基于前景理论的投标报价博弈模型研究

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摘　要：前景理论能够准确刻画决策者现实决策时的个体心理及行为，针对一般的投标报价问题本文运用前景理论进行了分析，推导了考虑心理行为偏差的投标者的价值函数、主观概率以及决策权重函数，并分析了决策者行为对投标报价策略的影响。算例分析分别从决策者具有不同的心理参考点和损失厌恶系数两个角度分析了决策者的心理行为偏差对其投标决策的影响，结果表明当投标者损失厌恶系数较小时，投标决策对心理参考点不敏感，投标者更倾向于低价中标；当投标者损失厌恶系数较大时，投标决策对心理参考点非常敏感，进一步说明此模型能较好地描述投标者的实际投标决策行为。

关键词：前景理论；投标决策；博弈；价值函数；决策权重函数
中图分类号：F284　**文献标识码：**A

Research on Bidding and Quotation Game Model based on Prospect Theory

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Abstract: Prospect theory can accurately depict the individual psychology and behavior when decision-makers reality, for the bid model of cost estimate of the general problem in this paper, using the prospect theory was analyzed, and the psychological deviation is developed, with the consideration of the value of the bidders function, subjective probability and decision weighting function, and analyzes the policymakers' behavior affect the bid strategy. The results show that when the loss aversion coefficient is small, the bidding decision is insensitive to the psychological reference point, and the tenderer is more inclined to bid at a low price. When the loss aversion coefficient of tenderers is large, the bidding decision is very sensitive to the psychological reference point, which further indicates that the model can describe the actual bidding decision behavior of tenderers well.

Keywords: Prospect theory; Bidding decision; Game; Value function; Decision weight function

引言

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1 前景理论

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2 问题描述及模型构建

A B i

$i = \mathrm{A,B}$

i c_i

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i

c_i $[m,n]$ c_i

$f(x)$ c_i

$[m,n]$ $f(x)=1/(n-m)$ i

b_i c_i $b_i(c_i)=r_i+s_ic_i$ r_i

S_i

$b_i \ge c_i \ge 0$

[4-5]

2.1

$$\Delta\pi_i=\pi_i-\pi_{i0}=\begin{cases} b_i-c_i-\pi_{i0}, & if\ b_i<b_i \\ (b_i-c_i)/2-\pi_{i0}, & if\ b_i=b_i \\ -\pi_{i0}, & if\ b_i>b_i \end{cases} \quad 1$$

π_{i0} i i

$b_i=b_i$ b_i

0

$b=b^*(c)$

A B A

A “ ”

$$\begin{cases} b_A<b_B \\ b_A-c_A-\pi_{A0}\ge 0 \end{cases} \Rightarrow \begin{cases} b_A<b_B \\ b_A\ge c_A+\pi_{A0} \end{cases}$$

$b_B<c_A+\pi_{A0}$

$b_B>c_A+\pi_{A0}$ $c_A+\pi_{A0}\le b_A<b_B$

$\Delta\pi_{A1}=b_A-c_A-\pi_{A0}$

$$P_1^+=p\left(c_A+\pi_{A0}\le b_A<b_B\right)=\frac{r_B+s_B^*c_B-c_A-\pi_{A0}}{r_A(n-m)}$$

∴ A

$$E\left(v_1^+\left(\Delta\pi_{A1}\right)\right)=\left(b_A-c_A-\pi_{A0}\right)^{\alpha}\frac{r_B+s_B^*c_B-c_A-\pi_{A0}}{r_A(n-m)} \quad 2$$

B

$$E\left(v_1^-\left(\Delta\pi_{B1}\right)\right)=-\lambda\left(\pi_{B0}\right)^{\beta}\frac{r_B+s_B^*c_B-c_A-\pi_{A0}}{r_A(n-m)} \quad 3$$

A “ ”

