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Strategic Selection and Design of the First Auction Item: Analyzing Auction Dynamics through “Motion in Mind” and “Potential Reinforcement Energy”

Pemilihan dan Reka Bentuk Strategik Item Lelongan Pertama: Menganalisis Dinamika Lelongan melalui "Motion in Mind" dan "Potential Reinforcement Energy"

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ABSTRACT

This study examines how the strategic selection and design of the first auction item using the "Motion in Mind" and "Potential Reinforcement Energy" frameworks influence auction dynamics, affecting participation and competitiveness. The initial item's selection, based on its starting and expected prices, triggers bidder motivations such as personal expression, artistic appreciation, and status signaling, driven by gameplay incentives, which dictate the auction's competitive pace. Data from major auction houses, including Christie's and Sotheby's, were analyzed using correlation analysis and multivariate regression modeling. The findings indicate that the strategic placement of the initial item significantly impacts auction velocity and the deviation of final auction prices from pre-auction estimates, highlighting the auction's multidimensional nature influenced by economic, psychological, and social factors. The research suggests that effective auction design requires accommodating diverse bidder preferences across financial, personal, and social dimensions. A deep understanding of bidder motivations, precise pricing strategies, and nuanced market analysis is crucial for maintaining participant engagement and optimizing auction success. This paper underscores the transcendence of auctions beyond economic transactions, involving a complex interplay of strategic, self-actualization, and engagement motives, as well as non-economic utilities, reflecting broader human behavior and social interactions.

Keywords**:** Motion in Mind; Potential Reinforcement Energy; Auction Design; First Auction Item; Gameplay Incentives

ABSTRAK

Kajian ini mengkaji bagaimana pemilihan dan reka bentuk strategik item lelongan pertama menggunakan rangka kerja "Motion in Mind" dan "Potential Reinforcement Energy" mempengaruhi dinamika lelongan, memberi kesan kepada penyertaan dan daya saing. Pemilihan item awal, berdasarkan harga permulaan dan harga jangkaannya, mencetuskan motivasi pembida seperti ekspresi peribadi, penghargaan seni, dan isyarat status, yang didorong oleh insentif permainan yang menentukan kelajuan persaingan lelongan. Data daripada rumah lelongan utama, termasuk Christie's dan Sotheby's, dianalisis menggunakan analisis korelasi dan pemodelan regresi multivariat. Dapatan kajian menunjukkan bahawa penempatan strategik item pertama memberi kesan yang ketara kepada halaju lelongan dan penyimpangan harga akhir lelongan daripada anggaran pra-lelongan, menonjolkan sifat multidimensi lelongan yang dipengaruhi oleh faktor ekonomi, psikologi, dan sosial. Kajian ini mencadangkan bahawa reka bentuk lelongan yang berkesan memerlukan pengambilan kira terhadap keutamaan pembida yang pelbagai merentasi dimensi kewangan, peribadi, dan sosial. Pemahaman mendalam tentang motivasi pembida, strategi penetapan harga yang tepat, dan analisis pasaran yang terperinci adalah penting untuk mengekalkan penglibatan peserta dan mengoptimumkan kejayaan lelongan. Kertas ini menekankan bahawa lelongan bukan sekadar transaksi ekonomi, tetapi melibatkan interaksi kompleks antara strategi, pemenuhan diri, dan motivasi penglibatan, serta utiliti bukan ekonomi, yang mencerminkan tingkah laku manusia dan interaksi sosial yang lebih luas.

Kata kunci: Motion in Mind; Potential Reinforcement Energy; Reka Bentuk Lelongan; Item Lelongan Pertama; Insentif Permainan

INTRODUCTION

The auction market is a significant component of the economic market. Unlike negotiated markets, auctions follow specific transaction rules, making them a vital area for studying resource allocation and price formation (W. Vickrey, 1961). Auctions adhere to rules set and announced by the organizers, with bidders placing bids within a specified timeframe according to these established rules, and completing the payment transaction as per the rules once bidding concludes. The clear transaction rules and defined transaction timeframe have attracted numerous economists and game theory researchers, including many Nobel laureates in economics, to focus on auctions as a research field (The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel, 2020). The complexity and competitiveness of the auction process create a classic game structure where participants' dynamic decisions and actions during auctions can be modeled, enriching the theories and applications in game theory and its subfield, auction theory (Majadi et al., 2017). Auction dynamics have been extensively studied to understand how various factors influence bidder behavior and auction outcomes. Traditional methods typically focus on economic and strategic factors, such as bidder rationality, auction formats, and price determination mechanisms. These studies have laid a

solid foundation for understanding the fundamental economic interactions that occur during auctions.

