Chapter 121
Universities Capital Construction Project Cost Estimation Method for Practical Research in Decision-Making Stage

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Abstract At present ordinary universities in China at decision-making stage of infrastructure projects have no fixed practical calculation methods for project cost estimation. In this article, various project cost estimation methods are used for theoretical analysis and research, for instance, the combination of the estimate index method and the similar engineering budget method, to practically calculate the project investment cost estimated value of Guangdong ordinary universities' planning student dormitories.

Keywords University • Infrastructure projects • Project decision-making • Investment estimation

The construction engineering cost at project decision-making stage is the determination of reasonable investment estimation. Some traditional commonly used investment estimation methods are: the production capacity index method, the estimate index method, the similar project budget method [1]. Recently, there are some new methods of study: the gray system theory model method [2–5], the fuzzy mathematical evaluation model method [6, 7], combination of grey system theory and fuzzy mathematics [8, 9], combination of case reasoning and fuzzy mathematics [10], the linear regression method [11], the neural network to [12, 13], etc.

The grey system theory applies to analyze those small or incomplete information. It's research objects are systems with small sample, poor information and uncertainty. It is worked mainly through known information generation, development, extraction of valuable information to get correct understanding and exact

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description of the operating pattern of system, and get scientific prediction based on them. The most common model is GM (1, 1) model.

Using the theory of fuzzy mathematics, six characteristic elements (labor, materials, machinery, comprehensive fee, spreads and indirect cost) corresponding to the main characteristics of the vector (area and cost) to build an engineering project are chosen. According to the expert evaluation method, a few membership functions tables of existing buildings and proposed buildings are built, the close degree between the proposed construction project and the built construction project is calculated, and then the nearly choice principle is used to find the closest built project. After that, exponential smoothing method is applied to establish the evaluation model, and estimate the engineering project cost.

Case reasoning and fuzzy mathematics combination method uses a basic thought about separation of quantity and price to calculate main material consumption of the target house. Nine characteristic factors involved include: building area, worth area, width, eaves high, roofs, depth, foundation bearing capacity, seismic intensity, wall thick. Through calculation of similar house close degree, some most similar cases are found, and then the average value of these cases is used as the estimation value of the target house.

Linear regression method is a method that chooses several typical engineering to have multiple regression analysis, use factors such as building acreage and height as independent variables and cost as dependent variable, to calculate project cost estimation.

When using the factor analysis and RBF neural network combination constructing model to do the calculation, we select indexes like construction and installation price index, structure, basic types, building acreage, underground layer number, to the upper number and building height, then determine most of them as training and the remaining as verifying in dozens of sample. In case training, through the factor analysis we find three principal components, and then have a RBF network design and simulation, at last, use Matlab environment to set up network.

At present, infrastructure investment estimation of China's province-owned universities has no fixed practical calculation method, most of which are based on past experiences and estimated costs of recent similar projects cost. Since there has no scientific consideration of factors such as price difference correction, adjustment and rising construction period prices, the error of estimation is large and the estimation is often lower than the actual settlement accounts. New method which is researching recently has smaller error, but it takes a large amount of engineering practice and design scheme data, and has more mathematics theory calculation. Due to this, there is no clear design scheme in project engineering decision stage, and enough engineering design data cannot be generally gotten, so the practical application has some limitations.

According to China's province-owned universities characteristics, we try to use a practical estimation method of combination of budget index method and similar engineering budget method to calculate the estimated cost of conventional engineering.

121.1 The Structure of the Construction Project Cost

121.1.1 Construction Engineering Cost Structure and Characteristics

Construction engineering cost is usually referred as a project construction cost (expected or actual) expense. It is formed by the construction and installation costs, equipment, work, appliances purchase expenses and other expenses.

The characteristics of the engineering cost valuation are single valuation, multiple valuations and branches combination valuation.

121.1.1.1 Single Valuation

Because of the oneness of architectural design, construction engineering generally cannot be priced singly by the state or company. It can only be priced by special programs (preparing estimation, estimation, budget, contractual price, settlement price and final determination settled cost etc.).

