

Overbidding in All Pay Auctions with Incomplete Information

Introduction

The presence of overbidding in all-pay auctions with incomplete information challenges traditional economic predictions, raising questions about the applications of Nash equilibrium and other standard models in explaining more complex human behaviors. Experimental studies across various contexts consistently reveal a tendency for overbidding, where resource expenses often exceed the prize's value. This survey article condenses findings from the literature by examining important studies to explore the causes and effects of overbidding. By investigating factors like risk aversion, bounded rationality, and non-monetary motivations, these studies offer a detailed perspective on the strategic irregularities that define competitive environments.

Additionally, the article highlights methodological advancements and policy insights from this body of research, paving the way for future studies to address inefficiencies and improve theoretical models.

Previous Work

In their paper, *All-Pay Auctions: An Experimental Study*, Gneezy and Smorodinsky examine the dynamics of overbidding in repeated all-pay auctions under conditions of complete information and common value. Their experimental findings reveal significant overbidding, with seller revenues reaching two to three times the prize value, a result that challenges traditional economic predictions of bidding being close or equivalent to a prize's value.¹ While early rounds show revenue strongly correlated with the number of participants, this effect dissolves with

¹ Gneezy, Uri, and Rann Smorodinsky. "All-pay auctions—an experimental study." *Journal of Economic Behavior & Organization* 61.2 (2006): 255-275.

repetition, leading to revenues that are homogenous across group sizes. The study highlights the inaccuracy of Nash equilibrium in predicting the observed behaviors, as bidders consistently deviate from equilibrium strategies. Instead Logit equilibrium explains bidding behavior in the initial rounds, but as the game progresses Logit equilibrium becomes less accurate. Gneezy and Smorodinsky propose a two-stage decision framework to model bidding behavior: an initial stage determining whether or not to participate, followed by a second stage focused on how much to bid. Their work lays the foundation for understanding overbidding in all pay auctions with incomplete information. Gneezy and Smorodinsky's study serves as a foundational reference for understanding overbidding in all-pay auctions with incomplete information, as it highlights deviations from equilibrium predictions even in a complete information setting. Starting with this paper emphasizes the importance in identifying key behavioral patterns and decision-making processes that shape later research on auctions with incomplete information. Sheremeta² expands on these foundations by showing that overbidding is a persistent phenomenon in contests, with a median overbidding rate of 72% even among symmetric participants. His survey highlights psychological and strategic factors, such as the intrinsic value of winning. This offers insights into bidder behavior to guide future research in all-pay auctions with both complete and incomplete information.

Overbidding in all pay auctions with incomplete information is an extensive topic with a large literature, thankfully, Aycinena, Baltaduonis, and Rentschler's study, *Valuation Structure in Incomplete Information Contests: Experimental Evidence*³, provides us with a comprehensive

² Sheremeta, Roman M. "Overbidding and heterogeneous behavior in contest experiments." *A Collection of Surveys on Market Experiments* (2013): 109-134.

³ Aycinena, Diego, Rimvydas Baltaduonis, and Lucas Rentschler. "Valuation structure in incomplete information contests: experimental evidence." *Public Choice* 179 (2019): 195-208.

literature to help build a foundation for understanding this topic. The study of overbidding in all-pay auctions with incomplete information highlights the relationship between uncertainty, strategic behavior, and inefficiencies caused by rent-seeking. All-pay auctions are a well-researched topic in contexts ranging from monopoly lobbying to warfare. Previous research has identified conditions for symmetric, monotone equilibria based on affiliation assumptions. Later research built upon computational and theoretical frameworks but continued to rely on restrictive monotone assumptions. Studies have primarily focused on contests with independent private values, leaving a gap in understanding contests involving common values or mixed-value settings. These scenarios are especially relevant because they introduce the potential for the winner's curse, a phenomenon well-documented in winner-pay auctions. Recent experimental studies address this gap by examining overbidding behavior across pure common-value, pure private-value, and mixed-value environments. These investigations reveal that overbidding is widespread, consistent with the winner's curse, and varies in severity based on the valuation structure. These findings carry important implications for understanding rent dissipation and the inefficiencies of rent-seeking in real-world scenarios. These findings highlight the need for further exploration of how valuation structures influence strategic behavior and economic outcomes in all-pay auctions.