Iida et al. have long been dedicated to research based on game and game behavior, proposing the Game Refinement Theory. Recent theoretical developments have introduced new dimensions to auction dynamics analysis, such as the "Motion in Mind" framework, which offers a new perspective on the field (Mohd Nor Akmal and Iida, 2021). In our previous research, we found that auctions exhibit significant "non-economic utilities" based on the concept of "conspicuous consumption" (T. Veblen, 2017), where participants display their wealth and social status by owning and using these items (P. West, 2004). This behavior aligns with the efforts of game participants to "win," driven by gameplay incentives. When participants are not particularly sensitive to the auction's final price, auctions can be viewed as a form of entertainment (Li et al., 2024). The game psychology and the duration of the game in auctions can significantly impact bidders' participation and decision-making processes. We analyze auctions using the "Motion in Mind" framework, which emphasizes the psychological dynamics bidders experience during auctions, influencing their perception of value and willingness to continue participating. Recent theoretical developments have introduced new dimensions to auction dynamics analysis, such as the "Motion in Mind" framework, which offers a new perspective on the field (Mohd Nor Akmal and Iida, 2021). In our previous research, we found that auctions exhibit significant "non-economic utilities," a concept often discussed in game theory and behavioral economics (Li et al., 2024), where participants derive value not just from the economic gain but also from displaying their wealth and social status, a phenomenon closely related to "conspicuous consumption" as described by Thorstein Veblen (T. Veblen, 2017). Participants demonstrate their social standing through their bidding behavior and the items they acquire (P. West, 2004). This behavior aligns with the efforts of game participants to "win." When participants are not particularly sensitive to the auction's final price, auctions can be viewed as a form of entertainment (Li et al., 2024). The game psychology and the duration of the game in auctions can significantly impact bidders' participation and decision-making processes. We analyze auctions using the "Motion in Mind" framework, which emphasizes the psychological dynamics bidders experience during auctions, influencing their perception of value and willingness to continue participating.

Similarly, the "Potential Reinforcement Energy" framework introduces a new method for understanding auctions by focusing on the reinforcement and motivational aspects of bidding. This theory suggests that auctions are not just economic transactions but involve complex psychological engagement that can profoundly affect bidder behavior. By examining the potential energy bidders accumulate through the anticipation and fulfillment of winning bids, this framework provides insights into the emotional and psychological rewards of participation.

This paper focuses on the analysis of the first auction item in each English auction. English auctions have a long history, dating back approximately 2,500 years to ancient Babylon as recorded by Herodotus in the 5th century BC (Baranwal et al., 2018). Auction houses, such as the renowned Christie's and Sotheby's, established in 1744 and 1766 respectively, also have a long history. The design of the auction order for each auction item by auction houses has been

proven effective through historical examination. The first auction item plays multiple roles, setting the tone for the auction, establishing the bidding pace, and attracting potential bidders. The design of the first auction item by auction houses can significantly influence the overall rhythm and competitive environment. By carefully selecting and designing the first item (considering factors like price range, starting price, expected price, and auction game velocity), auction houses can manipulate the dynamics of the auction to enhance bidder participation and maximize final outcomes.

In this paper, we explore the intricate dynamics of auction design through the lenses of the "Motion in Mind" and "Potential Reinforcement Energy" frameworks. The remainder of this paper is structured as follows: Section 2 reviews related theories, including Game Refinement Theory, Game Progress Model, and Reinforcement Theory, and their applications to auction analysis. Section 3 details the methodology employed in our study, including data collection and analytical techniques. Section 4 presents the results of our analysis, highlighting the impact of the first auction item on overall auction dynamics. Section 5 provides a comprehensive discussion of the findings, emphasizing the psychological and economic implications for auction design. Finally, Section 6 concludes the paper with a summary of key insights and suggestions for future research directions.