In compiling project proposal and feasibility study stage (engineering decision stage), generally we can estimate cost according to ruled investment estimate index, similar project cost material and current equipment material price, combining them with engineering practice.

121.1.1.2 Multiple Valuation

Construction project shall be priced severally from rough to subtle according to different project construction stages:

1. Put forward project proposal, feasibility study stage → investment estimation;
2. The preliminary design stage → design the total budget;
3. Technology design stage → amend total budget;
4. The construction drawing design stage → construction drawing budget;
5. Engineering bidding stage → the contract price;
6. Contract implementation stage → the clearing price;
7. Completion acceptance stage → the final accounts of the completed project.

This paper research the first time of investment estimate valuation.

121.1.1.3 Branches Combination Valuation

It is referred as dividing the project (such as the construction project down into individual engineering, then down into the unit engineering, division engineering), and pricing it according to combination of engineering formed.

Unit engineering construction drawing budget usually uses relevant fixed unit price and cost standard according to division or general component project for its calculation. This method is known as unit appraisal method.

Besides we can also use project budget norm, collecting and computing labor, materials, construction machinery number and amount that unit engineering or single project need, and then multiplied by local price at that time to get direct engineering cost, finally calculating indirect cost and profit tax according to fee standard. This method is called real method.

121.1.2 Project Static Cost

Usually building installation fees, equipment fees, instruments fees, sum of other costs and general reserve fees are treated as static cost. It refers to when making expected cost (sum of estimation, the floorboard of the cost estimates and the budget), calculating instantaneous cost on the basis of the construction element unit price of a benchmark year or month.

Static cost estimate has no fixed formula. In real work, as long as there is a component of the project cost data, we can use all sorts of methods to estimate.

When time of making static cost estimation is far away from the start time, we must use the year before the start year as the benchmark year, and adjust the static cost according to recent price indexes. Otherwise the benchmark role will be lost and the accuracy of the estimated cost will be influenced.

121.1.3 Engineering Dynamic Cost

It refers to the sum of investments that a construction project is expected to require, including static cost, the rising price of risk factors, the need to increase the investment and interest payments which are expected to require.

Estimation of the cost of the dynamic mainly includes the investment amount which may increase according to price change, interest and fixed asset investment direction regulating tax. It should be on the standard of investment funds in static use plan as the basis for calculating amount above all kinds of changes, not with the static cost of years for calculation.

121.2 Construction Engineering Cost Valuation Basis

121.2.1 Fixed Cost

It refers to the consumption of the necessary amount of society which finishing the appointed single construction content in human, material and financial resources that needs for. In China, it has the fairness, authority, and belongs to the voluntary economic indicators. After legal standard procedure, we also can make it has statutory force within the specified range.

121.2.2 Cost Index

It reflects comprehensive general requirements of human, material and financial resources that specific individual engineering requires. It has a greater generality, bounteous degrees and error range, and belongs to the reference of economic indicators, such as budget index, investment estimation index, and index of 10,000 RMB Yuan.

Among them, the investment estimate index is a fixed amount which is used in the project proposal of feasibility study stage for investment estimation, and calculation of project cost. It is very brief, often by independent individual engineering or completed engineering projects for the calculation object, and its feasibility study stage outlined degree matches outlined degree. Its main function is to provide the basis for project decision-making and investment control.

121.2.3 Fees Fixed Amount

It generally uses one (or more) independent variable as computing basis to reflect special charges (should be variable) social necessary work or the percentage of the standard. It is a special form of quota.

121.2.4 Basic Unit Price

It is the sum of unit price of labor, materials, machinery and equipment, work, and tools consumed in construction project.

121.2.5 Construction Engineering Cost Index

It is the index that tells the relative change trend and degree of different period project cost, and is an important tool of dynamic study cost. Generally price index should be made according to main elements respectively, and then we get project cost index by collecting.

121.2.6 The Stability of the Engineering Cost Basis

Bill calculation rules is stable which can keep for years. Work, materials, machine quota consumption have elative stability, and can maintain from 5 to 10 years.

