From Price Competition to Mechanism Design: An Economic Analysis of Tendering Based on Auction Theory

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Abstract. The tendering and bidding system constitutes a core mechanism for public procurement and resource allocation, with its economic essence amenable to the analytical framework of auction theory. This paper systematically reviews the application logic of auction theory in tendering analysis, revealing the mechanisms through which different bidding formats influence bidder behavior, allocative efficiency, and procurement costs. The research indicates that the economic performance of bidding mechanisms depends not only on the intensity of competition but also on the institutional design of information structure, scoring rules, and budget constraints. Although first-price sealed bidding is theoretically equivalent to English auctions in terms of expected revenue, structural differences exist in anti-collusion capabilities. Two-stage bidding may inadvertently facilitate collusion by reducing coordination costs. Multi-attribute scoring auctions and budget-constrained auctions introduce new strategic dimensions that can suppress low-quality competition. The findings suggest that tendering reform should transcend traditional thinking centered on "highest price wins" or "lowest price wins", moving toward mechanism design concepts grounded in incentive compatibility.

Keywords: Auction theory, tendering and bidding, mechanism design, collusion, multi-attribute auctions.

1. Introduction

Tendering and bidding represent fundamental institutional arrangements for resource allocation in modern economies. In the realm of public procurement, tendering expenditures account for approximately 15%-20% of GDP in developed economies, occupying a central position in government procurement activities [1]. In China, critical sectors including land transfer, construction engineering, and equipment procurement predominantly rely on tendering as the primary allocation mechanism. However, tendering practices have long confronted two major dilemmas: first, quality risks arising from "lowest price wins" approaches; second, the erosion of competitive order by collusion and corruption. How to design effective bidding mechanisms has become a focal issue for both economic inquiry and public policy.

Auction theory provides systematic analytical tools for understanding tendering problems. Since Vickrey's (1961) pioneering research, auction theory has developed a comprehensive framework concerning information structures, bidding strategies, and revenue equivalence. Tendering essentially constitutes a reverse auction—where the buyer, as the tenderee, seeks the lowest procurement price, forming a symmetrical structure with standard auctions where sellers seek the highest selling price [2]. This theoretical correspondence implies that insights from auction theory can be directly transferred to tendering analysis.

This paper aims to systematically analyze the economic logic of tendering mechanism design from the perspective of auction theory. The structure is as follows: Section 2 elucidates the core propositions of auction theory and their applicability to tendering; Section 3 analyzes the impact of bidding format selection on bidding behavior and collusion risks; Section 4 examines theoretical advances in novel mechanisms such as multi-attribute auctions and budget-constrained auctions; Section 5 summarizes policy implications for tendering reform.

2. Core Propositions of Auction Theory and Applicability to Tendering

2.1. The Benchmark Model and Revenue Equivalence Theorem

Standard auction theory is built upon the Independent Private Values (IPV) model. This model assumes that each bidder has independent private valuations for the subject matter, valuations are drawn from a commonly known distribution, bidders are risk-neutral and symmetric, and payments are functions solely of bids. Under these assumptions, the four standard auction formats—English auction (ascending bid), Dutch auction (descending bid), first-price sealed bid, and second-price sealed bid—yield identical expected revenue for the auctioneer. This is the Revenue Equivalence Theorem [3].

The Revenue Equivalence Theorem holds fundamental significance for tendering analysis. It demonstrates that, under ideal conditions, the choice of bidding format does not affect procurement costs—whether through open bidding or sealed bids, the expected price paid by the tenderee remains the same. This theorem shifts analytical focus from "which format to choose" to "which assumptions to relax": when private value assumptions are replaced by common values or affiliated values, when bidders exhibit non-neutral risk attitudes, or when collusive behavior exists, performance differences among formats become apparent [4].

2.2. Tendering as Reverse Auction: Symmetry and Specificity

The core distinction between tendering and standard auctions lies in price direction: the former involves buyers seeking low prices, while the latter involves sellers seeking high prices. This difference generates mirrored strategic behavior. In standard auctions, bidders face a trade-off: higher bids increase probability of winning but decrease profits; in tendering, bidders confront the inverse: lower bids increase probability of winning but decrease profits [5].