RELATED THEORIES

Our analysis employs three pivotal theories to dissect the essence of game playing and its manifestation in auctions: the Game Refinement Theory, the Game Progress Model, and Reinforcement Theory. Game Refinement (GR) theory assesses a game's allure and the predictability of its outcomes through an information science lens, suggesting that a GR value between 0.07 and 0.08 denotes optimal player engagement (Iida et al., 2004) (Sutiono et al., 2014). The computation of GR is tailored to the game type and involves metrics such as average branching factor (*B*), game length (*D*), successful scores (*G*), and attempts per game (*T*):

$$GR = \frac{\sqrt{B}}{D} = \frac{\sqrt{2G}}{T} = \sqrt{a} \qquad (1)$$

The Game Progress Model quantifies how players' perceptions evolve during gameplay, particularly as they draw analogies to decipher new patterns and abstract concepts. This model mathematically expresses the resolution of uncertainty as velocity (*v*) and the complexity of decisions as mass (*m*), enhancing our understanding of strategic thinking in games that reflect real-world physics:

$$v = \frac{B}{2D} = \frac{G}{T} = 1 - m \qquad (2)$$

Reinforcement theory complements this by considering how game outcomes (rewards, punishments) shape player behavior through variable-ratio reinforcement schedules (*V R(N)*), which sustain engagement by delivering rewards at unpredictable intervals (Iida and Mohd Nor Akmal, 2020) (C. B. Ferster and B. F. Skinner, 1957).

1. Cognitive Dynamics in Games

The analogy of free-fall motion describes players' experience of resolving uncertainties in games, akin to uniformly accelerated motion influenced by mental gravity, depicted in the following equations:

$$y = \frac{1}{2}a_0 t^2 \qquad (3)$$

$$y = vt \ \ where \ \ v = \frac{1}{N} \qquad (4)$$

The intersection of these dynamics at specific points (Eq. (5)) illustrates the peak of uncertainty resolution during gameplay, providing a visual representation in Figure 1.

$$y_{12} = y(t_{12}) = y(\frac{T}{N}) = \frac{T}{N^2} \qquad (5)$$

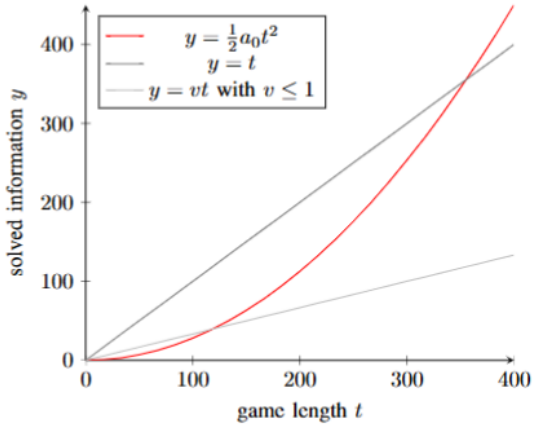

FIGURE 1. An illustration of the process of solving uncertainty of the outcome of a thing: straight line and gravity-in-mind curve

Figure 2 illustrates the potential reinforcement energy (*PRE*) and magnitude of extraordinary experience (*MEE*) with a focus on the two cross points. It suggests that people would be highly engaged in a purely random reward event around the cross point between Eq. (6) with η = N and Eq. (7). On the other hand, people would be highly engaged in a competitive event around the cross point between Eq. (6) with η = 1 and Eq. (7).

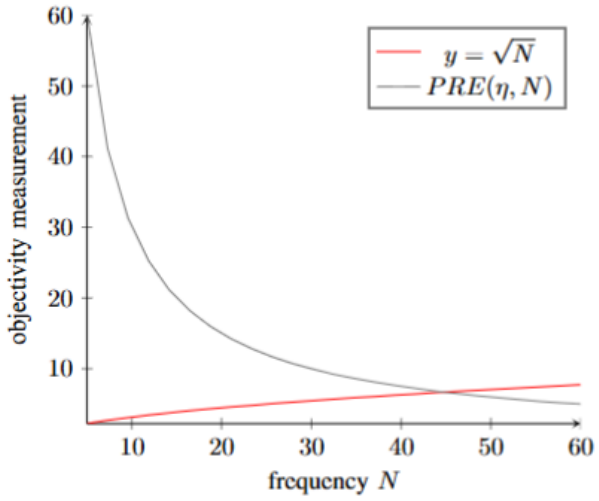

FIGURE 2**.** An illustration of potential reinforcement energy (PRE) and magnitude of extraordinary experience (MEE)

