[14] C. Cai, "Construction project cost index and application", *Coal Technol.*, vol. 31, no. 7, pp. 107-109, 2012.

[15] H.E. Deve, D.E. Johnson, "*Overhead electrical power transmission line,*" U.S. Patent 11/617,461, June 2009.

[16] L. Wei, L. Shujuan, and Q. Caihong, "Compilation of annual funds plan for power construction investment projects", *J. Shenyang Inst. Eng. (Nat. Sci.)*, vol. 8, no. 2, pp. 187-189, 2012.

[17] E. Ervin, "How to protect profit as material prices rise". [Online]. Available: http://www.bizjournals.com/seattle/stories/20-07/06/11/f-ocus10.html?page=all

[18] P. Zhang, and Y. Li, "Analysis of the main factors t-hat affects cost of power line corridors", *Electric. Power Stand. Construct. Cost Cont. Infor.*, vol. 6, pp. 4-8, 2009.

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