Profit mechanisms in penny auctions: Unraveling the impact of sunk costs

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Abstract. This study provides a distinctive perspective on the intricate dynamics of penny auctions, which are characterized by incremental bid costs and potential sunk costs, constituting a significant area of research in existing literature. Our research takes a unique approach by specifically delving into the profit mechanisms inherent in penny auctions, with a focused examination on the profound impact of the sunk-cost fallacy on bidder behavior. To achieve this, we employ a custom model built upon the structural elements proposed in previous works, aiming to scrutinize the dynamics of bid costs and bid increments. In the course of our investigation, we uncover counterintuitive strategies employed by bidders that have a substantial impact on auctioneer profitability. This revelation contributes to a deeper understanding of bidder decision-making processes and their consequential influence on auction outcomes. By shedding light on these nuanced aspects, our study provides valuable insights that extend the current understanding of the intricate dynamics governing penny auctions. The implications of our findings have relevance not only for academic researchers seeking to expand their knowledge in this domain but also for industry professionals involved in auction platforms, offering practical considerations for optimizing profitability in this unique auction format.

1 Introduction

Penny auctions, often hailed for their profitability, have long captivated researchers seeking to understand the behavioral intricacies of participants. Prior studies by Augenblick and Brünner et al. have laid a robust foundation by dissecting the unconventional nature of pay-per-bid auctions and introducing prospect theory into the analytical framework. Building upon these insights, our study shifts the focus to the core of auction profitability, unraveling the mechanisms that drive lucrative outcomes for auction platforms [1, 2].

Intriguingly, our investigation reveals that the setting where bid costs surpass bid increments engenders counterintuitive bidder strategies. We explore scenarios that challenge traditional economic models, providing a comprehensive understanding of how the sunk-cost fallacy amplifies auctioneer profitability. The work by X. Zhang et al. contributes a rich empirical perspective by studying the bidding behavior on DealDash [3]. The findings reveal a significant optimization of bids aligned with the pay-per-bid structure, with a notable pattern of bids being placed just before the timer expiration. This predictability in bidder behavior, as highlighted by the study, provides a valuable foundation for understanding the strategic aspects of penny auctions. By integrating empirical data from DealDash, we validate our model's predictions against real-world auction dynamics, solidifying the significance of our findings.

As we navigate through the intricacies of bidder decision-making, our study not only contributes to the academic discourse on auction dynamics but also offers practical insights for auction platforms aiming to optimize their profitability. The subsequent sections delineate our model framework, incorporating insights from Augenblick and Brünner et al., and delve into empirical evidence, providing a comprehensive analysis of penny auctions' profit dynamics [1, 2].

2 Literature review

The profitability of penny auctions has been a subject of enduring interest among researchers, driven by the intricate behaviors of participants in these auctions. Augenblick and Brünner et al. have provided foundational insights by dissecting the unconventional nature of pay-per-bid auctions and incorporating prospect theory into the analytical framework. Expanding on these foundations, our study directs attention to the core of auction profitability, unveiling the mechanisms that underlie lucrative outcomes for auction platforms [1, 2].

Our investigation uncovers counterintuitive bidder strategies in scenarios where bid costs surpass bid increments, challenging traditional economic models. This exploration provides a comprehensive understanding of how the sunk-cost fallacy amplifies auctioneer profitability. Zhang et al.'s empirical contribution, focusing on bidding behavior on DealDash,

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adds a valuable perspective [3]. The study highlights a significant optimization of bids aligned with the pay-per-bid structure, particularly emphasizing a notable pattern of last-minute bids just before the timer expiration. This predictable bidder behavior, as illuminated by the study, establishes a crucial foundation for comprehending the strategic aspects of penny auctions. The integration of empirical data from DealDash serves to validate our model's predictions against real-world auction dynamics, reinforcing the significance of our findings.

As we delve into the intricacies of bidder decision-making, our study not only contributes to the academic discourse on auction dynamics but also offers practical insights for auction platforms aiming to optimize profitability. Beyond Augenblick and Brünner et al., our analysis draws on additional literature that enriches our understanding of penny auctions [1, 2].

