Innovations in Defense Acquisition Auctions: Lessons Learned & Alternative Mechanism Designs

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# Innovations in Defense Acquisition Auctions: Lessons Learned & Alternative Mechanism Designs

## Abstract

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## Subject Terms

unclassified

## Security Classification of:

- **a. Report:** unclassified
- **b. Abstract:** unclassified
- **c. This Page:** unclassified

## Limitation of ABSTRACT

Same as Report (SAR)

## Number of Pages

27
Objectives

• How are auctions used in DoD acquisition?
  – Effective
  – Appropriate

• Suggest alternative auction structure
  – Iterated Information Aggregation Auction ($I^2A^2$) Mechanism
  – Quality of fit affects productivity of relationship

• Test current & alternative auction structure
Project Deliverables

• Electronic Reverse Auctions in the Federal Government
  – MBA Project Report, Whitney E. Brown and Lana D. Ray

• Improving the Efficiency of Defense Auctions: Multi-Stage Auctions as a Market Research Tool
  – MBA Project Report, Steven W. Vanden Bos

• Innovations in Defense Acquisition Auctions: Lessons Learned & Alternative Mechanism Designs
  – Technical Report, P. Coughlan, W. Gates and J. Lamping
Auctions as Exchange Mechanisms

- Single Seller
  - Forward Auction
  - Multiple Buyers
  - Negotiation
  - Single Buyer
  - Reverse Auction
  - Multiple Sellers
  - Market or Double Auction
Auction Characteristics

Forward
- Open / Sequential Bid
  - English
  - Dutch

Reverse
- Sealed / Simultaneous Bid
  - First Price
  - Second Price
Additional Auction Structures

• **Multiple–Item**
  - **Multiple–Price**
  - **Single Price**

• **Multi–Attribute**
  - **Participants Submit Multi–Dimensional Bids**

• **Combinatorial**
  - **Participants Submit Monetary Bids for Multi–Dimensional Items**

• **Hybrid**
  - **English/Second–Price (proxy bidding)**
DoD Auctions

- Auctions Consistent with FAR
- Auctions credited with significant savings
- Auctions used primarily as market research tool

Auctioned Items
- Commercial Items
  - Computer Software and Hardware
  - Office Supplies
  - Field Warfare Supplies (Tents, Batteries, Flashlights, Flak vests)
  - Trailers
  - Refrigerators and Dishwashers
  - Plasma Televisions

- Commercial services
  - Hotel Room and Conferencing Services
  - Copier Maintenance
  - Training
  - Services Related to Commodity Purchases (Installation Services)
Lessons Learned

Single Seller

Forward Auction

Single Buyer

Negotiation

Multiple Buyers

Reverse Auction

Market or Double Auction

Multiple Sellers
The Procurement Decision

• Any procurement decision involves several interdependent choices:
  1) **What** should be procured
  2) **How** it should be procured
  3) **From whom** it should be procured
  4) **At what price** it should be procured

• Economic analysis has generally ignored question #1
  – Either assumes buyer knows perfectly well what is needed …
  – Or assumes question better left to other research disciplines

• However, **auction theory** and **mechanism design** can greatly assist in determining **what** should be procured
  – We propose a procurement mechanism – answer to the **how** question – which endogenously answers other 3 questions
The Information Problem

• Determining *what* to procure is complicated by the fact that the relevant information is:
  – **Incomplete**: Neither the procuring organization nor any individual contractor possess all the relevant information
  – **Diffuse**: Relevant information is spread out among the procuring organization and all of its potential contractors
  – **Private**: Relevant information may be known by one or few contractors who have little incentive to truthfully reveal

• The economic field of **mechanism design** is devoted to developing systems which:
  – Create incentives for actors to **truthfully reveal** information
  – **Efficiently aggregate** diverse and often conflicting information
  – **Identify optimal choices** based on aggregated information
Stylized Procurement Problem

• True value of procured product/service depends on:
  – Performance along various measures \((M_1, M_2, M_3, \ldots)\)
    • Aircraft example: Speed, maneuverability, range, reliability, etc.
  – Relative importance/weighting of each measure \((\alpha_1, \alpha_2, \alpha_3, \ldots)\)
    • Information about appropriate weights incomplete, diffuse, and private
  \[\Rightarrow \text{Value} = \alpha_1 M_1 + \alpha_2 M_1 + \alpha_3 M_1 + \ldots - P\]

