Application of the bid amount model to cost estimation systems for public works

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Introduction-1

In Japan,
the national or a local government are required
a threshold price when they order a public work.

A threshold price is the upper limit of the biding price.

⇒The contractor who bids exceed the upper limit price is disqualified in bidding.

The lowest limit price is set as calculated from **a threshold price**.

⇒The contractor who bids below the lowest limit price is **asked closely the reason of such low price**.

Introduction-2

JACIC is a foundation authorized by the Ministry Land, Infrastructure, Transport and Tourism (MLITT).

MLITT is responsible for public works administration.

To promote the smooth procurement of public works

JACIC has been provided

the data and cost estimation systems

to **local government.**

JACIC

Threshold Price

Discription in law

The national and local governments shall set a threshold price for public procurement.

“Accounting Law”(established in 1889)

”The cabinet order on budget, finance and accounting ” in article 79

Estimation Standard Of Public Works-1

A cost estimation system and Database are accoding with the Estimation Standard Of Public Works.

Estimation Standard Of Public Works

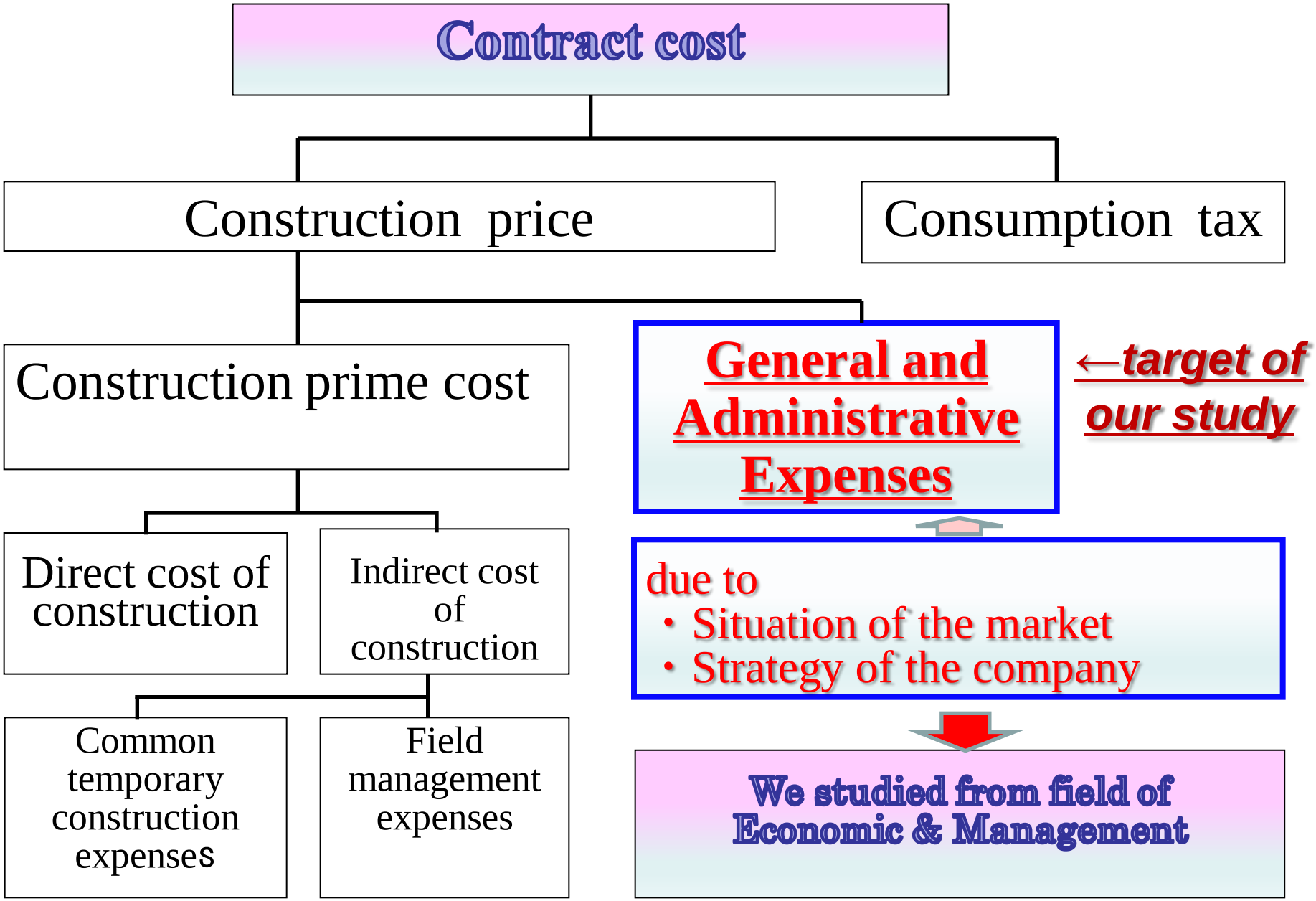
A cost estimation system

Database

A threshold price

Anyone computes the same amount of money.