2.1 Dynamic volunteer's dilemma and war of attrition

A dynamic volunteer's dilemma, where risk arises from others' decisions, mirrors a general war of attrition [4, 5]. This scenario, described by Bulow and Klemperer in various contexts such as natural monopoly markets, bargaining, and election campaigns, highlights the prevalence of risk in interpersonal interactions [6]. While Brünner et al. emphasize the limited application of prospect theory (PT) in such scenarios, our study bridges this gap by proposing a dynamic game-theoretic model incorporating endogenous risk from interpersonal interactions, utilizing PT preferences [2].

2.2 Applications beyond penny auctions

Building on Platt et al., Hinnosaar, and Augenblick, our study extends existing models by incorporating PT into the analysis of pay-per-bid auctions [1, 7, 8]. These auctions, often termed penny auctions, deviate substantially from traditional formats like eBay, featuring an open-end structure and requiring bidding fees from all participants. The anomalies observed in bidding behavior, such as average auctioneer revenues surpassing the retail price and the sunk cost fallacy, present a unique context for testing PT.

2.3 Empirical insights into bidder behavior

Caldara and Wang and Xu offer alternative explanations for bidder behavior in pay-per-bid auctions [9, 10]. Caldara's laboratory experiments indicate that auction revenues surpass the values of products, even with revealed information [9]. Wang and Xu empirically show that bidder sophistication and experience positively affect consumer surplus [10]. Our study incorporates these insights to provide a unified explanation for anomalies, demonstrating that PT effectively describes bidder behavior in pay-per-bid auctions.

In conclusion, our study bridges the gap in the literature by applying PT to dynamic scenarios where risk arises from interpersonal interactions, focusing on pay-per-bid auctions. The empirical findings support the effectiveness of PT in describing and predicting bidder behavior, offering valuable insights for both researchers and practitioners in auction settings.

3 Model framework

Our model follows the structure proposed by Augenblick [1]. Like Table 1, there are n+1 players, including a non-participating auctioneer (player 0) and n bidders. There is a single item for auction. Bidders have a common value v for the item. There is a set of potentially unbounded periods t, each period is characterized by a publicly observable current leader "Lt", with L0 = 0. In each period t, bidders simultaneously choose Bid or Not Bid. If any of the bidders bid, one of these bids is randomly accepted. In this case, the corresponding bidder becomes the leader for the next period and pays a non-refundable cost c. If none of the players bids, the game ends at period t and the current leader receives the object

In addition to the bid costs, the winner of the auction must pay a bid amount. The bid amount for the good at time t is t_k. Therefore, at the end of the game, the auctioneer's payoff = t_k+t_c.

Table 1. Model description.

Parameter	Description
Players	Non-participating auctioneer (Player 0) and Bidder (Player 1)
Valuation	Common value for the item (v) = $1
Bid Increment (k)	Increment in auction price with each bid (k1 = k2) = 15 cents
Bidding Cost (c)	Non-refundable cost incurred for each bid = 10 cents
Sunk-Cost Effects	Considered in bid decisions, influencing bidder behavior
Bid Amount (tk)	Represents the bid amount for the item at time t
Dynamic Bidding	Simultaneous bid decisions in each period
Bid Acceptance	Random acceptance of bids if placed
Cost Incurred	Winning bidder pays cost (c) in addition to bid amount
Parameter Settings	Adjustable bid increment and cost for scenario exploration

Then this paper simplified this model by assuming only two players, one item, and both players valuing the item at $1. The bidding stages are denoted as p1, p2, p3..., with each bid increment (k1=k2) set at 15 cents and a bidding cost (c) of 10 cents per bid. In analyzing returns based on surplus, factoring in sunk costs makes it harder for players to exit the auction, even exceeding their initial valuation of the item. (Fig. 1) By controlling variables in scenarios one and two (Fig. 2), considering with and without sunk costs, we observed that it actually change the equilibrium, if seem it as player 2 left when

the surplus is 0. There is a shift from an auction resembling an English Auction (the highest price win, but pay the second highest price) to a auction that benefits the auctioneer. This illustrates that sunk costs alter the original player equilibrium, significantly impacting outcomes.