On the other hand, basic unit price, the cost of the project construction, and the construction cost index etc. change fast, they only have stable time of about a year, so always needed to be adjusted.

121.3 Investment Decision Stage Construction Project Cost Estimation Method

121.3.1 Project Post Estimation Method of Traditional

121.3.1.1 Production Capacity Index Method

It is a method to estimate the cost of aiming project amount according to production capacity and investment of completed construction project of similar device, and scale of production capacity of planning construction project device. This law shall not be applied to civil engineering projects of universities.

121.3.1.2 Estimate Index Method

When the preliminary design depth is not enough, and cannot accurately calculate the amount of sectional works, as long as the project technology is more mature, and the project has similar structure estimation index to use, we can use this method.

Budget index refers to consumption standard and cost index of labor, materials, machines of branch engineering or unit engineering which are more comprehensive than budget norm.

121.3.1.3 The Similar Project Budget Method

It refers to using unilateral budget cost of past similar projects to estimate proposed construction project's cost.

When this method is used to estimate project's cost, the difference between the proposed projects structural characteristics and the similar projects structure characteristics should be amended.

The difference of artificial man-days unit price, material price, mechanical budget number unit price, other direct and indirect cost rate between the proposed construction project region and similar project region should be amended using the K difference correction coefficient.

The investment estimate aiming project cost = aiming project construction area × similar engineering cost unilaterally × K.

K is the project and the difference between the coefficient similar engineering. The following is steps and methods for calculating:

1. Calculation similar projects, the settlement of labor, the cost of raw materials, machinery fee and other fees and the indirect cost directly in all project total cost of the proportion of the. With its percentage points respectively said: $Pi\ \%$ $(\mathrm{I} = 1, 2, 3, 4, 5)$.
2. The proposed construction project with similar calculation in project area in artificial cost unit price ①, the cost of unit price ②, machine fee unit price ③, other direct fee rate ④ and indirect cost rate ⑤ the differences between coefficient: $Kj =$ proposed projects area (j) unit price/similar project area unit price (j) $\times\ \%(\mathrm{j} = 1, 2, 3, 4, 5)$.
3. Differences coefficient calculation, $K = P_1\ \% \times K_1 + P_2\ \% \times K_2 + P_3\ \% \times K_3 + P_4\ \% \times K_4 + P_5\ \% \times K_5$.

121.3.2 New Practical Estimation Method: Estimate Index Method, Combined with Similar Engineering Budget Method of

With lack of design project data at infrastructure project decision-making stage, this method aggregates the advantages of estimate index method and similar engineering budget method, considers cost index and dynamic cost, and reduces estimation error. And the calculation is simple and practical. At the same time it avoids problems that other new methods have, such as more practical design data is needed or calculation is complex.

121.3.2.1 Calculation Steps

1. Collect cost information of recent similar and relevant all kinds of constructions.
2. According to own university's engineering structure and current decoration standard, adjust and amend adjustment existing cost estimate index.
3. Through adjustment of labor, materials, mechanical unit price, compile own university's recent (such as year 2010) all kinds of project cost estimation index (unilateral cost).
4. Count and analyze recent years' fluctuations of local labor, materials, mechanical unit price, and predict the next 3-5 years fluctuations trend of labor, materials, mechanical unit price.
5. According to own university's recent all kinds of project cost estimation index and fluctuations trend of estimation of labor, materials, mechanical unit price in next 3-5 years, calculate planning new project's investment estimation (unilaterally investment and total investment).

121.3.2.2 Workout Own University's Project Cost Estimation Index

According to actual situation of China's province-owned universities, we choose certain method to reasonably determine cost estimation index of own university's conventional buildings, and then we can estimate the dynamic cost amount of the proposed new project.

