Payback Scheme in First-price Sealed-bid Auctions: An Experimental Study

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Abstract

- In this paper, we design a payback scheme in first-price auctions which aims to increase the seller's revenue. In this payback scheme, before the auction starts, the bidders are given a fixed amount of initial capital balance to bid. Only the winner keeps the initial capital balance and the losers need to pay it back to the seller. We provide and compare the risk aversion and loss aversion equilibrium bidding models and revenue in first-price auctions in two cases: with and without the payback scheme. The model predicts that the scheme can increase the seller's revenue only if the bidders are loss averse. In a series of experiments, we compare the revenue and efficiency of these two designs. We find that, in terms of revenue, the payback scheme can generate more revenue only if the initial capital balance retained by the winner is smaller than a critical value. However, the payback scheme has no influence on efficiency.

Introduction

- Vickrey (1961) was the first to apply game theory to build the theoretical model for independent private value actions. By assuming risk neutral bidders, he derived the unique risk neutral Nash equilibrium (RNNE) bid functions for first-price given that the private values are drawn from a uniform distribution.
- Overbidding in first-price auctions with independent private values is consistent with experimental findings which suggest that bidders consistently bid above the RNNE prediction (CSW, 1982; Kagel & Roth, 1995; Kagel & Levin; 2011). This overbidding anomaly was initially explained by the constant relative risk aversion model - CRRA (CSW, 1988).
- Lange and Ratan (2010) develop the Koszegi-Rabin framework in first-price auctions and find an additional explanation - loss aversion also leads to overbidding in induced private value first-price auctions. For the standard first-price auction, there is no monetary loss for the bidders since the payoff for the losers is zero; they fail to buy the item but also do not pay at all. As a result, the 'loss' actually occurs when the bidder expects to win but loses the auction. **Naturally, we consider what might happen if we come up with an auction scheme in the first-price auction in which the losers really lose some money. Would such a scheme generate even stronger overbidding? If so, we also want to know whether it will enhance the seller's revenue, since maximising such revenue is one major goal of an auction design.**

Theoretical models

- n bidders
- Each bidder $i = \{1, 2, \dots, n\}$ has a private value v_i which is an independent draw from a uniform distribution F defined on [0,1].
- The number of bidders n and the distribution F are common knowledge, but the value realization v_i is private information.
- With the payback scheme, each bidder receives an initial capital balance K before the auction starts
- **Model 1**
  - Bidders share the homogeneous risk preference parameter r
  - Risk Averse Symmetric Nash Equilibrium model (RASNE)

$$b(v_i)^{RASNE} = K + \frac{n-1}{n+r-1} v_i$$

- **Model 2**
  - Bidders share the homogeneous loss aversion coefficient λ
  - Loss Averse Symmetric Nash Equilibrium model (LASNE)

$$b(v_i)^{LASNE} = \lambda K + \frac{n-1}{n} v_i$$

- Expected revenue predictions
  - Hypothesis 1a (RASNE): $R_{k=0} = R_{k=0.5}$
  - Hypothesis 1b (LASNE): $R_{k=0.5} \geq R_{k=0}$ $(if\ \lambda \geq 1)$
  - Hypothesis 2: (RASNE & LASNE): $R_{n=6} > R_{n=3}$

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Experimental design

- The first lottery experiment stage
- The second lottery experiment stage
- The auction experiment stages: within-subject variation
  - payback scheme (k5) and standard first-price auction (k0)

Results

- Loss aversion is a significant pattern for the subjects.
- In our experiment of 60 subjects, 45% of them are risk loving; whereas 11 subjects (18.33%) are risk neutral, and the remaining 22 subjects (36.66%) are risk averse.