However, tendering possesses specificities beyond reverse auctions. First, procurement targets often exhibit multi-dimensional attributes—beyond price, factors such as quality, delivery time, and after-sales service affect procurement value. This renders tendering inherently multi-attribute, extending beyond the single-dimensional price framework of standard auctions. Second, public procurement is subject to rigid budget constraints; tenderees typically have fixed budget ceilings, which often remain undisclosed. Third, tendering involves complex performance stages, where post-award moral hazard may erode procurement benefits. These specificities necessitate extensions and modifications when applying auction theory to tendering.

3. Bidding Formats, Bidding Strategies, and Collusion Risks

3.1. Strategic Differences Between Sealed Bids and Open Bidding

In tendering practice, sealed bids (first-price) and open bidding (English) constitute two mainstream formats. According to the Revenue Equivalence Theorem, they are equivalent under private value assumptions. However, once assumptions are relaxed, differences emerge.

In common value environments—such as mineral extraction rights or spectrum license auctions—bidders face winner's curse risk: the winner tends to be the bidder with the highest valuation, but if valuations contain common components, winning implies potential overvaluation. In tendering scenarios, construction engineering and equipment procurement similarly exhibit common value characteristics: although bidders possess private information about costs, cost structures themselves are influenced by common factors such as raw material prices and technical conditions. Under these circumstances, open bidding allows bidders to observe competitors' exit prices, helping mitigate the winner's curse and potentially yielding lower winning bids.

However, open bidding also creates conditions conducive to collusion. Throughout transparent, multi-round bidding processes, participants can observe each other's behavior, transmit coordination signals, and monitor defections, thereby reducing the organizational costs of collusion [6].

3.2. The Economics of Collusion in Two-Stage Tendering

Two-stage tendering is widely adopted in public procurement across many countries. Taking China's urban land transfer as an example, the two-stage listing mechanism allows bidders to submit bidding intentions in the first stage, followed by on-site bidding in the second stage. Superficially, this design enhances information transparency, potentially promoting competition.

However, recent research has revealed potential risks in two-stage tendering. Empirical analysis of 8653 land transactions across 15 Chinese cities from 2006-2016 demonstrates that the proportion of transactions concluding at reserve prices is significantly higher in two-stage tendering compared to single-stage auctions—in industrial land, over 96% of two-stage transactions ended at reserve prices. This phenomenon cannot be explained by land quality or demand insufficiency, but more plausibly stems from bidder collusion: during the listing phase, potential bidders can transmit coordination signals through non-bidding or low bids, forming tacit or explicit bid rigging agreements enabling a member to acquire at the reserve price, with subsequent profit sharing.

Theoretical models indicate that two-stage tendering facilitates collusion by reducing coordination costs and monitoring costs. Transparent bidding processes enable colluding members to observe whether participants adhere to agreements; the phased rhythm provides time windows for signal transmission; while undisclosed reserve prices render collusion more concealable—when collusion succeeds, transactions precisely conclude at reserve prices, appearing superficially unremarkable. The policy implication of this finding is that tendering transparency is not always beneficial; there exists a tension between transparency and collusion prevention requiring careful balancing.

3.3. Scoring Rules and Collusion Constraints

If information transparency may facilitate collusion, might introducing uncertainty help suppress collusion? The procurement tendering reform by Japan's Ministry of Land, Infrastructure, Transport and Tourism provides natural experimental evidence. The ministry introduced "subjective scoring" mechanisms in road construction project tendering—beyond price, evaluation committees assign subjective scores to technical proposals, with the highest comprehensive score winning. The introduction of subjective scoring significantly reduced winning prices, an effect difficult to explain through intensified competition alone [7].

Structural model-based inference suggests that subjective scoring's effectiveness lies in undermining collusion stability. In dynamic collusion models, members need to monitor each other's adherence to agreements; prices are easily monitored public information, while subjective scoring introduces unverifiable random components, preventing members from distinguishing whether low scores result from defection or low scores result from evaluation randomness, thereby weakening collusion enforcement. This finding reveals a deeper dimension of scoring rule design: scoring subjectivity serves not only to incorporate quality considerations but also as a strategic tool for collusion suppression.

4. Theoretical Frontiers in Mechanism Design

4.1. Multi-attribute Auctions: Beyond Single-Dimensional Price Competition

The drawbacks of traditional "lowest price wins" tendering have been recognized in practice: excessive price suppression often leads to corner-cutting and quality degradation, ultimately undermining procurement value. Multi-attribute auction theory offers solutions to this dilemma.

