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

William R. Gates

Peter J. Coughlan

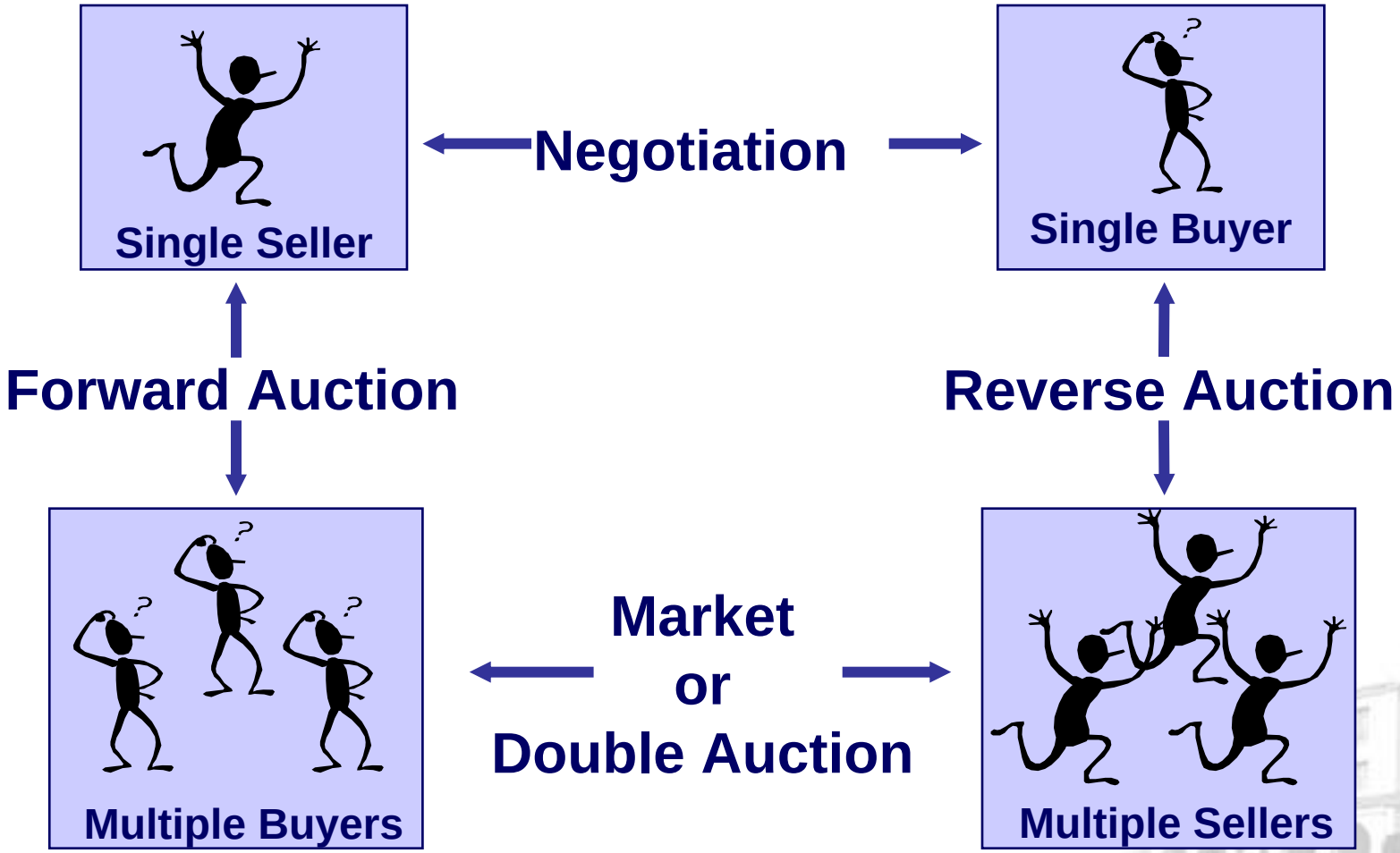
Objectives

- 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