In the third scenario, seem in Fig. 3, this research set the bid increment (k) to be less than the cost (c), aligning with the notion that, when treating cost c as a fixed cost, minimizing losses and maximizing surplus often involves smaller bid increments. However, through the same sequential game analysis, we discovered that compared to the case where k is greater than c, people exhibit greater stickiness in auctions when k is less than c. The sunk cost fallacy has a more pronounced effect, exacerbating losses and revealing a counterintuitive and intriguing phenomenon.

This paper believes that, in addition to the perspective of increased risk and enhanced risk-bearing capacity due to a heightened estimation of product value, there is also a sensitivity issue. Our assumption is that people's sensitivity to sunk costs is higher than their sensitivity to existing surpluses.

In real auction platforms, the common practice of setting bid increments lower than the bid cost to some extent supports the validity of this situation. Auctions, by capitalizing on individuals' sunk costs and leveraging this mindset, significantly increase their profitability.

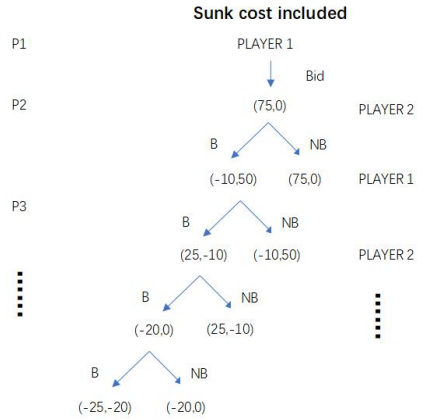

Fig. 1. Sunk cost included (Picture credit: Original).

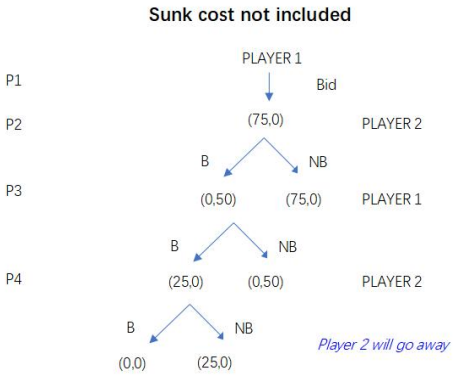

Fig. 2. Sunk cost not included (Picture credit: Original).

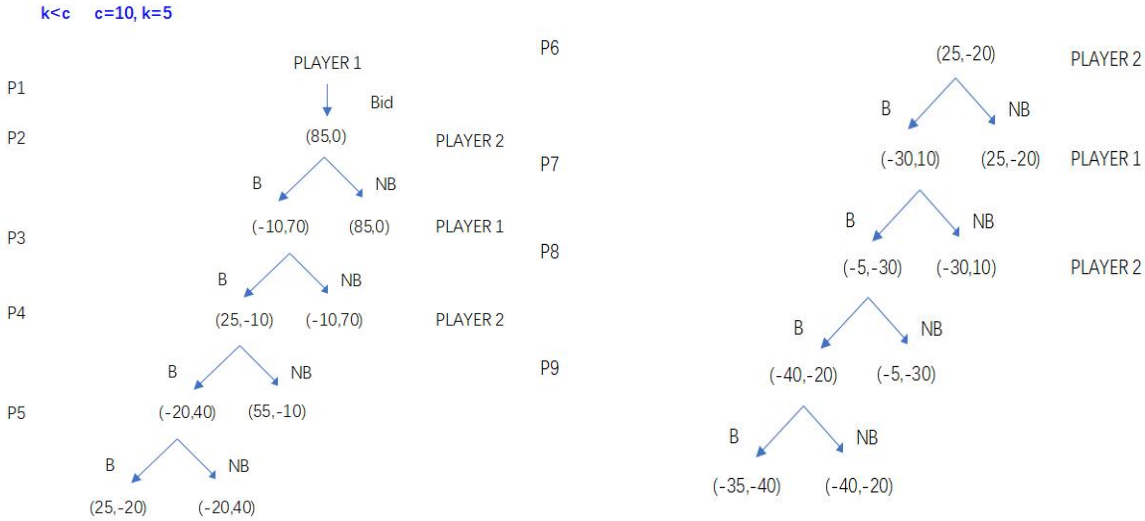

Fig. 3. Model when k < c (Picture credit: Original).