Potential Reinforcement Energy (*PRE*) quantifies the energy exerted by players in navigating challenges, expressed as:

$$PRE(\eta) = \eta \frac{\mathrm{T}}{\mathrm{N}^2} \qquad (6)$$

Magnitude of Extraordinary Experience (*MEE*) gauges the intensity of mental exertion relative to a normative baseline, calculated as follows:

$$MEE = \frac{a}{a_0} = \sqrt{N} \quad (7)$$

2. Applying Game Dynamics to Auction Analysis

Integrating GR theory and cognitive dynamics into auction analysis offers novel insights into bidder strategies and behaviors, reflecting how deeply game theory concepts are interwoven with the mechanics of auctions.

Consumers engaging in conspicuous consumption often pay a price exceeding an item's actual value (T. Veblen, 2017). Auctions can be seen as a leisurely game when participants are less sensitive to final prices (Iida et al., 2004). Bidders in some auctions appear less sensitive to the final auction price, indicating that price is not always the primary decision-making factor. This could be due to non-price factors such as rarity, emotional value, or strategic purposes, as well as the purchasing power required to participate in the auction. For unique items, sentimental or commemorative value may exceed market value. Therefore, analyzing decision-making behavior patterns in auction markets should consider non-economic utilities. Real-world auction decisions are complex to measure, but within the context of GR theory and the Motion-in-Mind framework, players reduce uncertainty as auctions progress. Uncertainty arises from the final sale price or hammer price. Auctions begin with a starting price and end when a winner is declared. The frequency of bids and the success rate of the winner become certain.

This research provides an analysis of the auction system through the combined perspectives of GR theory and the Motion-in-Mind framework. It emphasizes the parallels between auction dynamics and game mechanics, particularly within the realm of leisure games, where the act of bidding itself is inherently a strategic game. In these settings, auction participants often exhibit reduced sensitivity to the final price outcomes, influenced by factors such as the item's rarity, emotional significance, or strategic use, along with their financial capacity. Whether in English or Dutch auction formats, the transformation from an initial asking price (I_{price}) to the final selling price (F_{price}) serves as a key metric. The extent of this price transformation is assessed by the relative change between the initial and final prices. Drawing on GR theory and the game progress model, we define the metric *m* to quantify the challenge presented by the price change throughout the auction, where *m* ranges from 0 (indicative of mild competition) to 1 (indicative of intense competition). The concepts of velocity and frequency of the auction are quantified next.

$$m = \frac{|Final\ Price - Initial\ Price|}{max(Final\ Price, Initial\ Price)} \quad where \quad 0 \leq m \leq 1 \qquad (8)$$

$$v = 1 - m = \frac{min(Final\ Price, Initial\ Price)}{max(Final\ Price, Initial\ Price)} \qquad (9)$$

$$N = \frac{1}{v} = \frac{max(Final\ Price, Initial\ Price)}{min(Final\ Price, Initial\ Price)} \qquad (10)$$

These equations standardize our approach to analysing the dynamics of auction pricing, allowing for a deeper understanding of the strategic decision-making processes in auction markets, beyond just economic factors. In addition to the 'non-economic value' derived from ostentation in auctions, the gamification of the process introduces a novel 'non-economic utility' for participants, referred to as 'game value'.

Two points warrant further clarification. Firstly, despite the variance in currency across different auction markets, this study focuses exclusively on the relative numerical differences in prices, avoiding currency conversion to ensure a more focused analysis of the psychological and strategic impacts of these price variations. Secondly, given the high stakes typically involved in art auctions, where bid increments are substantial, we adjust our analysis to align with cognitive processing patterns commonly observed in humans; both the initial and final prices are normalized by the smallest bid increment. This normalization not only aids in simulating a sense of acceleration in the bidding process but also mirrors the psychological state and strategic decisions of the bidders during the auction.