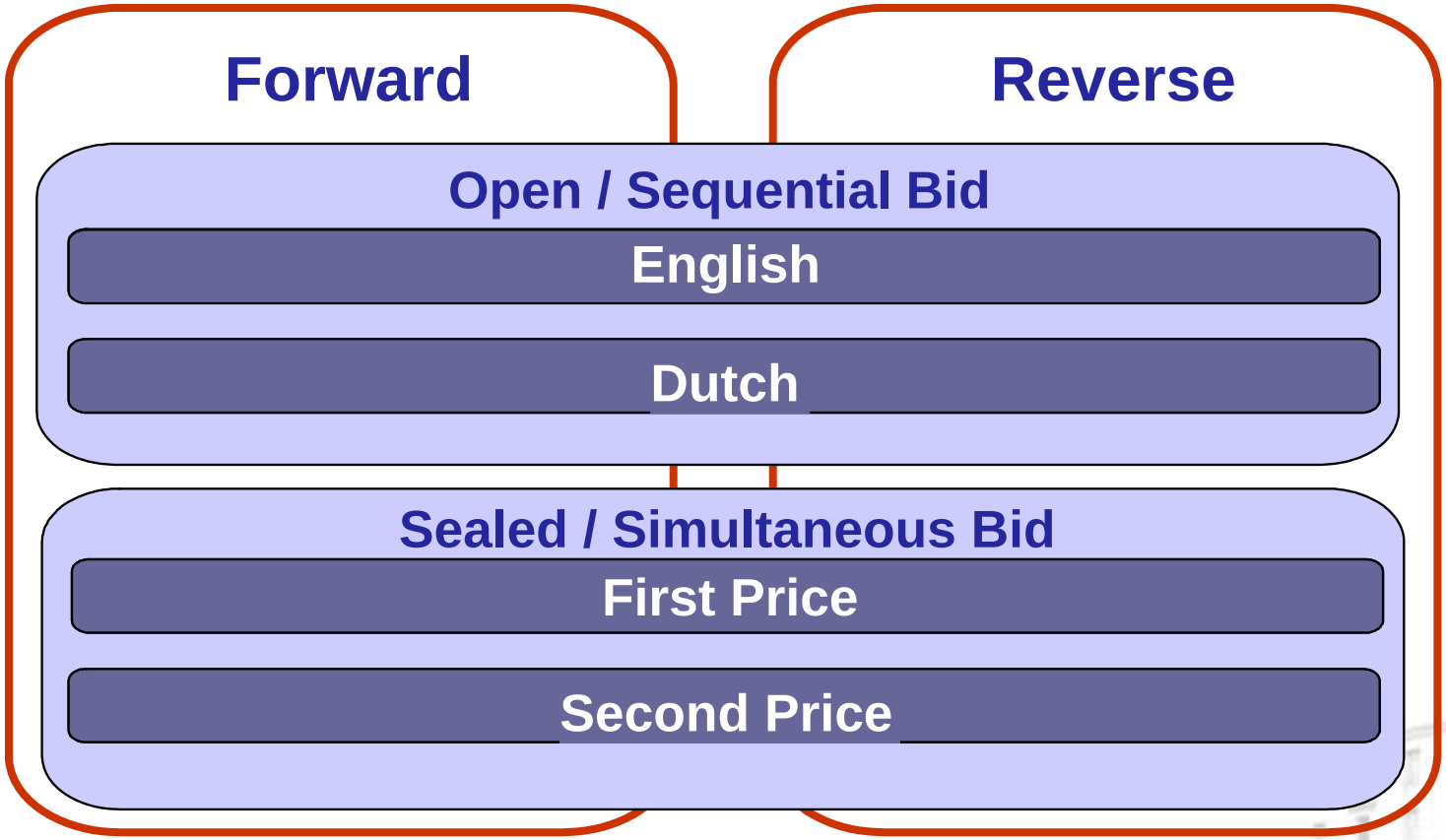
Project Deliverables

- **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**
  - **Journal Paper, P. Coughlan and W. Gates (in progress)**