• Ex ante information (before bids or announcements):
  – DoD and contractors have some incomplete and independent information about optimal weighting of each performance measure
    • Precision of information reflected in number of “draws from an urn”
    • DoD may have more, less, or same precision as any contractor
  – Each contractor knows its own cost function
The Iterated Information Aggregation Auction (I²A²) Mechanism

1) Initial auction: Each contractor submits bid \((M_1, M_2, M_3, \ldots, P)\) based on own estimates of weights \((\alpha_1, \alpha_2, \alpha_3, \ldots)\)

2) Update: DoD updates its estimates of appropriate weights based on contractor bids and announces new estimates

3) Elimination: Contractors with least value initial bids (according to updated weights) are eliminated

4) Final auction: Each remaining contractor submits a new bid based on updated weights

5) Award: Winning contractor selected based on updated weights
1) **Publish** (optional): DoD publishes its own estimates of weights
2) **Auction**: Each contractor submits bid \((M_1, M_2, M_3, \ldots, P)\) based on own estimates and (perhaps) DoD estimates of weights
3) **Update** (optional): DoD updates its own estimates of weights based on contractor bids
4) **Award**: Winning contractor selected based on (possibly) updated weights

Two optional stages create four single auction variations:
- No Publish, No Update
- No Publish, Update
- Publish, No Update
- Publish, Update
## Auction Scenarios

<table>
<thead>
<tr>
<th>DoD Info</th>
<th>Low</th>
<th>Low</th>
<th>High</th>
<th>High</th>
<th>Low</th>
<th>Low</th>
<th>High</th>
<th>High</th>
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<tbody>
<tr>
<td>Contractor Info</td>
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<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
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<td>1st Round Sellers</td>
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</table>
## Auction Scenarios:
### Draws Per Contractor Bid/DoD Selection

<table>
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<tr>
<th>DoD Info Contractor Info Competition</th>
<th>Low Low</th>
<th>Low Low</th>
<th>High Low</th>
<th>High Low</th>
<th>Low Low</th>
<th>Low High</th>
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<th>High High</th>
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<td>15</td>
<td>15</td>
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<tr>
<td>I²A²</td>
<td>25</td>
<td>25</td>
<td>55</td>
<td>55</td>
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<td>35</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>155</td>
<td>75</td>
<td>75</td>
<td>165</td>
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</tbody>
</table>

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**Note:** The table above illustrates different auction scenarios based on DoD and contractor information, with draws per contractor bid/doD selection. Each row represents a scenario with varying degrees of information availability, and the numbers indicate the typical outcomes or values associated with each scenario.
Effects of Competition:
DoD Value as Percent of Perfect Information

![Bar Chart]

- DoD Info High
- Cont Info High
- Comp High
- DoD Info High
- Cont Info High
- Comp Low
- DoD Info Low
- Cont Info Low
- Comp High
- DoD Info Low
- Cont Info Low
- Comp Low

Percent of Optimal

- No Publish
- No Publish
- Publish
- Publish
- I2A2

Acquisition Research Program: Creating Synergy for Informed Change
Naval Postgraduate School
Monterey, CA
Sample Simulation Outcome:
DoD Value as Percent of Perfect Information

![Bar Chart]

- **DoD Info Low, Cont Info Low**: 37.2%
- **DoD Info Low, Cont Info High**: 62.8%
- **DoD Info High, Cont Info Low**: 76.9%
- **DoD Info High, Cont Info High**: 97.3%

The chart illustrates the percent of perfect information for different combinations of DoD and Cont information levels, with updates indicated by different colors.
Mean Simulation Results

![Graph showing the percent of perfect information for different conditions.]

- Publish: 91.7
- No Publish: 93.9
- No Update: 57.1
- Update: 85.6

Legend:
- Publish
- No Publish
- No Update
- Update
- I2A2
Selected Simulation Results

• Competition has bigger impact with low information
  – Models Second-Price auction w/truthful revelation
  – Competition likely more effective in first-price auction
• Significant benefit from info pooling w/low DoD info
• Two stage auction captures ~90–100% of optimal DoD value in all scenarios
  – Primary benefit related to systematic info pooling
  – DoD captures ~30–80% of optimal value without info pooling
• Two stage auction reduces chance DoD picks sub-optimal contractor
Conclusions

• Auction theory and mechanism design have a lot to offer for defense procurement
  – Provide a cost-effective and efficient procurement process
  – Truthfully illicit and aggregate diffuse, private information

• Procurement mechanisms can be designed that:
  – Create incentives for actors to truthfully reveal information
  – Efficiently aggregate diverse and often conflicting information
  – Identify optimal choices based on aggregated information