METHODOLOGY

In our study, data were sourced from the world's leading auction houses, Christie's and Sotheby's. We accessed public auction data through their official websites and YouTube channels. The URLs for these sources are https://www.christies.com and https://www.sothebys.com, with the corresponding YouTube channels being https://www.youtube.com/@christies and https://www.youtube.com/@sothebys. To ensure the

legality of our data collection process, we refrained from using web scraping techniques and instead opted for manual data collection. After acquiring the data, we utilized MATLAB R2022b for conducting correlation analysis and multivariate regression modelling, which facilitated the modelling of participant perspectives.

Moreover, our analysis was bifurcated into two distinct viewpoints: the observer and the participant. Using game trees and game refinement theory, we analysed the behaviours and motivations of viewers during the auction process and their impact on auction dynamics. This analysis helps us understand how observers perceive various dynamics of the game by witnessing the actions of the participants, potentially motivating them to transition from mere viewers to active participants.

From the participant's perspective, i.e., the bidders, we focused on analysing the influence of starting bids, final prices, and the pace of the auction on their decision-making processes. Additionally, a comparative analysis was conducted, comparing the starting and final prices and the pace of the first auctioned item against the averages for other items in the auction.

These comprehensive analyses not only enhance our understanding of auction dynamics but also provide strategic insights for auction houses on designing auction processes and items to attract more participants. Our findings illustrate that auctions are not merely economic transactions but involve complex psychological and social dynamics, characterizing them as strategic games.

RESULTS

In this study, we compared the first lots of Christie's and Sotheby's auctions in different regions (Hong Kong, London, New York) with the average data of the entire auction. We found that the first lots exhibited significant attractiveness and artistic value in multiple dimensions. Specifically, the average number of bids (*BID*) for the first lots was 19, compared to the average of 10 for the entire auction, indicating higher market attention from participants (see Table 1). Additionally, the average game mass (*m value*) for the first lots was 0.716, much higher than the overall auction average of 0.331, suggesting that the first lots typically had higher game quality (see Figure 3). In terms of game velocity (*v value*), the first lots had an average value of 0.284, lower than the overall average of 0.669, reflecting more intense competition among participants (see Figure 4). Finally, the average game frequency (*N value*) for the first lots was 3.950, significantly higher than the overall average of 1.504, indicating that the first lots triggered more frequent bidding activities (see Figure 5).