Auctions as Exchange Mechanisms



Auction Characteristics



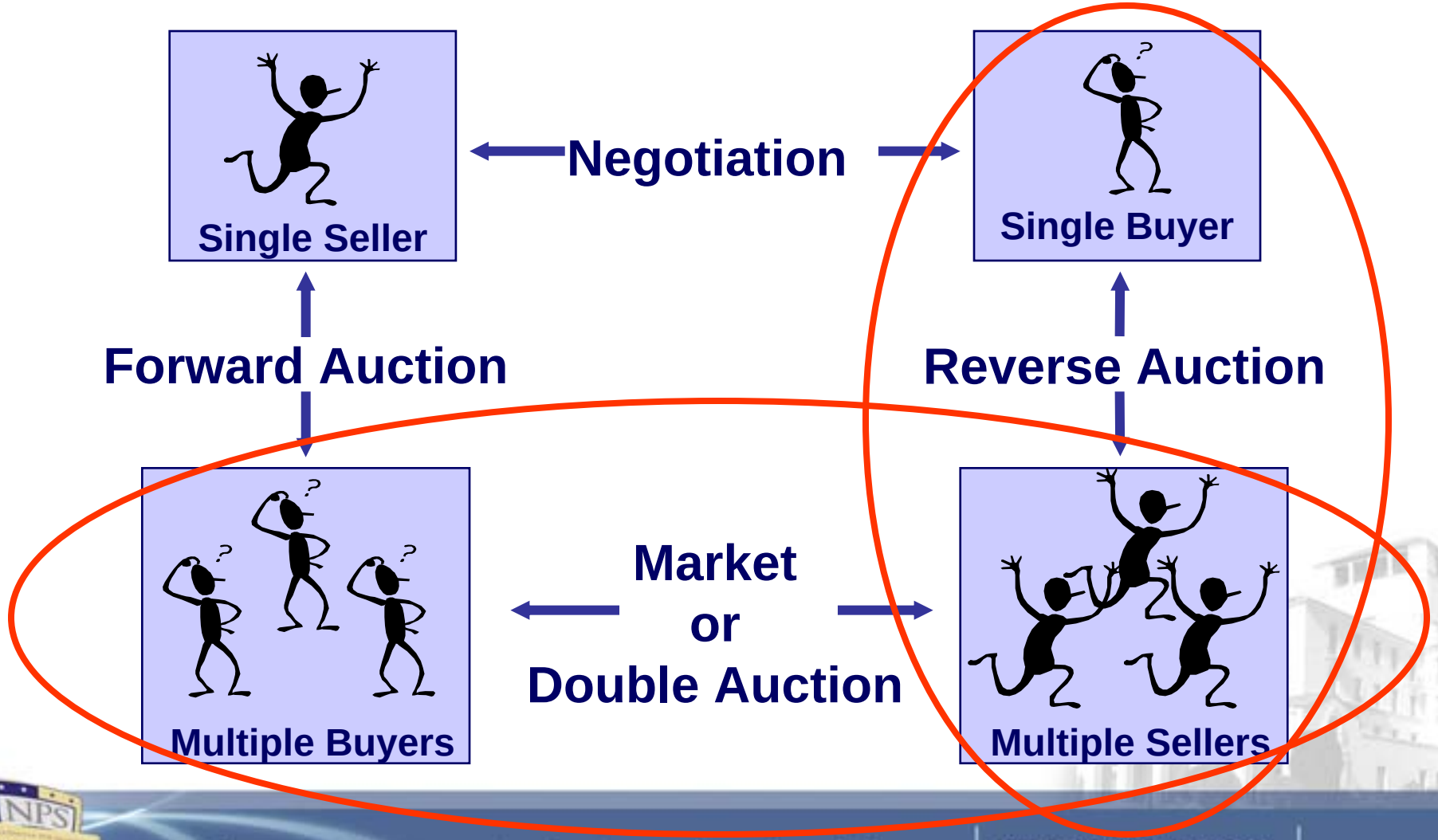
Additional Auction Structures

- **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



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, …)
    - Aircraft example: Speed, maneuverability, range, reliability, etc.
  - Relative importance/weighting of each measure (α_1, α_2, α_3, …)
    - Information about appropriate weights incomplete, diffuse, and private

  $\Rightarrow$ 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 (I^2A^2) Mechanism

1) **Initial auction:** Each contractor submits bid (M_1, M_2, M_3, …, P) based on own estimates of weights (α_1, α_2, α_3, …)
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

Single Auction Alternatives

1) **Publish** (optional)**:** DoD publishes its own estimates of weights
2) **Auction:** Each contractor submits bid (M_1, M_2, M_3, …, 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
- Publish, No Update
- No Publish, Update
- Publish, Update