Cost estimation index of building project often use m^2, m^3 or m of completed building or structure as the calculating unit. Because of the fluctuation of the constant price, artificial man-days unit price, materials, and machinery unit price keep rising, cost index subsequently changes. For this reason, estimating index needs to use separation of "consumption" and "unit price" method, according to the main resources consumed standard of different buildings and structure types of unilateral construction area. Then according to local artificial man-days unit price, material price, mechanical budget number unit price and indirect cost fees standard at the time of calculation to calculate the applicable estimate index. Then according to the following formula, estimate the cost of aiming project:

$$\begin{aligned}\text{The estimate cost of aiming project} = {} & \text{the architectural area of the aiming project} \\ & \times \text{corresponding estimate index}\end{aligned}$$

When estimating cost with estimate index method, if there are parts of differences between the structure characteristics of the proposed construction project and estimated indicators, we should first amend estimate index, then use the amend estimate index to estimate cost.

121.3.2.3 Compute Project Cost Index

Construction project cost structure index should be worked out follow certain levels:

1. Firstly should workout input products price index, including all kinds of materials, artificial and mechanical number and price index;
2. Secondly calculate expense index (including artificial cost index, and materials index, machine fee index) base on input products price index;
3. Thirdly further collect cost item index (namely direct cost is index, indirect cost index);
4. Lastly according to above indexes, workout project cost index.

All levels of indexes can be calculated by Sent type comprehensive price index formula and its deformation calculation formula, namely:

$$K_P = \sum P_1 q_1 / \sum P_0 q_1 \ or \ K_P = \sum P_1 q_1 / \left(\sum P_1 q_1 / K_i \right) \qquad (121.1)$$

In the formula,

K_P – price index;
P_1 – data of the price of the period;
q_1 – the amount of during the data;

P_0 – base period price data;
K_i – price subentry coefficient.

Because of the uniqueness of the fabrication engineering, even in the same kinds of engineering, there are differences, according to the social average of consumption and cost measure proportion, the method to solve the problem is weight (set weight type): choose one or several typical examples of engineering (relative stability) with representative characteristics in same kind of fabrication engineering, strictly censor, review and analyze normal consumption level, reasonable construction standards and construction method, and eliminate the abnormal factors as a measure of price index weight basis. Then put information such as price data of basis period which equals to the reporting period and consumption of example engineering into the formula.

Price index of equipment and instrument has many kinds, variety and specifications, so choose those which has large amount, high price, and the dosage changes more to collect purchasing quantity and the unit price for statistics, and then press the following formula for calculation:

$$\text{Equipment and instrument, price index} = \sum(\text{the reporting period in equipment tools, equipment unit price} \times \text{during the purchase quantity}) / \sum(\text{foundation period of the equipment tools, equipment unit price} \times \text{during the purchase quantity})$$

Engineering construction other expenses which have various content and a proportion of relatively modest, don't be prepare for other cost index.

Construction engineering cost index = (the reporting period in construction and installation investment + the reporting period in equipment tools, equipment investment + the reporting period in other expenses investment)/[(the reporting period in construction and installation investment/construction and installation price index) + (the reporting period in equipment tools, equipment investment/equipment and tools price index) + (the reporting period in other expenses investment/other cost price index)]

Project cost index can be predicted with finding provinces' project cost information documents at that time, or calculating the cost difference between similar engineering projects of a year in the past and now.

121.3.2.4 Determine the Dynamic Cost

The increased investment for price change, namely the reserve fee of price difference can be calculated generally by the formula below:

$$V = \sum K_t\left[(1+i)^t - 1\right] \tag{121.2}$$

In the formula,

V – the price of reserve;
K_t – year plan for using the investment amount (by using the capital construction project schedule that);
i – the price change rate (according to project cost index of the accumulation of information analysis);
t – 0,1,2, . . ., n;
n – construction period of years.

121.4 Specific Calculation Example

Now we use an example of an university's student dormitory investment estimation to illuminate an alternative practical cost estimate calculation method in project decision-making stage.