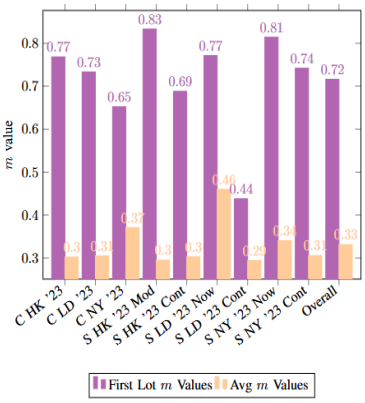

Fig. 3. Comparison of m value: First Lot vs Average for One Auction

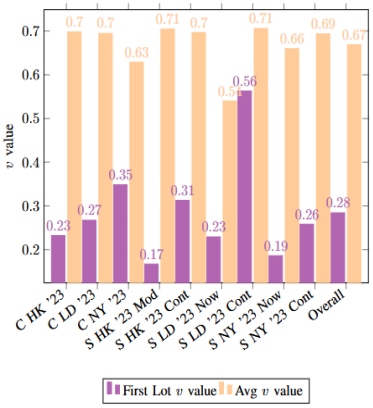

Fig. 4. Comparison of v value: Average vs First Lot for One Auction

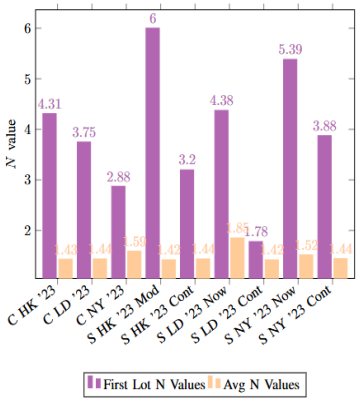

Fig. 5. Comparison of N Values: First Lot vs Average for One Auction

TABLE 1. Comparison of the First Lot of the Auction VS. Average Data

Auction	The First Lot of the Auction				Avg. data for One Auction			
	BID	**M**	**V**	**N**	**BID**	**M**	**V**	**N**
HK '23	34	0.768	0.232	4.313	8	0.302	0.698	1.433
C LD '23	14	0.733	0.267	3.750	9	0.305	0.695	1.438
C NY '23	18	0.652	0.348	2.875	11	0.371	0.629	1.590
S HK '23 Mod	25	0.833	0.167	6.000	7	0.295	0.705	1.418
S HK '23 Cont	17	0.688	0.313	3.200	8	0.303	0.697	1.435
S LD '23 Now	23	0.771	0.229	4.375	12	0.460	0.540	1.852
S LD '23 Cont	8	0.438	0.563	1.778	8	0.294	0.706	1.417
S NY '23 Now	20	0.814	0.186	5.385	13	0.340	0.660	1.516
S NY '23 Cont	15	0.742	0.258	3.875	12	0.306	0.694	1.442
Overall	19	0.716	0.284	3.950	10	0.331	0.669	1.504

Note 1: C: Christie's; S: Sotheby's

Note 2: HK: Hong Kong; LD: London; NY: New York

Note 3: Mod: Modern; Cont: Contemporary

1. Game Analysis

From the perspective of early GR theory, as shown in the table below, Mohd Nor Akmal, K et al.'s previous research paper concluded that $m \approx 0.79$ indicates the zone for competitive play mode, $m \approx 0.5$ indicates the neutral zone (such as Go and score-limit sports like table tennis and badminton), and $m \approx 0.21$ indicates the zone for easy-win play mode (Mohd Nor Akmal and Iida 2021). The auction data shows that the average m value of the first lots is 0.716, which is close to the competitive play mode zone (0.79), while the average m value of all lots in the entire auction is 0.331, falling between the neutral zone (0.5) and the easy-win zone (0.21), as shown in Table 2.

TABLE 2: Game Analysis

Category	Game	v	m
Board Games	Chess	0.22	0.78
	Shogi	0.35	0.65
	Go	0.60	0.40
Sports	Soccer	0.11	0.89
	Badminton	0.58	0.42
	Basketball	0.27	0.73
	Basketball	0.50	0.50
Major Public Gambling	Online casino	0.96	0.04
	Pachinko/Pachislot	0.85	0.15
	Horse race	0.80	0.20
	Speedboat race	0.75	0.25
	Bicycle race	0.75	0.25
	Auto race	0.70	0.30
	Lottery	0.46	0.54
Auction	Average Data	0.67	0.33
	The First Lot	0.28	0.72
	Core auction items	0.71	0.29

2. Understanding the Motivations and Addiction Mechanisms Behind the m value in Auctions

In an auction environment, the m value of a lot reflects its level of uncertainty and challenge, significantly impacting participants' behaviour and psychological responses. In an auction environment, the m value of a lot reflects its level of uncertainty and challenge, significantly impacting participants' behaviour and psychological responses. According to the research by Mohd Nor Akmal and Iida (Mohd Nor Akmal and Iida, 2021), in high-risk and uncertain decision-making environments, people tend to overestimate the psychological impact of potential losses compared to gains of the same value.

The average m value of the first lots is 0.716, significantly higher than the average m value of all lots in the entire auction, which is 0.331. This significant difference reveals the uniqueness of the initial lots in attracting participants. A higher m value indicates greater uncertainty and challenge, making these lots more attractive. In the context of an auction where the items being traded are luxury goods, the price elasticity of luxury goods differs from that of essential goods (W. E. Hauck and N. Stanforth, 2007). Although luxury goods are generally more elastic, their scarcity significantly influences consumer demand. Higher uncertainty implies greater difficulty and challenge in acquiring the item, reinforcing the notion of the item's high scarcity in the minds of participants. The higher m value of the first lots (average 0.716 as shown in Table 2) indicates that these initial lots are not only more challenging but also likely to evoke a stronger sense of potential victory, thus stimulating more active participation. This psychological state can lead to higher engagement and addictive behaviour, as participants, especially those who did not win the lot, become more actively involved in subsequent bids to win.

On the other hand, as shown in Table 3, the initial and final prices of the first auction items are lower than the average initial and final prices of the entire auction. This places participants in an intriguing position where the cost of participating in this game is relatively low, but the challenge is high. This greatly enhances the enjoyment for participants. Additionally, because the challenge is significant, participating but not winning is not a cause for embarrassment. Combined with the relatively low cost of participation, the failure to win is decoupled from the individual's asset level, thus removing the burden of losing.