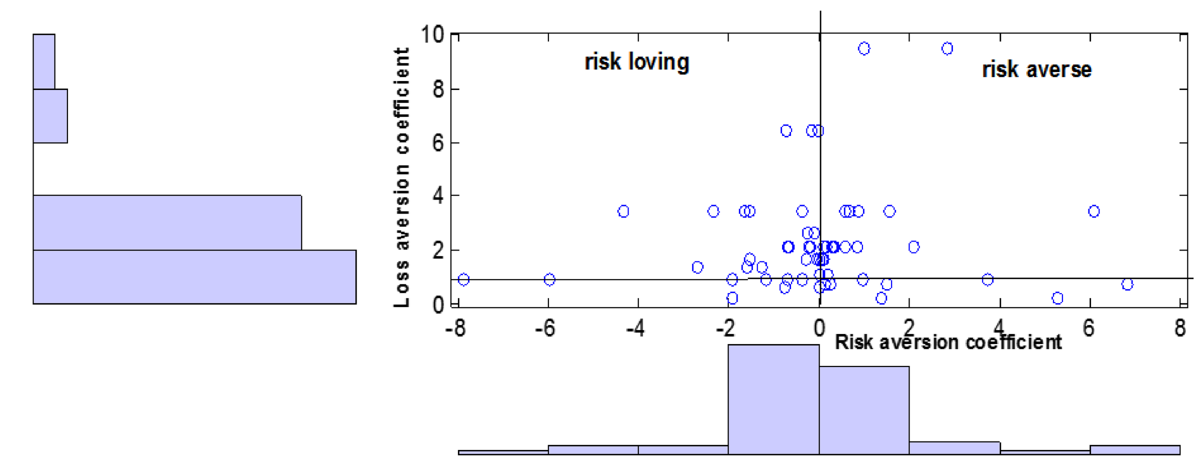

Figure 1 Graphical illustration of the relationship between loss aversion and risk aversion coefficients using a scatter plot and histograms

- Revenue Result
  - **Payback scheme effect**: $R_{k5}^{n=6} < R_{k0}^{n=6}$; $R_{k5}^{n=3} = R_{k0}^{n=3}$

Table 1 Coefficients of random effect and pooled Ordinary Least Squares (OLS) regressions for two market sizes

Independent Variable	Dependent variable: Revenue		
	n=6		n=3
	RE model	Pooled OLS	RE model
Intercept	7.41* (0.138)	7.41* (0.136)	5.35* (0.159)
Dk	-0.37* (0.075)	-0.38* (0.078)	-0.50 (0.330)
Order	0.49* (0.153)	0.49* (0.150)	0.77* (0.104)
#Observations	240	240	160
BP test	p=0.32		p<0.05

  - **Order effect**: $R_{k0_2} > R_{k0_1}$; $(R_{k0_2} - R_{k0_1})_{n=3} > (R_{k0_2} - R_{k0_1})_{n=6}$

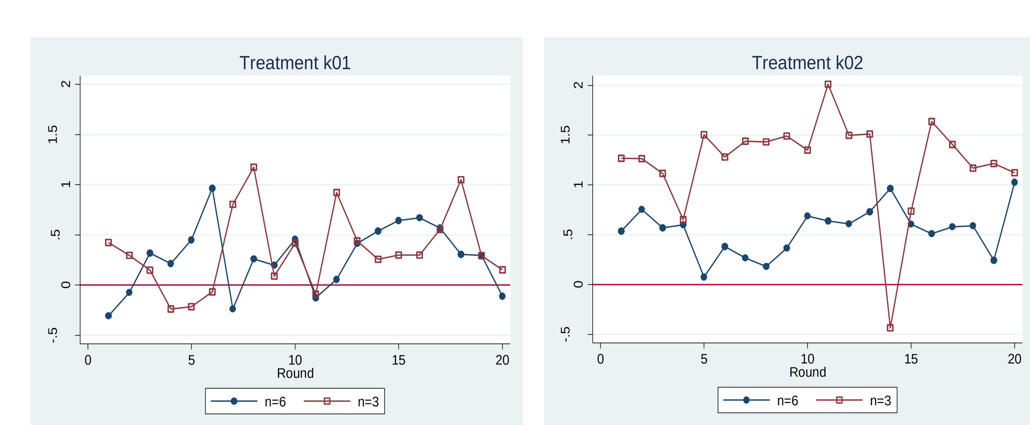

Figure 2 The difference between observed prices and RNNE prices in the k01 and k02 treatments

Conclusions

- The experimental results do not support the hypothesis. More specifically, the revenue within the payback scheme is statistically less than in the standard auction in the 6-bidder market and is not significantly different in the 3-bidder market.
- We suggest that the reason the payback scheme fails to enhance revenue in our experiment is that although the subjects submit higher bids, this does not offset the cost of the initial capital balance retained by the winner.
- Under the following two conditions, the seller's revenue may increase in a payback scheme first-price auction:
  - Small market size
  - Initial capital balance $K < 0.5\,\overline{v}$

References

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