$b_A<c_A+\pi_{A0}$ $s_A<1$

$$P_1^-=p\left[(1-s_A)c_A>r_A-\pi_{A0}\right]=\left(1-\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 4$$

A

$$E\left(v_1^-\left(\Delta\pi_{A2}\right)\right)=-\lambda\left(c_A+\pi_{A0}-b_A\right)^{\beta}\left(1-\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 5$$

B

$$E\left(v_2^-\left(\Delta\pi_{B2}\right)\right)=-\lambda\left(\pi_{B0}\right)^{\beta}\left(1-\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 6$$

$b_A<c_A+\pi_{A0}$ $s_A>1$

$$P_2^-=p\left[(1-s_A)c_A>r_A-\pi_{A0}\right]=\left(\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 7$$

A

$$E\left(v_2^-\left(\Delta\pi_{A2}\right)\right)=-\lambda\left(c_A+\pi_{A0}-b_A\right)^{\beta}\left(\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 8$$

B

$$E\left(v_3^-\left(\Delta\pi_{B2}\right)\right)=-\lambda\left(\pi_{B0}\right)^{\beta}\left(\frac{r_A-\pi_{A0}}{1-s_A}\right)\Big/ n-m \quad 9$$

$b_B<c_A+\pi_{A0}$ $b_A<b_B$

$$P_3^-=p\left(b_A<b_B\right)=1-\left(\frac{b_A-r_B}{s_B}\right)\Big/ n-m \quad 10$$

A

$$E\left(v_3^-\left(\Delta\pi_{A2}\right)\right)=-\lambda\left(c_A+\pi_{A0}-b_A\right)^{\beta}\left(1-\left(\frac{b_A-r_B}{s_B}\right)\Big/ n-m\right) \quad 11$$

B

$$E\left(v_4^-\left(\Delta\pi_{B2}\right)\right)=-\lambda\left(\pi_{B0}\right)^{\beta}\left(1-\left(\frac{b_A-r_B}{s_B}\right)\Big/ n-m\right) \quad 12$$

B A A

A “ ”

$b_A > b_B \quad \Delta\pi_{A3} = \pi_A - \pi_{A0} = -\pi_{A0}$

$$P_4^- = p(b_A > b_B) = p\left[b_A > r_B + s_B c_B\right] = \frac{b_A - r_B}{s_B(n-m)} \quad (13)$$

∴ A

$$E\left(v_4^-(\Delta\pi_{A3})\right) = -\lambda(\pi_{A0})^{\beta}\frac{b_A - r_B}{s_B(n-m)} \quad (14)$$

B

$$E\left(v_1^+(\Delta\pi_{B3})\right) = (b_B - c_B - \pi_{B0})^{\alpha}\frac{b_A - r_B}{s_B(n-m)} \quad (15)$$

2.2

Kahneman [2]

$$U(x) = \sum v_j(\Delta\pi)\cdot\omega(P_j) \quad (16)$$

∴ $b_B \ge c_A + \pi_{A0} \quad s_A < 1$ 16

A

$$U_{A1}(s) = E\left(v_1^+(\Delta\pi_{A1})\right)\bullet\omega^+(P_1^+) + E\left(v_1^-(\Delta\pi_{A2})\right)\bullet\omega^-(P_1^-) + E\left(v_4^-(\Delta\pi_{A3})\right)\bullet\omega^-(P_4^-) \quad (17)$$

B

$$U_{B1}(s) = E\left(v_1^-(\Delta\pi_{B1})\right)\bullet\omega^-(P_1^+) + E\left(v_2^-(\Delta\pi_{B2})\right)\bullet\omega^-(P_1^-) + E\left(v_1^+(\Delta\pi_{B3})\right)\bullet\omega^+(P_4^-) \quad (18)$$