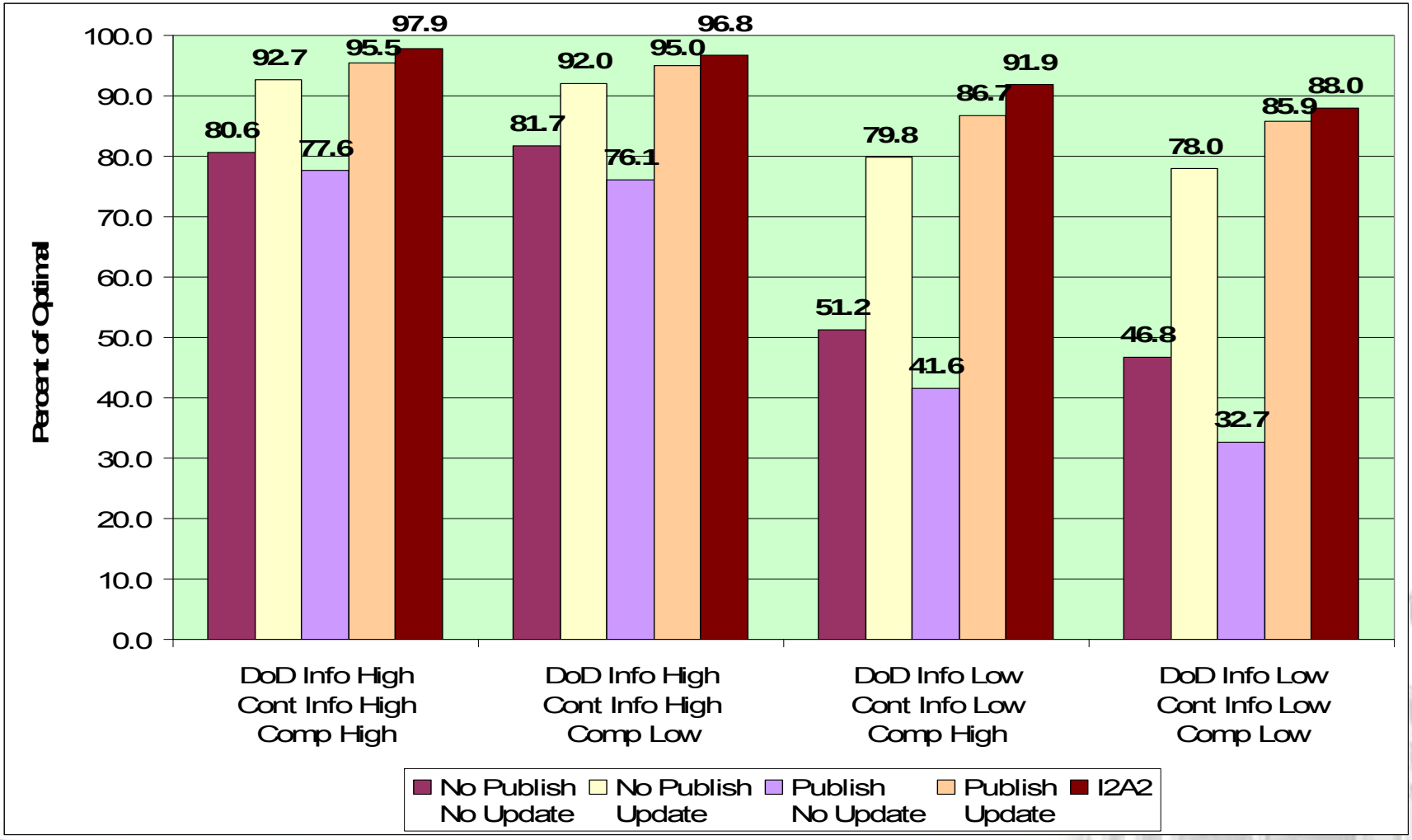
Auction Scenarios

DoD Info	Low	Low	High	High	Low	Low	High	High
Contractor Info	Low	Low	Low	Low	High	High	High	High
Competition	Low	High	Low	High	Low	High	Low	High
DoD Draws	5	5	15	15	5	5	15	15
Seller Draws	5	5	5	5	15	15	15	15
1st Round Sellers	4	10	4	10	4	10	4	10
2nd Round Sellers	2	5	2	5	2	5	2	5