Aycinena, Baltaduonis, and Rentschler's study, *Valuation Structure in Incomplete Information Contests: Experimental Evidence*, examines how valuation structures influence bidding behavior in all-pay contests under incomplete information. Comparing private-value (PV), common-value (CV), and mixed private-common value (PC) contests, the authors find that participants consistently overbid relative to Nash equilibrium predictions, leading to significant

losses in prize value. Overbidding is most pronounced in CV contests, driven by uncertainty about the prize's value and the winner's curse, while PV contests exhibit the least overbidding due to known values. PC contests show intermediate behavior, blending elements of both structures.⁴ Despite feedback, participants struggle to adopt equilibrium strategies, particularly in CV and PC settings, highlighting the inefficiencies in rent-seeking environments. By introducing a mixed-value structure, the study bridges theoretical models and real-world contests, offering insights into the strategic and behavioral drivers of overbidding and its broader social costs.

Ewert, Heidekrüger, and Bichler's study, *Approaching the Overbidding Puzzle in All-Pay Auctions: Explaining Human Behavior through Bayesian Optimization and Equilibrium Learning*, introduces new methodology for understanding overbidding in all-pay auctions. By leveraging Bayesian optimization and equilibrium learning, the authors propose a regression framework to model unobservable parameters of bidders' utility functions from experimental data. This allows for direct comparisons of competing behavioral theories on overbidding. Their findings demonstrate that risk aversion better explains behavior in two-player auctions, while anticipated regret aligns more closely with data from four-player contests, suggesting that the environment influences overbidding. Using a Gaussian Process model, the framework evaluates and estimates equilibrium strategies, achieving a high goodness-of-fit across datasets.⁵ This methodology not only addresses observed deviations from risk-neutral Bayesian Nash equilibrium but also provides a tool for analyzing human behavior in complex auction

⁴ Aycinena, Diego, Rimvydas Baltaduonis, and Lucas Rentschler. "Valuation structure in incomplete information contests: experimental evidence." *Public Choice* 179 (2019): 195-208.

⁵ Ewert, Markus, Stefan Heidekrüger, and Martin Bichler. "Approaching the overbidding puzzle in all-pay auctions: Explaining human behavior through Bayesian optimization and equilibrium learning." In *Proceedings of the 21st International Conference on Autonomous Agents and Multiagent Systems*, pp. 1586-1588. 2022.

environments, which offers insights into the psychological and strategic factors in the overbidding puzzle.

Breaban, Noussair, and Popescu's study, *Contests with Money and Time: Experimental Evidence on Overbidding in All-Pay Auctions*, investigates bidding behavior in contests with both monetary and time-based rewards, they find evidence of overbidding in both mediums. In monetary auctions, participants bid currency for a prize; while in time auctions, they bid reductions in waiting time, with non-winners extending their wait by their bid amount. Overbidding is a constant across both formats, with bids exceeding risk-neutral Bayesian equilibrium levels, which leads to excessive rent losses and negative average earnings for participants.⁶ The magnitude of overbidding does not differ significantly between the two mediums, which highlights the consistency of overbidding regardless of reward framing. The authors find that cognitive factors influence outcomes, as higher CRT scores correlate with lower bids and better performance. This is especially the case in monetary auctions, while probability miscalculation is linked to more aggressive overbidding in time auctions. Gender differences are also notable, with women bidding more aggressively in monetary contests but not time-based contests.