• Updating requirements and evaluation criteria significantly increases DoD’s value
  – Carefully designing how we procure can help determine what to procure, from whom and at what price
Issues For Further Research

- Single Buyer
- Single Seller
- Negotiation
- Multiple Buyers
- Forward Auction
- Reverse Auction
- Multiple Sellers
- Double Auction
- Market or
Backup Slides
Electronic Reverse Auctions in DoD

• Consistent with FAR and DFARS
  • FAR Part 1.102 (d)
  • FAR Part 4.502 (a)

• Buy American Act

• Procurement Integrity Act
  • FAR 15.306(e)(3)

• Socioeconomic Concerns
  – Small and Disadvantaged Businesses
    • FAR 19
    • FAR 19.5
    • FAR 13

• Vendor Concerns
## Federal Reverse Auctions: Estimated Savings

<table>
<thead>
<tr>
<th>Government Agency</th>
<th>Number of Awards</th>
<th>Independent Government Estimate</th>
<th>Final Award Price</th>
<th>NET Savings in Dollars</th>
<th>NET Savings in Percentage</th>
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</thead>
<tbody>
<tr>
<td><strong>FEDERAL GOVERNMENT</strong></td>
<td>18,401</td>
<td>$1,187,932,046</td>
<td>$1,037,440,499</td>
<td>$150,491,548</td>
<td>12.7%</td>
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<tr>
<td><strong>DEPARTMENT OF DEFENSE</strong></td>
<td>5,932</td>
<td>$351,179,597</td>
<td>$320,444,507</td>
<td>$30,735,089</td>
<td>8.8%</td>
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<tr>
<td>Department of the Army</td>
<td>3,101</td>
<td>$146,222,796</td>
<td>$132,698,678</td>
<td>$13,524,119</td>
<td>9.2%</td>
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<tr>
<td>Department of the Air Force</td>
<td>316</td>
<td>$58,553,765</td>
<td>$53,909,867</td>
<td>$4,643,898</td>
<td>7.9%</td>
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<td>Department of the Navy</td>
<td>1,710</td>
<td>$70,127,231</td>
<td>$63,805,400</td>
<td>$6,321,831</td>
<td>9.0%</td>
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<tr>
<td>Other DoD Agencies</td>
<td>805</td>
<td>$76,275,804</td>
<td>$70,030,563</td>
<td>$6,245,241</td>
<td>8.2%</td>
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<td><strong>USAAVEAuctions (2000-2007)</strong></td>
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<td>CECOM</td>
<td>188</td>
<td>$153,865,877</td>
<td>$105,214,195</td>
<td>$48,651,682</td>
<td>31.62%</td>
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(After: Brown and Ray, 2007)
Federal Reverse Auctions: Competition

FedBid Results FY2002 – FY2007

<table>
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<tr>
<th>Government Agency</th>
<th>Number of Awards</th>
<th>Ave # of Sellers Bidding</th>
<th>Ave # of Bids per Auction</th>
<th>Ave # of “No bids” per Auction</th>
<th>Ave. No. of Sellers Notified</th>
<th>Ave. Savings in Dollars</th>
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<td>18,401</td>
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<td>8.9</td>
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<td>----------------------------------------------</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>English</td>
<td>Bid Up to True Value</td>
<td>Highest Bidder Wins at 2\textsuperscript{nd} Price</td>
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<td>Dutch</td>
<td>Trade-Off Between Risk and Return</td>
<td>Guess 2\textsuperscript{nd} Price No Bid Above Value</td>
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<tr>
<td>First-Price Sealed-Bid</td>
<td>Trade-Off Between Risk and Return</td>
<td>Guess 2\textsuperscript{nd} Price No Bid Above Value</td>
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<td></td>
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<tr>
<td>Second-Price Sealed-Bid</td>
<td>Bid True Value</td>
<td>Highest Bidder Wins at 2\textsuperscript{nd} Price</td>
<td></td>
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</tbody>
</table>
Binomial Distribution

- Binomial Distribution
  - Actual probability = .6
  - 68% of random observations within one standard deviation from the mean
  - Draws as specified

<table>
<thead>
<tr>
<th>Draws</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>80</th>
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<tr>
<td>1 STD</td>
<td>±.220</td>
<td>±.155</td>
<td>±.109</td>
<td>±.077</td>
<td>±.055</td>
<td>±.039</td>
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<tr>
<td>+ 1 STD</td>
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