Estimation Standard Of Public Works-2



Application an Auction Theory-1

Game Theory

The game theory has been developed based on
"Theory of Games and Economic Behavior",
established by mathematician John von Neumann and economist Osker Morgenstern in 1944.

The game theory has evolved various fields by the concept of Nash equilibrium which John F. Nash invented.
The economic model for "General and Administrative expenses" that we show in this paper is a type of the equilibrium solution called Bayesian equilibrium point.

Application an Auction Theory-2

Auction Theory

・Auctions include an open auction system and a sealed-price auction system.
・An open auction system is a system that the bidders decide bid prices looking for other bidders' actions each other, like the auction of pictures.
・A sealed-price auction system is a system that the bidders decide the bid prices without knowing other bidders' actions each other.
・The purpose of our research is to examine “General and Administrative expenses” for “a cost estimation system” of public works. We adopted a sealed-price system.

Bidding Model –1

Based on ***First-price Sealed-bid Auction***

・When the lowest bidding price is less than a threshold price, the company that bids the lowest price wins.

・When the lowest price exceeds a threshold price, the bid ends in failure.

We needed four assumptions to build a model.

Assumption 1: The contract office and the tender person are risk-neutral. This means that a winner of the competitive bid is decided only by a bidding price, not other factors.

Assumption 2: The tender companies expect the bidding price independently.

Assumption 3: The tender companies are symmetric. This means that a construction amount money of each company follows the same function, and the tender companies are considered to be homogeneous by all other companies.

Assumption 4: A payment from a contract party to the winning company depends on only bidding price.

Bidding Model –2

The following two conditions are needed to build a model which is derived from the Symmetric Nash Equilibrium Strategy, in this case.

Condition 1: All bid companies which estimate an equal cost (c_i) bid the same bidding prices.

Condition 2: When all the tender companies except for the company i, set the bidding price $B(c_j)$, $B(c_i)$ is the optimal bidding price for the company i.

Bidding Model –3

To the company i win the company j, b_i must less than b_j.
b_n: a bidding price of the company n .
The probability that company i win other company j is

$$\mathbf{1\text{-}F(c_i)}$$

$F(c_i)$:Probability distribution function about a construction cost.

Each tender company sets up a tender price independently.
The probability of winning the company i is set to (A).

$$\mathbf{Pi = (\ 1\text{-}F(c_i))^{n-1} \qquad (A)}$$

The expected profit of the tender company *i*:

$$\mathbf{E_i = (b_i - c_i)\ (1 - F(c_i))^{n-1}}$$

Bidding Model –4

(B) : A necessary and sufficient condition for $b_i(=B(c_i))$ to be the symmetric Nash equilibrium strategy by assumption3.

$$\left.\frac{\partial E_i}{\partial b_i}\right|_{b_i=B(c_i)} = 0 \qquad \text{(B)}$$

(C):The symmetric Nash equilibrium strategy of the successful company i.

$$B(c_i) = c_i + \int_{c_i}^{r} \frac{(1-F(x))^{n-1}}{(1-F(c_i))^{n-1}}\,dx \qquad \text{(C)}$$

(D):The density function we defined.

$f(x)=c$ (constant) (D)

Bidding Model –5

We get $B(c_i) = c_i(1-1/n) + r/n$

As "General and Administrative expenses" to α,

$r = c_i\,(1+\alpha)$.

$c_i = r/\beta$, $(\beta = 1+\alpha)$

$\alpha = n(r-b)/(b \cdot n - r)$

This α is "General and Administrative expenses"
by the symmetric Nash equilibrium
based on a market mechanism.

Model Analysis–1

- Using data: The public works of Ministry of Land, Infrastructure, Transport and Tourism.
  Kanto Regional Development Bureau
  in the 2013 fiscal year.

- Rate of General and Administrative expenses in the present system

Construction prime Cost	5 million yen or less	exceeds 5 million yen and 3 billion yen or less	exceeding 3 billion yen
Rate of General and Administrative expenses	14.38%	Based on the following calculation formula.	7.22%

[Rate calculation formulas]

$Gp = -2.57651 \times \mathrm{Log}(Cp) + 31.63531(\%)$

***Gp*: Rate of General and Administrative expenses (%)**

***Cp*: Construction prime cost (yen)**

Model Analysis–2

- Used data:

  The number of target construction is 781.