The fundamental approach of multi-attribute auctions is that tenderees care not only about price but also about attributes such as quality and delivery time, necessitating scoring rules that transform multi-dimensional information into comparable single indicators. Theoretical research shows that, under conditions where bidders possess private cost information, optimal scoring rules require calibration based on information structure rather than simple weighted averaging. In practical applications, two-stage evaluation—scoring technical proposals first, then conducting price

competition among technically qualified bids—represents a common form of multi-attribute auctions. Second-lowest sealed bidding (a variant of Vickrey auctions) has also been shown to help control prices while preventing collusion [8].

4.2. Budget-Constrained Auctions: Quantity Maximization Under Fixed Budgets

Standard auction theory assumes tenderees seek minimum prices for fixed quantities. However, in many real-world scenarios, tenderees face fixed budget constraints and aim to maximize procurement quantities within these budgets. Austria's 2020 tendering for remote area mobile network coverage exemplifies this: the regulator had fixed budgets, operators bid required subsidy amounts, and the tenderee selected bid combinations maximizing covered villages within budget.

This budget auction model generates unique strategic effects. In standard fixed-quantity tendering, increasing bids reduces winning probability (quantity effect); in budget auctions, increasing bids for certain units also reduces remaining budget, thereby decreasing procurement probabilities for other units (budget effect). This dual suppression effect leads bidders to quote lower prices, yielding lower procurement costs for tenderees compared to fixed-quantity tendering. This finding carries significant implications for public procurement: when budget rigidity is pronounced, tenderees should avoid pre-fixing procurement quantities and instead adopt budget-constrained quantity maximization mechanisms.

4.3. Special Mechanisms for R&D Procurement: Multi-Stage Elimination Tournaments

R&D service procurement constitutes a special area of tendering. Unlike traditional goods procurement, R&D project value is difficult to assess ex ante, and the R&D process itself creates value. The European Union's recent Pre-Commercial Procurement (PCP) initiative employs multi-stage elimination mechanisms: multiple suppliers receive small-scale funding in early stages for concept validation, winners proceed to prototype development phases, and ultimately a few suppliers receive commercialization contracts.

Auction-theoretic analysis of this mechanism reveals a counterintuitive finding: two-stage all-pay elimination tournaments may prove less efficient than single-stage tendering. Under budget constraints, strong suppliers can secure entry with minimal bids in the first stage, reserving resources for the second stage, thereby crowding out competition. This finding suggests that R&D procurement mechanism design requires careful balancing of incentive structures across different stages; multi-stage design alone does not necessarily outperform one-time competition.

5. Conclusions and Policy Implications

Economic analysis of tendering based on auction theory demonstrates that bidding mechanism performance depends on institutional design across multiple dimensions, including information structure, scoring rules, and budget constraints. Main conclusions can be summarized in three points:

First, bidding format selection involves trade-offs between efficiency and risk. While open bidding may mitigate the winner's curse, it may also facilitate collusion by reducing coordination costs. Two-stage tendering's transparency exhibits double-edged effects, requiring balance between information disclosure and collusion prevention.

Second, scoring rules serve not only as quality screening tools but also as strategic game dimensions. Subjective scoring can suppress collusion stability by introducing uncertainty; multi-attribute scoring can extend competition from single price dimensions to comprehensive value dimensions, alleviating "low price and low quality" dilemmas.

Third, budget constraints alter bidder strategic structures. Quantity maximization auctions under fixed budgets strengthen price suppression mechanisms through budget effects, offering new approaches beyond traditional tendering.

These conclusions yield clear implications for tendering system reform. First, we should transcend singular thinking centered on "highest price wins" or "lowest price wins", selecting appropriate

mechanisms based on different procurement characteristics. Second, transparency principles require nuanced design—information disclosure levels should balance competition-promotion effects against collusion-facilitation effects. Third, mechanism innovation should be encouraged, exploring applications of multi-attribute auctions, budget-constrained auctions, and other novel tendering models in practice.

Auction theory provides rigorous analytical language for tendering analysis, but translating theoretical insights into institutional design requires contextual specification. Future research directions include: further empirical testing of different mechanisms' performance in real-world settings; exploring integration of auction theory with contract theory to incorporate post-award performance issues into analytical frameworks; and introducing behavioral economics insights into mechanism design, considering bidder bounded rationality and non-standard preferences.

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