Noussair and Silver's paper, *Behavior in All-Pay Auctions with Incomplete Information*, examines bidder behavior, revenue, and efficiency in single-unit all-pay auctions under an incomplete information framework. Their experimental design includes 25 auction periods, where participants bid nonrefundable amounts against valuations drawn from a uniform distribution. Results reveal that bidders consistently overbid relative to Bayesian Nash

⁶ Breaban, Adriana, Charles N. Noussair, and Andreea Victoria Popescu. "Contests with money and time: Experimental evidence on overbidding in all-pay auctions." *Journal of Economic Behavior & Organization* 171 (2020): 391-405.

equilibrium predictions, particularly for high valuations above 800, which drives the auction's revenue above theoretical benchmarks and that of comparable winner-pay auctions.

Low-valuation bidders frequently bid zero, aligning with equilibrium predictions for risk-averse behavior, while mid-range valuations (500–800) exhibit bids below equilibrium, participants then shifted to overbidding for higher valuations. Over time, participants adjust their strategies which reduces extreme overbidding, yet bids remain consistently above equilibrium even in later rounds. This behavior is consistent with risk aversion, as high-valuation bidders prioritize winning despite costs exceeding equilibrium levels. Overbidding increases revenue and offsets inefficiencies caused by zero bids from low-valuation participants, while learning effects indicate gradual movement toward more strategic bidding. The study highlights how incomplete information increases revenue generation in all-pay auctions and demonstrates the role of behavioral factors in competitive decision-making.

Barut, Kovenock, and Noussair (2002) examine overbidding behavior in multiple-unit all-pay auctions under incomplete information, using a model based on an independent private values (IPV) framework. In their setup, bidders compete for k identical units, with each bidder's valuation for a unit drawn independently from a uniform distribution on $[0,1]$. These valuations are private and differ across both bidders and units. While the Bayesian Nash equilibrium predicts full rent dissipation in this auction format, the authors observe significant overbidding.⁷ This overbidding arises from the strategic complexity of balancing the desire to secure higher winning probabilities against the cost of inflated bids. Despite this deviation from equilibrium predictions, the auction remains efficient, as units are awarded to those with the highest

⁷ Barut, Yasar, Dan Kovenock, and Charles N. Noussair. "A comparison of multiple-unit all-pay and winner-pay auctions under incomplete information." *International Economic Review* 43, no. 3 (2002): 675-708.

valuations. However, the observed overbidding drives auction revenues above theoretical expectations, illustrating how incomplete information can influence outcomes in all-pay auctions.

Overbidding in all-pay auctions with incomplete information arises from strategic uncertainty and the challenge of anticipating competitors' unknown values or bidding strategies. Galgana and Golrezaei (2023) shed light on this behavior within the context of repeated multi-unit pay-as-bid auctions, where bidders compete for multiple units by submitting bid vectors. In their model, each bidder's valuation exhibits a diminishing marginal value structure, meaning the value of additional units decreases as more units are acquired.⁸ This structure, combined with incomplete information about competitors' bids, creates a complex strategic environment where bidders may overbid to avoid losing desired units. The authors address these dynamics using dynamic programming techniques and online learning algorithms, demonstrating that bidders can adapt their strategies over time, ultimately converging to equilibria with uniform bids that maximize welfare. Despite this, the inherent challenges posed by diminishing marginal valuations and limited information help explain why overbidding remains prevalent.