For auction organizers, understanding the differences in m value between the first lots and overall lots is crucial for designing auction strategies. By placing more challenging lots at the beginning of the auction, organizers can effectively increase initial interest and overall auction activity. Meanwhile, organizers should adjust strategies for subsequent lots to maintain participants' interest and engagement.

3. Impact of Auction Pricing Strategies

How do auction houses achieve this design?

In our analysis of auction pricing dynamics, we observed significant differences between the initial prices and final prices of the first lots and the entire auction (see Table 3).

TABLE 3. Auction Data

Auction	Currency	The First Lot of the Auction			Average Data		
		Initial Price	Final Price	Hammer Price Premium	Initial Price	Final Price	Hammer Price Premium
C HK '23	HKD	1,600,000	6,900,000	5,300,000	8,185,283.019	11,731,698.11	3,546,415
C LD '23	GBP	24,000	90,000	66,000	593,893.9394	854,015.1515	260,121
C NY '23	USD	800,000	2,300,000	1,500,000	5,537,619.048	8,802,777.778	3,265,159
S HK '23 Mod	HKD	200,000	1,200,000	1,000,000	3,821,081.081	5,418,918.919	1,597,838
S HK '23 Cont	HKD	500,000	1,600,000	1,100,000	10,286,086.96	14,758,695.65	4,472,609
S LD '23 Now	GBP	48,000	210,000	162,000	328,285.7143	607,857.1429	279,571
S LD '23 Cont	GBP	450,000	800,000	350,000	1,327,142.857	1,880,000	552,857
S NY '23 Now	HKD	65,000	350,000	285,000	1,711,667	2,595,278	883,611
S NY '23 Cont	HKD	200,000	775,000	575,000	3,297,717.391	4,753,695.652	1,455,978

Note 1: C: Christie's; S: Sotheby's

Note 2: HK: Hong Kong; LD: London; NY: New York

Note 3: Mod: Modern; Cont: Contemporary

We converted all prices to a common currency, USD, for consistency in analysis. Specifically, the average starting price of the first lots was approximately $1,098,229, while the average final price was approximately $4,588,888, with an average price increase of $3,490,659. In contrast, the average starting price for the entire auction was approximately $4,289,171, with an average final price of $6,445,888, resulting in an average price increase of $2,156,717.

These findings indicate that there is usually a significant escalation in bidding activity during the auction, with initial prices and final prices generally being much higher compared to the first lots. This difference in pricing and price increase suggests that while the first lots attract great interest, they typically start at lower prices and achieve substantial gains, whereas the overall auction starts at higher initial prices and achieves larger absolute price increases.

This provides auction organizers with important insights into how to optimize auction processes and strategies to maximize engagement and ensure the health and sustainability of auction activities. By precisely setting the starting prices of lots, organizers can regulate market expectations and participants' psychology, thereby influencing the activity level and final success rate of the entire auction.

DISCUSSION

1. First Item Impact: Setting the Psychological and Economic Tone of Auctions

The first auction item not only sets the pace for the bidding session but also establishes a psychological benchmark for the participants, significantly influencing subsequent bidding behaviours. This benchmark affects not only those who participate in the first auction but also those who are eligible to bid throughout the session but choose to observe initially. The sale of the first auction item involves more than just determining the highest bidder; more broadly, it serves as a complex interplay of strategy, psychology, and social status. According to neurological research, particularly the principles of mirror neurons, spectators experience a sense of enjoyment as if they are personally competing. Based on principles of neuroscience, particularly the concept of mirror neurons, we understand that spectators experience a vicarious pleasure of competition, a topic elaborated in our other paper, 'Rational Bidding Meets Emotional Viewing: The Landscape of English Auction Livestreams in the Age of Algorithms,' and will not be reiterated here (Li et al., 2024). When a participant pays a deposit and earns the right to bid but hesitates before the first item is auctioned, observing the intensity of the bidding may spur their interest to engage, ultimately deciding to participate.

As a psychological anchor, the first auction item sets expectations for the value and engagement of the auction for both active bidders and spectators. This plays a crucial role in maintaining the consistency of the auction design, thereby enhancing competitiveness. Bidders' behaviour is not only driven by potential economic gains but also by the opportunity to express personal taste, seek social recognition, and satisfy emotional needs.