4 Empirical validation

To validate our model, this paper leverages data from DealDash, one of the largest penny auction platforms. Our empirical analysis supports the counterintuitive finding that higher bid costs relative to increments enhance auctioneer profitability. The observed bidding patterns and outcomes align with our theoretical predictions, confirming the impact of sunk costs on bidder behavior.

In the case study of DealDash, researchers aimed to gain insights into bidding behavior and patterns within the unique structure of penny auctions. DealDash, one of the largest and oldest penny auction websites since 2009, operates with distinct features: a bid fee of 12-15 cents, a fixed price increment of 1 cent, and a countdown clock that expires in 10 seconds. The platform also supports a buy-it-now function and a BidBuddy helper script.

The empirical analysis covered a 166-day period, from October 19th, 2017, to April 3rd, 2018, and included a total of 134,568 auctions with 174 million bids from 101,936 unique users. The researchers sought to answer two key questions: first, to understand the bidding patterns and their predictability, and second, to identify common bidding strategies and their quantifiable outcomes.

The findings from the case study revealed several significant aspects of bidding behavior:

(1) Optimization of Bids: Users tended to optimize their bids in alignment with the pay-per-bid auction structure. The majority of bids were placed at the last possible second before the timer expiration, indicating a strategic approach to maximize their chances.

(2) Repetitive Bidding Behavior: Users exhibited repetitive bidding behavior across auctions, leading to highly predictable sequences of bids. This pattern suggests that participants followed specific strategies influenced by the auction mechanics.

(3) Clustering of Bidders: Using similarity analysis, bidders were clustered based on their bidding behavior into five key categories, each defined by the dominant bidding strategy observed. Aggressive and persistent bidders were found to win a disproportionately high number of auctions, earning significant gains per auction.

(4) Low-Activity Bidders: Bidders with limited activity or constrained by budget won fewer auctions per user and faced challenges recouping losses from bid payments, resulting in a net loss.

Overall, the case study provided valuable insights into the predictability and strategies employed by users in the DealDash penny auctions. The findings contribute to understanding the dynamics of bidding behavior in the context of specific auction mechanisms and serve as a foundation for further research and analysis.

Shown as Fig. 2, through this paper's analysis of data from Swoopo, a similar characteristic is evident [11]. Similarly, prices exhibit predictable trends. However, according to my model analysis, when the bid fee is relatively low, individuals tend to increase the number of bids. Consequently, this leads to a higher final price for the same product. In empirical validation, this confirms the theoretical framework this paper has proposed.

5 Price predictability in Swoopo data

Similar to the observations in DealDash, the analysis of Swoopo data reveals a notable characteristic of price predictability. This consistency across different penny auction platforms strengthens the generalizability of the observed phenomena.

5.1 Impact of bid fee on bidding behavior

Diverging from DealDash, my model delves into the specific influence of bid fees on bidding behavior. In instances where the bid fee is lower, my analysis suggests a tendency among participants to increase their bidding frequency. This is a nuanced understanding that goes beyond the generic predictability of prices and sheds light on the factors influencing bidding strategies.

5.2 Correlation between bidding frequency and final price

Building on the bid fee influence, the analysis indicates a corresponding impact on the final price. With increased bidding frequency, a higher final price is likely to be observed. This correlation is a crucial insight that aligns with the theoretical framework proposed in my model.

5.3 Empirical validation of theoretical propositions

The empirical validation of my model involves scrutinizing real-world data from Swoopo, providing tangible evidence supporting the theoretical ideas presented. This not only strengthens the validity of the proposed model but also adds a layer of robustness through cross-platform consistency.

6 Further analysis emphasizing penny auctions and sunk-cost theory

In delving deeper into the realm of penny auctions and the sunk-cost theory, it is crucial to highlight the counterintuitive effects generated by auction platforms when setting bid fees higher than the incremental price 'k.' Additionally, understanding player stickiness, or the persistence of certain behaviors, adds a layer of complexity to the analysis.

