The Mathematical Model Analysis by Direct Negotiation of the Price in Small Procurements for Pharmaceutical Factory Construction Projects

Wei Zeng *

Tongji University Shanghai Tongji Engineering Consulting Co.,Ltd. 200092, China

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Abstract

This paper is to study the mechanism by direct negotiation of the price in small procurements for the pharmaceutical factory construction projects. Provided that two parts estimate the construction price as the sum of cost and profit, the paper forms target price for owners and contractors after adjustment of the profit and price by each other according to the owner and contractor's principal and subordinate, friendly and information asymmetry situation, then imitates the contract price according to the owner and contractor's principal and subordinate situation.

Keywords: owner; contractor; direct negotiation; mathematical model

1 Introduction

In pharmaceutical factory construction projects, large products often can be purchased by tender. Through tender with full competition, the owner can get a reasonable price. Tender is with its defects of long progress and high cost, that is not suitable for small purchases. This paper is to study the mechanism by direct negotiation of the price for small procurements [2].

2 The Forming Process of Contract Prices and Relevant Factors

2.1 THE FORMING PROCESS OF CONTRACT PRICES

This paper is based on the following forming process [1] of contract price as Figure 1.

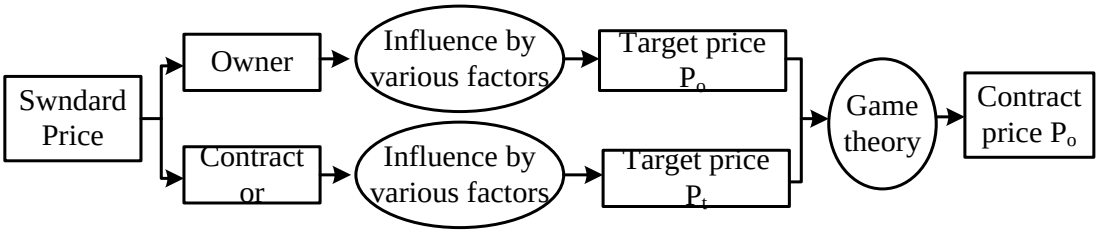

FIGURE 1: The forming process of contract price

2.2.1 Three key elements

To high efficiency of study, we ensure three factors, which are closely related with the contract price at last, by inquiry, investigation, filtering and induction. Those are Activity/Passivity (A/P) [4], friendship between owners and contractors, owners' cognitive degree.

2.2.2 The parameter definition

2.2.2.1 A/P between owners and contractors

(1) αo: the position of activity for owners, αo∈[0,1].
As (αo=0), owners is in the position of full passivity, then owner has no other choice.
As (αo=1), owners is in the position of full activity, then owners can choose contractors freely.
Other figures are situations by insertion method between above value.

(2) αc: the position of activity for contractors, αo∈[0,1], and αo+αc=1.

2.2.2.2 Friendship between owners and contractors

(1) Description and definition to friendship for owners βo:, βo∈[0,1].
(2) Description and definition to friendship for contractors βc:, βo∈[0,1].
(3) The friendship of owners and contractors is with no relationship.

2.2.2.3 Cognitive degree of owners and contractors

(1) γo: The cognitive degree for owners, γo∈[0.2,1].
(2) This paper believes that the insufficient knowledge level of owner will have two effects: Firstly own understanding bias to information. Secondly, lower the cognitive degree, easier being persuaded by contractors.

* ***Corresponding author's*** e-mail: zweizeng@163.com

(3) Cognitive degree of contractors is "1", extremely high.

3 The formation of psychological price of the owners and contractors

3.1 THE QUESTIONNAIRE SURVEY AND ANALYSIS

3.1.1 Questionnaire distributed, taken back, analysis

3.1.1.1 Questionnaire distributed and taken back

The survey questionnaires is distributed 493 copies, and taken back 298 copies, then the questionnaires as following are eliminated: 1) There are many lacks in questionnaire. 2) The questionnaire is of forward, reverse logic relationship terms, there are logic confusion phenomena. 3) The questionnaire of "not sure" chooses too much; 4) The questionnaire response options is considered to be the regular shape of man-made. Finally we obtain 221 valid questionnaires [3].