Rentschler and Turocy (2020) explore overbidding in all-pay auctions with incomplete information, focusing on a valuation structure where each bidder's private value is independently drawn from a uniform distribution over $[0,1]$. In this strategic environment, bidders must decide how much to bid without knowing their opponents' valuations. The authors find that bidding behavior consistently deviates from the predictions of the symmetric Bayes-Nash equilibrium, which suggests that rational bidders should bid proportionally to their valuations to maximize

⁸ Galgana, Rigel, and Negin Golrezaei. "Learning in Repeated Multi-Unit Pay-As-Bid Auctions." *arXiv preprint arXiv:2307.15193* (2023).

expected utility. Instead, participants often bid more than the equilibrium predicts, even when this reduces their expected payoffs. This overbidding is driven by behavioral factors such as risk-seeking, where bidders are willing to take gambles on uncertain payoffs, and the psychological satisfaction of winning, regardless of monetary outcomes. Additionally, the study identifies cognitive challenges in translating private valuation information into optimal bids, which further contribute to these deviations.⁹ Overall, the findings demonstrate how private valuations amplify strategic missteps, revealing the influence of incomplete information and behavioral biases on bidding in competitive all-pay auctions.

Implications and Future Research

Overbidding in all-pay auctions with incomplete information provides important insights into competitive behavior and the inefficiencies it creates in resource allocation. Research consistently shows that bidding often exceeds Nash equilibrium predictions. This effect is especially pronounced in contests with common-value components, where uncertainty encourages aggressive bidding. Factors such as bounded rationality, intrinsic motivations, and risk aversion drive this behavior, leading to substantial rent losses as participants spend resources exceeding the prize's value. These findings highlight the challenge of designing policy to reduce inefficiencies in settings like lobbying, defense procurement, and market competition.

Incomplete information further exaggerates deviations from equilibrium strategies. Uncertainty about opponents' valuations or the true value of the prize often leads to suboptimal decisions. Aycinena et al. show that mixed private-common value settings increase the winner's curse, causing participants to overbid even when it results in negative expected payoffs. The

⁹ Rentschler, Lucas, and Theodore L. Turocy. "Tu mihi soli places: An experiment on the competitiveness of all-pay auctions with private information." (2020).

persistence of overbidding, even with repeated feedback, highlights the difficulty of learning optimal strategies in these environments. This has significant policy implications, as excessive spending not only reduces individual payoffs but also creates broader social costs, which ultimately decreases the efficiency of resource allocation.

The diversity of bidding behaviors, influenced by factors such as risk tolerance, cognitive abilities, and valuation structures, complicates the ability of universal models to predict outcomes. Sheremeta and others argue that motivations like intrinsic satisfaction from participation or inequality aversion add further complexity to auction strategies. To address these challenges, innovative approaches like the Bayesian optimization models proposed by Ewert et al. provide tools to infer hidden preferences and refine theoretical predictions. Bridging experimental insights with robust theoretical frameworks enables future research to better understand overbidding and to design auction mechanisms that encourage more strategic and equitable outcomes.

Future research should focus on improving behavioral models to capture the psychological and strategic complexities of overbidding in all-pay auctions. While existing models such as symmetric Logit equilibria and Bayesian Nash equilibria offer valuable insights, they fall short in explaining consistent deviations from equilibrium behavior. Incorporating dynamic learning mechanisms, such as reinforcement learning or regret minimization, could reveal how participants adjust their strategies over time. Additionally, exploring the impact of external/internal factors such as incentive structures, framing effects, and prize visibility could improve understanding of bidding behavior. Further studies should test hybrid auction designs that combine features of all-pay and winner-pay mechanisms or implement dynamic pricing

systems to mitigate overbidding. Research into information disclosure, such as revealing partial valuations or providing real-time feedback, could also improve auction efficiency.

Conclusion

Research on overbidding in all-pay auctions with incomplete information highlights a complex interaction of psychological, strategic, and contextual factors that contribute to deviations from equilibrium behavior. Despite advancements in experimental design and modeling, significant gaps remain in understanding how participants adapt their strategies in dynamic and uncertain environments. This survey emphasizes the need to incorporate behavioral insights and improve auction mechanisms to reduce inefficiencies and promote strategic consistency. Future research directions, such as exploring hybrid auction formats, testing the effects of information disclosure, and applying innovative modeling approaches like Bayesian optimization, promise to enhance our understanding of these phenomena.

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