Counterintuitive Effects of Bid Fee Setting:

One of the key focal points of our analysis is the auctioneer's decision to set bid fees higher than the incremental price 'k.' Conventionally, one might expect that increasing bid fees would deter bidders, as it raises the cost of participation. However, our empirical findings, consistent with theoretical predictions, reveal a counterintuitive phenomenon.

When bid costs surpass bid increments, bidders exhibit a strategic response rather than withdrawal. This counterintuitive behavior challenges traditional economic models and underscores the intricate dynamics at play in penny auctions. It suggests that participants, influenced by the sunk-cost fallacy and potential losses, intensify their commitment, hoping for a favorable outcome despite rising bid costs.

Player Stickiness in Penny Auctions:

Player stickiness, or the persistence of certain bidding behaviors, becomes a critical aspect to consider. In the context of higher bid fees, our analysis indicates that bidders tend to exhibit stickiness in their strategic approach. Rather than abandoning the auction, participants adjust their bidding strategies to align with

the new cost structure, showcasing adaptability and persistence.

The sunk-cost fallacy, wherein individuals continue investing resources based on prior commitments, plays a pivotal role in player stickiness. Bidders, reluctant to abandon their investment in bids, adjust their behavior to mitigate perceived losses, contributing to the observed stickiness.

Strategic Adaptation and Optimizing Outcomes:

Bidders, faced with higher bid fees, strategically adapt to optimize their outcomes. The empirical evidence from DealDash and Swoopo showcases a pattern where participants intensify their bidding activity, especially as the auction approaches its conclusion. This strategic behavior aligns with the goal of maximizing gains, even in the face of escalating bid costs.

Understanding the interplay between bid fees, sunk-cost considerations, and player stickiness provides a comprehensive framework for explaining the observed dynamics in penny auctions. It also emphasizes the need for auction platforms to carefully consider the setting of bid fees to influence bidder behavior and overall profitability.

In conclusion, our extended analysis underscores the multifaceted nature of penny auctions, where bid fee decisions interact with psychological factors, resulting in counterintuitive bidder strategies and persistent player behaviors. This nuanced understanding contributes to both the academic discourse on auction dynamics and offers practical insights for auction platforms seeking to navigate the delicate balance between profitability and bidder engagement (see Fig. 4).