3.1.1.2 Data analysis

Then we analyze data of 221 valid questionnaires. Just 1.9 does not meet the requirements, because in too many questionnaires the maximum "0" are chose. The rest can satisfy the requirements. According to reliability 95%, we calculate the confidence range:

$$\frac{Z_{\alpha/2}}{\sqrt{n}} \tag{1}$$

Provided:

$$P\left\{\left|\frac{(X_a-\mu)}{\sqrt{n}}\right| < Z_{\alpha/2}\right\} = 1-\alpha = 0.95$$

Xa: Measurement of the mean; μ: The actual average; n: Sample size; σ: The standard deviation; Zα/2: The probability of unbelievable area. The confidence lies in the following range:

$$X_a \pm \frac{1.96\times\sigma}{\sqrt{n}} \tag{2}$$

3.1.2 Investigation content and result

1. Provided that the deviation coefficient is "1", as two parts are in balance, then in other cases the deviation coefficients to owner standard price are got in 1.1-1.9 of Appendix1.

2. Provided that the deviation coefficient is "1", as owners are in balance situation, in other cases the deviation coefficients of owners to standard price are got in 2.1-2.5 of Appendix1.

3. Provided that the deviation coefficient is "1", as contractors are in balance situation, in other cases the deviation coefficients of contractors to standard price are got in 3.1-3.5 of Appendix1.

4. According to the average profit rate got in 4.1 of Appendix1. We fix it as 15% to study.

5. Provided that the deviation range of reference to owners is (1,1), as owners are in full cognitive degree. In other cases the deviation range of reference to owners are got in 5.1-5.2 of Appendix1.

6. Faced with the highest and lowest price, owners prefer low to high price. Provided that the psychological accept weight "1" for owners to believe the highest is true, the psychological accept weight for owners to believe the lowest is true is got in 6.2 of Appendix1.

7.Compared with the lowest price, by the influence of contractors, provided that the psychological accept weight "1" for owners to believe the lowest is true, then under various cognitive degree, others psychological accept weights for owner to believe the highest is true are got in 7.2, 7.4 of Appendix1.

Detailed show is in Appendix1, the table of sample data descriptive statistics and confidence interval.

3.2. MATHEMATICAL SIMULATION ANALYSIS TO OWNER'S PSYCHOLOGICAL PRICE

The price acceptable to both sides can be split into construction cost and income:

$$Ps = Cs + Is \tag{3}$$

Ps is a market standard price, without deviation, in balance of A/P, full cognitive degree of two parts. Cs is the total standard cost of construction. Is is the standard income for construction.

Deviation from the Standard Price and Income to Cognitive Degree of Owners

1. Deviation from the standard price to cognitive degree of owners

(1) Faced with the highest and lowest price as the result of survey, owners prefer the lowest to the highest price.

Firstly, according to 3.1.2.5, after fitting, we can get the range about deviation from the standard price for owner defect of knowledge: [γo1/2, (2-γo1/2)] .

Secondly, there is also a psychological influence for the owner to accept the lowest price rather than the highest. According to 3.1.2.6/Table9, provided that the psychological accept weight "1" for owners to believe the highest is true, then the psychological accept weight for owners to believe the lowest is true is at the range of [2.97,3.05], this paper takes "3" to adjust the coefficient and gets as following: [3 • γo1/2 +(2-γo1/2)] /4 After reduction, we can get as following: (1+γo1/2) /2.

According to the above study, deviation of standard price owing to owner defect of knowledge and psychological factor can be described as following:

$$P_{o1} = P_s(1+\sqrt{y_o})/2 \tag{4}$$

Po1 is the price after Ps being adjusted by the first time for the above factors.

(2) By the influence of contractors, deviation from the standard price for owner cognitive degree

According to 3.1.2.7, after fitting, under various cognitive degree, others psychological accept weights for owner to believe the highest is true are as (2-γo).

As above study, the relevant deviation of standard price is as following:

$$P_{o2} = P_s[(2-\sqrt{\gamma}_o)(2-\gamma_o)+\sqrt{\gamma_o}]/(3-\gamma_o) \quad (5)$$

Po2 is the price after Ps being adjusted the by second time for the contractor influence factors.