$b_B \ge c_A + \pi_{A0} \quad s_A > 1$

$$U_{A2}(s) = E\left(v_1^+(\Delta\pi_{A1})\right)\bullet\omega^+(P_1^+) + E\left(v_2^-(\Delta\pi_{A2})\right)\bullet\omega^-(P_2^-) + E\left(v_4^-(\Delta\pi_{A3})\right)\bullet\omega^-(P_4^-) \quad (19)$$

B

$$U_{B2}(s) = E\left(v_1^-(\Delta\pi_{B1})\right)\bullet\omega^-(P_1^+) + E\left(v_3^-(\Delta\pi_{B2})\right)\bullet\omega^-(P_2^-) + E\left(v_1^+(\Delta\pi_{B3})\right)\bullet\omega^+(P_4^-) \quad (20)$$

$b_B < c_A + \pi_{A0}$

$$U_{A3}(s) = E\left(v_3^-(\Delta\pi_{A2})\right)\bullet\omega^-(P_3^-) + E\left(v_4^-(\Delta\pi_{A3})\right)\bullet\omega^-(P_4^-) \quad (21)$$

$$U_{B3}(s) = E\left(v_4^-(\Delta\pi_{B2})\right)\bullet\omega^-(P_3^-) + E\left(v_1^+(\Delta\pi_{B3})\right)\bullet\omega^+(P_4^-) \quad (22)$$

$$\omega^+(P_1^+) = \frac{(P_1^+)^{\gamma}}{\left((P_1^+)^{\gamma} + (1-P_1^+)^{\gamma}\right)^{1/\gamma}}$$

$$\omega^-(P_j^-) = \frac{(P_j^-)^{\delta}}{\left((P_j^-)^{\delta} + (1-P_j^-)^{\gamma}\right)^{1/\delta}}, \quad j = 1,2,3,4$$

α、β、γ、δ、λ 17 - 22 U s

Matlab7.0

$U(s)$ s

3 算例分析

A B

$[1,1.5]$

A $c_A = 1.49$ $b_A = 0.75 + 1.49 s_A$ B $c_B = 1.35$ $b_B = 0.75 + 1.35 s_B$

$\alpha = 0.88, \beta = 0.88, \gamma = 0.61, \delta = 0.69$ B 0.5 A 0

0.5 1 1.4 1.5 1.6 1.8 2.25

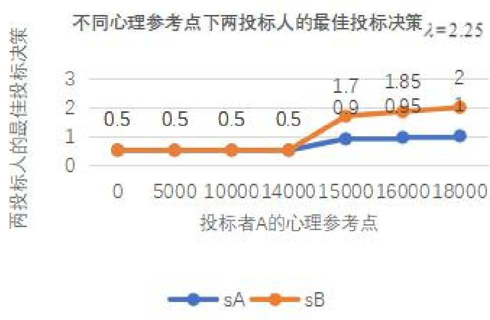
10

$\lambda = 2.25$

1

1 $\lambda = 2.25$

A	s_A	b_A	s_B	b_B
0	0.5	12473	0.5	12485
5000	0.5	12473	0.5	12485
10000	0.5	12473	0.5	12485
14000	0.5	12473	0.5	12485
15000	0.9	18499	1.7	28711
16000	0.95	19249	1.85	30803
18000	1	19998	2	32895



1 $\lambda = 2.25$

$\lambda = 5$

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2

2 $\lambda=5$

A	s_A	b_A	s_B	b_B
0	0.5	12473	0.5	12485
1000	0.5	12473	0.5	12485
2000	0.5	12499	0.85	16855
3000	0.5	12496	1.2	17944
5000	0.55	13249	1.05	19645
8000	0.65	14745	1.3	19023
10000	0.75	16249	1.4	24526
15000	0.9	18499	1.7	28711
18000	1	19998	2	32895

2 $\lambda=5$

1

$\lambda=2.5$

2 2 i A

ii B

A B 5000

B A

A

B

A B 5000

B A

B 5000 A

B A

2

1 2

i 2.25

1.5 ii

5

4 结语

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