Furthermore, the role of social dynamics in auctions cannot be overlooked. Auctions are often public performances where bidders display their economic and cultural capital (T. Veblen, 2017). Understanding these psychological and social motivations is essential for comprehensively grasping bidder behaviour, which transcends mere economic transactions. This discussion is further elaborated in our paper, 'Beyond Economic Incentives: Deconstructing the Multidimensional Motivations in Auction Behaviour via Motion in Mind,' which is currently under review (Li et al., 2024).

2. Implications for Auction Design

We have reason to believe that the findings of this study offer several practical recommendations for auction houses regarding the strategic placement and pricing of items. By deeply understanding the diverse motivations of bidders, auction houses can design their auctions to maximize financial returns and enhance bidder engagement and satisfaction.

Placing auction items with high game mass strategically at the beginning of an auction can stimulate higher engagement and sustain competitive bidding. This approach capitalizes on the initial excitement and sets a high benchmark for value growth, potentially increasing the overall yield of the auction. The effectiveness of this strategy can be quantified by measuring the price change game mass and game velocity ($m = \frac{F-1}{F}$ and $v = 1 - m = \frac{I}{F}$), where I is the initial price and F is the final price). This ratio highlights the price fluctuations from the beginning to the end of the auction and serves as a key indicator of auction vitality.

By understanding the diverse motivations of bidders—from investment and collection to social signalling and personal satisfaction—auction houses can tailor their marketing and cataloguing strategies to attract a broader audience. This may involve providing detailed provenance, background information on the artist, and highlighting the significance of the items to enhance their emotional and social appeal.

Assuming the bidder's maximum willingness to pay (*MWP*) is related to the purchasing power limit (PPL), the final bid can be expressed as:

$$F = min(MWP, PPL) \qquad (11)$$

When bidders select an auction item within a suitable price range as the first item, this dynamic can be further analysed mathematically. Assuming that bidders' motivation is determined by their psychological expectations of the item's value and their need for social expression, we can quantitatively describe their bidding decision process with the following formula:

$$MWP = \alpha \times PV + \beta \times SV \qquad (12)$$

Where, *PV* represents the personal valuation of the item, and *SV* represents the potential for social status enhancement from acquiring the item. The parameters α and β adjust the influence of these two factors.

In the context of market information updates or changes in bidder preferences, *MWP* may be adjusted based on new information, affecting the final bid (*F*). This dynamic can be modelled by introducing an adjustment factor γ to simulate the impact of new information:

$$MWP_{new} = MWP + \gamma \times new\ information\ impact \qquad (13)$$

Where, γ indicates the sensitivity of the bidder's willingness to pay to new information. Since bidders continuously observe the entire auction, we can consider the auction of the first item as an 'advertising event.' This 'advertising event' serves as a comprehensive 'new information impact' that ultimately influences the participation willingness of all auction participants.

Finally, potential changes and innovations in auction design could include the integration of technology to provide more immersive and interactive bidding experiences. For instance, virtual reality technology could allow bidders to visualize items in their own space before purchasing, enhancing emotional connection and perceived value. Additionally, leveraging data analytics to better predict bidding patterns and preferences can lead to more personalized and engaging auctions.

CONCLUSION

This study highlights the significant impact of the strategic selection and design of the first auction item on auction dynamics. Utilizing the 'Motion in Mind' and 'Potential Reinforcement Energy' frameworks, we demonstrate how the initial item influences bidder engagement and competition intensity. Key findings reveal that the first auction item establishes a psychological benchmark and drives the auction's pace.

Our new measurements show that the average m value of the first lots is 0.716, close to the competitive play mode zone ($m \approx 0.79$), indicating high competition at the auction's start. In contrast, the average m value for the entire auction is 0.331, highlighting a decrease in competition intensity as the auction progresses.

These metrics provide insights into optimizing auction design. Our analysis of data from Christie’s and Sotheby’s shows that the initial item’s starting and final bid prices can significantly deviate from overall trends, emphasizing its unique role.

Future research could explore the long-term effects of initial item design on auction house reputation and bidder loyalty, as well as integrating technologies like virtual reality to enhance the bidder experience. In summary, the strategic design and placement of the first auction item are crucial in shaping auction dynamics. This research offers practical implications for optimizing auction practices.

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