(3) After two above adjustments, we get the P_o' which can be accepted as standard price, not real, just by owners.

$$P_o^{'} = P_s(1+\sqrt{\gamma_o})[(2-\gamma_o)+\sqrt{\gamma_o}]/[2(3-\gamma_o)] \quad (6)$$

According to 3.1.2.4, contractor income rate is centrally at the range of ［14.71%, 14.97%］, this paper takes "15%" as the basis of study, then:

$$I_o^{'} = P_O \times 15\% \quad (7)$$

$$C_o = P_o^{'} \times 85\% \quad (8)$$

Io' and Co are contractor standard income and standard cost on the basis of P_o'.

Deviation from the Standard Price to A/P of Owners

According to 3.1.2.1, after fitting, Io' is adjusted by the first time for various A/P, and we can get I_{o1}.

Deviation from the Standard Price to Friendship of Owners

According to 3.1.2.2, after fitting, Io' is adjusted by the second time for various friendship situations, and we can get I_{o2}.

$$I_{o2} = [2(1-\beta_o)]^2$$

$$I_{o2} = [2(1-\beta_o)]^2{}_o, \beta_o \in [0.05]$$

$$I_{o2} = 2\sqrt{(1-\alpha_o)(1-\beta_o)}_o, \beta_o \in (0.5,1] \quad (10)$$

According above, we get the Io which can be accepted as standard income, not real, just by owners.

$$I_o = \sqrt{2(1-\alpha_o)}[2(1-\beta_o)]^2{}_o, \beta_o \in [0,0.5]$$

$$I_o = 2\sqrt{(1-\alpha_o)(1-\beta_o)}_o, \beta_o \in (0.5,1] \quad (11)$$

After Adjustment, We Can Get the Target Price of Owner: Po.

$$P_o = C_o + \sqrt{2(1-\alpha_o)}[2(1-\beta_o)]^2{}_o, \beta_o \in [0,0.5]$$

$$P_o = C_o + 2\sqrt{(1-\alpha_o)(1-\beta_o)}_o, \beta_o \in (0.5,1] \quad (12)$$

To put the equations (7) and (8) into equation (10):

$$P_o = \begin{cases} P_o = [0.85 + 0.85\sqrt{1-\alpha_o}(1-\beta_o)^2], \beta_o \in [0,0.5] \\ P_o = (0.85 + 0.3\sqrt{1-\alpha_o}(1-\beta_o)), \beta_o \in (0.5,1] \end{cases} \quad (13)$$

To put the equation (6) into equation (13), then:

$$\frac{P_s = (1+\sqrt{\gamma_o}) = [(2-\sqrt{\gamma_o}) = (2-\gamma_o)+\sqrt{\gamma_o}]}{2 = (3-\gamma_o)} \quad (14)$$

$$P_o = \begin{cases} = [0.85 + 0.85\sqrt{1-\alpha_o}(1-\beta_o)^2], \beta_o \in [0,0.5] \\ \frac{P_s = (1+\sqrt{\gamma_o}) = [(2-\sqrt{\gamma_o}) = (2-\gamma_o)+\sqrt{\gamma_o}]}{2 = (3-\gamma_o)} \\ = [0.85 + 0.3\sqrt{(1-\alpha_o)(1-\beta_o)}], \beta_o \in (0.5,1] \end{cases}$$

Po is a price adjusted by various factors, such as cognitive degree, A/P and its own friendship attitude, which is an individual target price just for owner to bargain with the contractor. Po is also a basis and expect price for owner to bargain [7].

3.3 MATHEMATICAL SIMULATION ANALYSIS TO CONTRACTOR'S PSYCHOLOGICAL PRICE

Provided that contractor is of the full cognitive degree for the market price, Ps, Cs and Is will directly be his decision basis.

3.3.1 Deviation from the standard price to A/P of contractor

Firstly, αc is with the relation of αo, αo+αc=1, which are known by both sides. Secondly, Is is the decision basis of contractor, compared with equation (4), deviation from Is can be got as following:

$$I_{C1} = \sqrt{2(1-\alpha_o)}I_S \quad (15)$$

3.3.2 Deviation from the standard price to friendship of contractor

According to 3.1.2.3 and equations (7) and (8), after fitting, we get the relevant deviation coefficient to Is: 2βc.

3.3.3 After adjustment, we can get the target price of contractor: Pc.

Then we can get the target price of contractor:

$$P_C = C_S + \sqrt{2(1-\alpha_o)}2\beta_C I_S = C_S + 2.83\sqrt{1-\alpha_o}\beta_C I_S \quad (16)$$

After further conversion and simplify, we get the Po as following:

$$P_C = P_S(0.85 + 0.425\sqrt{1-\alpha_o}\beta_c) \quad (17)$$

4 The analysis of game theory for bargain

According to above study, we get Po and Pc. And A/P of both sides is known as a fixed parameter. Then owner and contractor begin the complete information static game.