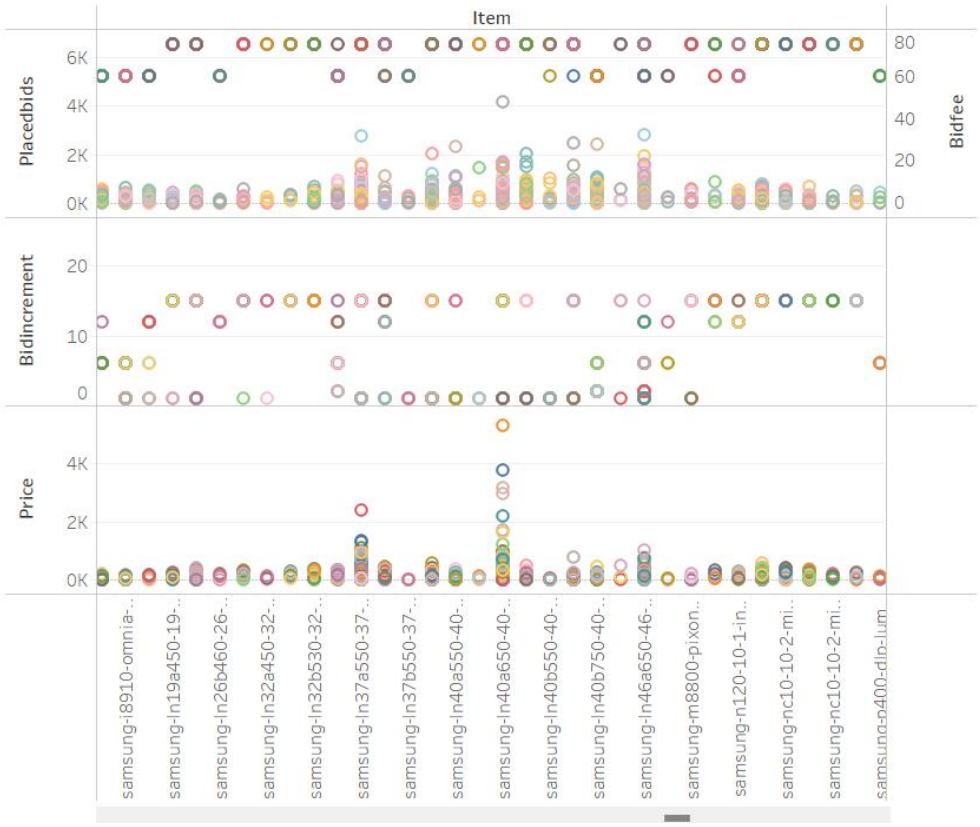

Fig. 4 Place bids, bid increment and bid fee comparison chart (Picture credit: Swoopo site)

7 Conclusion

In conclusion, the exploration of penny auctions, particularly within the context of the DealDash platform, sheds light on the intricate dynamics of user behavior and the underlying mechanisms that contribute to the profitability of such auctions. By integrating insights from the literature, model analysis, and the empirical case study, several key takeaways emerge.

Firstly, the empirical analysis of DealDash auctions reaffirms that users tend to strategically time their bids to maximize their chances of winning. The optimization of bids, especially observed in the last seconds before timer expiration, underscores the influence of the pay-per-bid auction structure on participants' decision-making.

Secondly, the identification of repetitive bidding behavior across auctions suggests that users develop and employ specific strategies in response to the unique features of penny auctions. This predictability in bidding sequences highlights the role of auction mechanics in shaping user interactions.

The clustering of bidders into distinct categories based on bidding behavior provides a nuanced understanding of the diverse strategies employed by participants. The dominance of aggressive and persistent bidders in winning auctions and achieving substantial gains emphasizes the competitive nature of these platforms.

Furthermore, the case study brings attention to the challenges faced by low-activity bidders or those constrained by budget limitations. Their struggle to win auctions and recoup losses underscores the potential risks and financial implications for participants engaging in penny auctions.

Drawing from the literature, the analysis aligns with previous discussions on the exploitation of human psychological tendencies, such as risk-seeking behavior and the sunk-cost fallacy, in penny auctions. The study contributes empirical evidence to the ongoing discourse on the profitability of penny auctions and the potential predictability of user behavior within these environments.

In the broader context, these findings have implications for both users and platform operators. Users may benefit from a more informed approach to bidding, considering the observed patterns and strategies. For operators, understanding the dynamics revealed in this study opens avenues for refining auction mechanisms or developing strategies to enhance user engagement and platform profitability.

While this research provides valuable insights, it also prompts further inquiries. Future studies could delve into the development of predictive models based on the identified bidding patterns, offering potential applications in designing adversarial bidding algorithms or refining auction platforms.

In essence, the multifaceted analysis presented here contributes to the evolving understanding of penny auctions, enriching the discourse on user behavior, predictability, and the intricate interplay between auction structures and participant strategies.

References

1. N. Augenblick, Rev Econ Stud **83**, 1 (2016)
2. T. Brünner, J. Reiner, M. Natter, B. Skiera, J Econo Behav Organ **164**, (2019)
3. Z. Xinyi, S. Shawn, T. Shiliang, Z. Haitao, Z. Ben Y., HT '18: Proceedings of the 29th on Hypertext and Social Media, (2018)
4. C. Bliss, B. Nalebuff, J Public Econ **25**, (1984)
5. H. Otsubo, A. Rapoport, J Confl Resolut **52**, (2008).
6. Bulow, Jeremy, Klemperer, Paul, Am Econ Rev **89**, 1 (1999).
7. B. C. Platt, J. Price, H. Tappen, Manag Sci **59**, 9 (2013).
8. T. Hinnosaar,. Penny Auctions. Northwestern Uni Working Paper, Dec (2016)
9. M. Caldara,. Uni Calif Irvine Working Paper, Dec (2013)
10. Z. Wang, M. Xu, Inf Econ Policy **36**, (2016)
11. J. Byers, M. Mitzenmacher, G. Zervas, Compu. Sci., Mar, (2010)