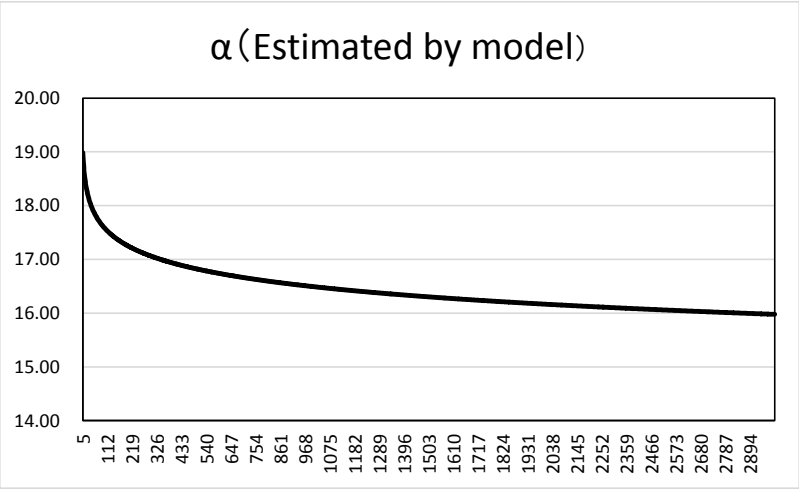
- The result regression：

  $Gp = -1.08382 \times \mathrm{Log}(Cp) + 26.24844$ (%)

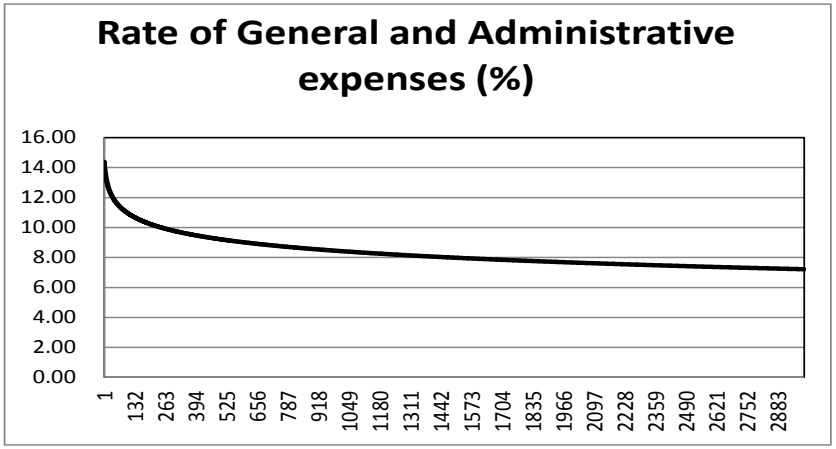
  Gp: Rates, such as administrative expenses (%)

  Cp: Construction prime cost (yen)

- To verify the model, we compared the values obtained by regression model with the values what the estimation system uses.



Result of the model of Rate of General and Administrative expenses



Estimation system

Model Analysis–3

- **Compare of General and Administrative expenses**

Construction cost	estimation system	model
5milion yen	14.38(%)	19.08(%)
3 billion yen	7.22(%)	15.87(%)
Difference	**7.16(%)**	**3.21(%)**

- The general administrative expense ratio by the model is estimated more highly then the estimation system use.
- The difference between two rates is caused of the correction values according to the conditions of a construction site which is added to present estimation standard. (A correction value can be calculated by investigating an addition result in detail, we cannot obtain the data now).
- Furthermore, by the principle of the market, the company may expect profits more greatly than an estimation standard.

Conclusion

We can improve the present traditional estimation system to more realistic system based on the situation of the market, by adding the data and logic which reflect the production cost of the tender company.

Moreover, in future Japan, many efficient public-works are needed for maintenance for natural disasters (such as an earthquake), Tokyo Olympic, and the superannuated society's infrastructure, etc.
We think that the economic approach is effective, and this research suggests that such model building is possible.

In this paper, we studied the profit of tender company by building a model. We would like to challenge the further concrete analysis and to arrange the improving point of a bid and contract method of the present public-works.

Thank You For Your Attention

質問1件あり。

【質問】
回帰モデルを作っているが、これ以外のファクターでのモデルは作ったか？

【回答】
作っていません。
このモデルは、ナッシュ均衡解から導かれるもので、この研究はそのモデルの実用性を検証したかったため、他のファクターでの回帰モデルの作成は不要です。