121.4.1 Composition of the Total Investment in the Project Construction

According to current investment estimation range of China's ordinary universities' infrastructure department, we do not have to consider the fixed assets investment direction regulating tax, the construction period of interest, circulating fund:

The first part is fabrication project cost (equipment cost generally applied by other departments);

The second part is other cost of project construction (mostly calculated using the first part as the base), including:

1. Land use fee and transfer compensation (do not have to consider in old school campus construction projects);
2. Construction management fee: specifically include ① construction department management fee (1 %), ② agent management fee of government investment projects (2 %), ③ bidding agent service charge (1 %), ④ supervision fee of project construction (about 2.5 %), ⑤ construction drawing technology application fee (0.5 %);
3. Project prophase consulting fee (0.5 %);
4. Engineering survey design fee (average about 3.5 %);
5. Engineering project evaluation headscarf fee (about 1 %);
6. Engineering insurance fee (0.5 %);
7. Facilities construction fee $(1080 \times 5\ \% = 54\,\text{yuan}/\text{m}^2)$;
8. Basement of air defense stuff construction fee (2 %);
9. Termites prevention and cure fee (3.5 yuan/m^2);

10. High reliability and temporary power supply expenses by electricity charges (240 yuan/KVA, 0.053KVA/m2, $240 \times 0.053 = 13$ yuan/m^2).

The third part is reserve expenses, including basic reserve fee (5 %), price increasing reserve fee (3 %, or calculate and determine as below).

121.4.2 Unilaterally Investment Cost Estimation

121.4.2.1 Calculation of the First Part of Expenses

1. It is known that one university's unilateral settlement cost of similar student dormitory engineering is 1,200 yuan/m^2 (civil engineering unilateral cost is about 1,000 yuan/m^2).
2. Make sure main material consumption index of civil decoration engineering (reference in 2005 in Guangzhou area construction engineering technical and economic index [14] adjustment). (see Table 121.1)
3. Third quarter of 2004 [15], fourth quarter of 2010 [16] material unit price and price adjustment civil engineering calculation. (see Table 121.1)

   Artificial cost difference of adjustment calculation (can take other direct expenses, scene funds, indirect expenses, planning profits and taxes): 226.86 yuan/$m^2 \times [1 + (12.67 + 0.28 + 4.17 + 3.42)\ \%] = 226.86 \times 1.2054 = 273.46$ yuan/m^2.
   Market material price difference of adjustment calculation (can take planning taxes): 146.04 yuan/$m^2 \times (1 + 3.42\ \%) = 151.03$ yuan/m^2.
   Total price difference is: $273.46 + 151.03 = 424.49$ yuan/m^2.
   Price increasing range is: $424.49 \div 1000 = 0.424$, which is about 42.4 % of the original unilateral civil engineering cost.

4. If installation project has no detailed material index, we can consult material unit price and the increasing range after price difference adjustment, consider the installation work material price and price adjustment range are 42.4 %, too.
5. A headscarf project cost from 1,200 yuan/m^2 in 2005, amend and adjust to $1200 \times (1 + 42.4\ \%) = 1709$ yuan/m^2 in 2010.

121.4.2.2 Calculation of the Second Part of Cost

1. According to the actual situation of Guangdong province-owned universities infrastructure department, the construction unit management fee (1 %), and the government investment projects acting system management fee (2 %) temporarily should not be considered.