4.1 THE ESSENCE OF A/P

Provided that owner and contractor are under the complete information, and on basis of A/P, two sides begin the static game [5].

Owner thinks it necessary to cooperate after weighing the possibility of other alternatives, which can be described as the following equation:

$$V_c = U_c - U_o, V_c \le 0 \quad (18)$$

V_c is the value of the relevant contract to owner, U_o is total expected value to owner, U_o is the opportunity income for owner to give up for the relevant contract. Obviously, V_c must greater than "0", the relevant contract to owner will not meaningless, and greater the

V_c, the wish of signing the contract will be stronger. Vice versa, to contractor, the relevant truth can be described as the following equation:

$$V_c' = U_c' - U_o', V_c' \le 0 \quad (19)$$

V_c' is the value of the relevant contract to contractor, V_c' must greater than "0", the relevant contract to contractor will not meaningless.

According to above study, the values of both sides will not same. If $V_t = V_c + V_c$, then the profit share of owner and contractor will be: "V_c/ V_t"and "Vc, / V_t".

Provided that the desire of two sides for signing contractor is proportional to the contract share distribution, then we can get α_o:

$$\alpha_o = V_c' / V_t \quad (20)$$

4.2 THE FOCUS OF GAME

According to above study, the focus of game between owner and contractor is to compromise the controversy from two sides, which can be described as following:

$$G = P_c - P_o, P_c \ge P_o \quad (21)$$

"G"is the concession game of two sides.

4.3 THE GAME TO CONTROVERSY

On basis of table 1 and table can analyze by game matrix:

Table 1 Analysis of concession game to contract negotiation (Ⅰ)

		Contractor	
		agree	disagree
owner	agree	$(V_c \pm G \bullet (2n-1)/2, V_c' \mp G \bullet (2n-1)/2)$	$(V_c - G/2, V_c' + G/2)$
	disagree	$(V_c + G/2, V_c' - G/2)$	$(0,0)$

According to Table 1, we analyze the concession game of negotiation of contract controversy:

Provided that two parts would both like to bear G/2 as concession, the value of signing contract of two parts is (Vc,Vc,), then owner and contractor both lost the value of contract, G • n/2, and they get the profit as following:

(Vc$\pm$G • n/2,Vc, G$\mp$• n/2), Among themn $\in$ [0, 1] ;

Provided that only owner would like to bear G as concession, the value of signing contract of two parts is (Vc-G/2,Vc,+G/2). Vice Versa, provided that only contractor would like to bear G as concession, the value of signing contract of two parts is (Vc+G/2,Vc,-G/2). And if both would like to bear nothing as concession, then neither of them can get any profit, the value of signing contract of two parts is (0,0).

On basis of assumption in 4.1 and Vc, Vc', αo, G as the known condition, we can analyze by game matrix:

TABLE 2 Analysis of concession game to contract negotiation(Ⅱ)

		Contractor	
		agree	disagree
owner	agree	$(V_c \pm G \bullet (2n-1)/2, V_c' \mp G \bullet (2n-1)/2)$ →	$(V_c - G/2, V_c' + G/2)$
	disagree	$(V_c + G/2, V_c' - G/2)$ ←	$(0,0)$ ↑

By arrow method, we can get three equilibriums: (Vc-G/2,Vc,+G/2), (Vc+G/2,Vc,-G/2) and mixed strategy.

We analyze further the mixed strategy, and then get the equation (22) as following:

$$(V_c \pm G \bullet (2n-1)/2)\alpha_o + (V_c - G/2)(1-\alpha_o) = (V_c' + G/2)\alpha_o \quad (22)$$

After simplifying, we get value of (2n-1), n$\in$[0, 1]:

$$2n-1 = \left|2 \cdot V_c \alpha_o + G - 2 \cdot V_c\right| / G \cdot \alpha_o$$
$$s.t. V_c \ge G \quad (23)$$

4.4 RESULT OF THE GAME

After derivation to equation (18) - (23), we get the result in the end:

$$P_\alpha = \frac{P_o + P_c}{2} \pm \left|2 \cdot V_c \alpha_o + G - 2 \cdot V_c\right| / 2 \cdot \alpha_o, P_c \ge P_a \ge P_o \quad (4)$$

"a"s the price of agreement to bargain.