Table 121.1 Students dormitory engineering price difference calculation table

Serial number	Every 100 m^2 building area			Third quarter of 2004 guided price (RMB yuan)	Fourth quarter of 2010 guided price (RMB yuan)	Calculate price difference (RMB yuan)/100 m^2
	Index of material					
	Name	Number	Unit			(Unit price difference × index)
1	Artificial	428.04	mandays	33	86	$(86 - 33) \times 428.04 = 22686$
2	Pipe pile D = 400	34.92	m	79	124	$(124 - 79) \times 34.92 = 1571$
3	Reinforced	4.71	t	3387.66	4,874	$(4874 - 3387.66) \times 4.7 = 7001$
4	Concrete products (C30, pumping)	34.27	m^3	308	325	$(325 - 308) \times 34.27 = 583$
5	Cement	6.43	t	362.37	490.21	$(490.21 - 362.37) \times 6.43 = 822$
6	18 mm thick waterproof plywood	20.1	m^2	43.15	34.99	$(34.99 - 43.15) \times 20.1 = -64$
7	Turnover materials	1.98	m^3	1209.18	1272.91	$(1272.91 - 1209.18) \times 1.98 = 126$
8	Lime	0.61	t	144.84	229.50	$(229.50 - 144.84) \times 0.61 = 52$
9	Medium sand	2.27	m^3	46.92	52.02	$(52.02 - 46.92) \times 2.27 = 12$
10	Gravel10~20	0.33	m^3	58.14	69.36	$(69.36 - 58.14) \times 0.33 = 4$
11	Suggested brick	3.54	$one thousand	190	305	$(305 - 190) \times 3.54 = 407$
12	Lightweight concrete small block 390 × 190 × 190	0.74	$one thousand	3,100	2323.04	$(2323.04 - 3100) \times 0.74 = -575$
13	Wear-resisting brick 500 × 500	0.3526	$one thousand	8072.37	8470.17	$(8470.17 - 8072.37) \times 0.3526 = 140$

14	Prevent slippery brick 300 × 300	0.058	$one thousand	2586.94	2668.54	(2668.54 − 2586.94) × 0.058 = 5
15	Exterior wall glazed pottery 45 × 95	66.94	m^2	51.48	71.04	(71.04 − 51.48) × 66.94 = 1309
16	Ceramics 200 × 300	36.16	m^2	48	59.76	(59.76 − 48) × 36.16 = 425
17	Fire doors	1.96	m^2	436	650	(650 − 436) × 1.96 = 419
18	Splint adornment door	14.39	m^2	210	380	(380 − 210) × 14.39 = 2446
19	Aluminum alloy push-pull window	10.12	m^2	187.26	194.16	(194.16 − 187.26) × 10.12 = 70
20	Modified asphalt coil	14.75	m^2	18	40	(40 − 18) × 14.75 = 325
21	Ordinary emulsion paint	40	kg	23	13.65	(13.65 − 23) × 40 = −374
	Total					Artificial cost difference is 226.86 yuan/m^2 Market material price difference is 146.04 yuan/m^2

2. Calculate other expenses:

$$1\ \% + 2.5\ \% + 0.5\ \% + 0.5\ \% + 3.5\ \% + 1\ \% + 0.5\ \% + 2\ \% + 0.4\ \% = 11.9\ \%, 54 + 3.5 + 13 = 70.5\ \text{yuan/m}^2.$$

121.4.2.3 Calculation of the Third Part of Cost

Basic reserve fee (5 %),
Increasing price reserve fee (calculate and determine as below):

From 2004 to 2010, in 6 years, material unit price increase range is about 42.4 % from calculation above, converse to yearly material unit price increase range: $(1 + x)^6 = 1.424$. Which is $1 + x^{1/6} = 1.424$, get $x = 0.06 = 6\ \%$ per year.

121.4.2.4 Calculation of Students' Dormitory Unilateral Total Investment in 2010

$$1709 \times (1 + 11.9\ \% + 5\ \%) + 70.5 = 2068\ \text{yuan/m}^2$$

121.4.2.5 Estimation of Planning Similar Project Unilateral Investment

According to China's current construction procedure, large and medium-sized project construction period is 3-5 years. If use average of 3 years to calculate reserve of increasing price, the new project's unilateral investment should be:

$$1709 \times \left[11.9\ \% + 5\ \% + (1.06)^3\right] + 70.5 = 1709 \times 1.36 + 70.5 = 2395\,\text{yuan/m}^2$$

In which cost is for: $1709 \times (1.06)^3 = 1709 \times 1.19 = 2034\,\text{yuan/m}^2$

121.5 Epilogue

Through analysis and research above, under the condition that lack of design project data in infrastructure project decision-making stage, in order to fully consider dynamic cost, improve the calculation precision, and simplify calculation, China's province-owned universities can use practical estimation method that combine province-owned budget index method and similar trial project budget method to calculate new planning ordinary projects' investment estimate amount.

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