5 Conclusion

This paper suggests that the formation of the bargain price is based on psychological contract prices of two sides [6], and through the game process. We ensure three factors, which are closely related with the contract price at last, which are A/P, friendship attitude of owner and contractor and owners' cognitive degree.

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Appendix1, the table of sample data descriptive

statistics and confidence interval

No.	Mean	Mean standard error	Standard deviation	Variance	Partial degrees	Partial degrees standard error	Kurtosis	Kurtosis standard error	$(Z_{\alpha/2})/(n)^{1/2}$	Confidence interval (%)	
									Confidence degree 0.95	Bottom	Top
1.1	141.3654	0.60790	13.86215	192.159	-0.063	0.107	-0.277	0.214	0.13184359	139.54	143.19
1.2	131.3654	0.60790	13.86215	192.159	-0.063	0.107	-0.277	0.214	0.13184359	129.54	133.19
1.3	121.8500	0.62739	14.30660	204.679	-0.070	0.107	-0.481	0.214	0.13184359	119.96	123.74
1.4	110.8269	0.60120	13.70937	187.947	0.040	0.107	-0.165	0.214	0.13184359	109.02	112.63
1.6	85.4231	0.46417	10.58473	112.037	-0.343	0.107	-0.203	0.214	0.13184359	84.03	86.82
1.7	70.3654	0.40938	9.33539	87.150	-0.144	0.107	0.592	0.214	0.13184359	69.13	71.60
1.8	49.7500	0.43243	9.86103	97.240	-0.749	0.107	-0.078	0.214	0.13184359	48.45	51.05
1.9	0.3654	0.10241	2.33536	5.454	6.966	0.107	50.761	0.214	0.13184359	0.06	0.67
2.1	144.4423	0.44498	10.14711	102.964	-0.375	0.107	-0.134	0.214	0.13184359	143.10	145.78
2.2	118.5577	0.41571	9.47955	89.862	-0.127	0.107	0.790	0.214	0.13184359	117.31	119.81
2.4	95.5577	0.27289	6.22294	38.725	-0.240	0.107	-0.619	0.214	0.13184359	94.74	96.38
2.5	84.8462	0.26244	5.98452	35.814	0.276	0.107	-0.371	0.214	0.13184359	84.06	85.64
3.1	84.8654	0.21940	5.00300	25.030	0.054	0.107	-0.425	0.214	0.13184359	84.21	85.53
3.2	92.2500	0.26580	6.06126	36.739	-0.153	0.107	-0.510	0.214	0.13184359	91.45	93.05
3.4	107.4231	0.30036	6.84918	46.911	0.380	0.107	-0.858	0.214	0.13184359	106.52	108.33
3.5	115.1154	0.34193	7.79717	60.796	-0.105	0.107	-0.379	0.214	0.13184359	114.09	116.14
4.1	14.8404	0.04372	0.99687	0.994	0.406	0.107	0.7358	0.214	0.13184359	14.71	14.97
5.1-1	45.0769	0.28025	6.39076	40.842	0.561	0.107	0.773	0.214	0.13184359	44.23	45.92
5.1-2	155.3269	0.31065	7.08392	50.182	-0.357	0.107	0.792	0.214	0.13184359	154.39	156.26
5.2-1	77.2692	0.32303	7.36632	54.263	-0.726	0.107	1.108	0.214	0.13184359	76.30	78.24
5.2-2	122.5577	0.35347	8.06026	64.968	0.531	0.107	-0.163	0.214	0.13184359	121.50	123.62
6.2	3.0067	0.01295	0.29520	0.087	0.330	0.107	0.719	0.214	0.13184359	297.00	305.00
7.2	179.7885	0.18936	4.31798	18.645	-0.117	0.107	0.843	0.214	0.13184359	179.22	180.36
7.4	140.1923	0.35064	7.99576	63.932	0.238	0.107	0.744	0.214	0.13184359	139.14	141.25

Authors

Wei Zeng, Guangdong Province of China

Current position, grades: senior engineer
University studies: PHD's degree was earned in major of construction engineering management, Tongji University in 2013.
Scientific interest: engineering supervision