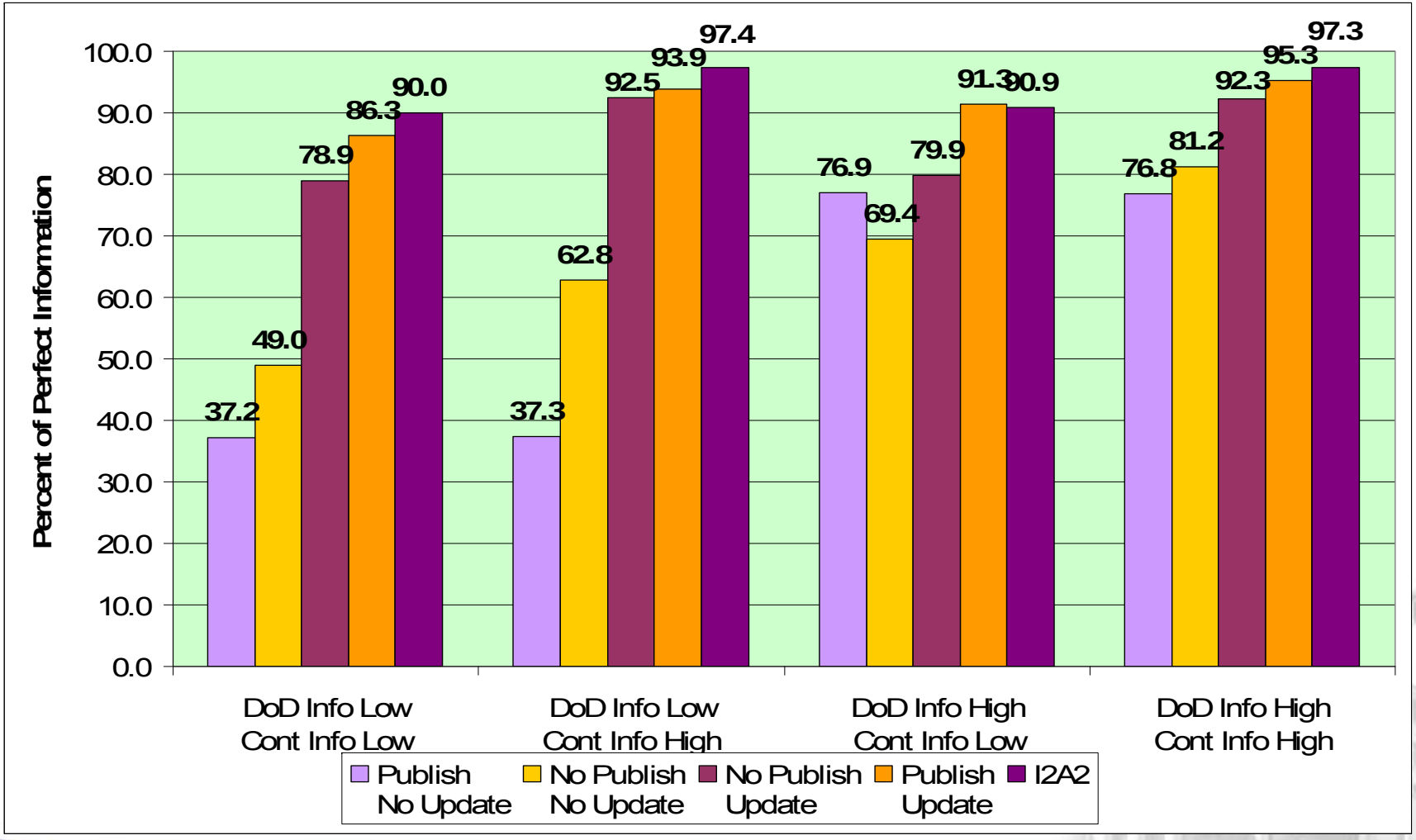
Auction Scenarios: Draws Per Contractor Bid/DoD Selection

DoD Info Contractor Info Competition	Low Low Low	Low Low High	High Low Low	High Low High	Low High Low	Low High High	High High Low	High High High
No Publish No Update	5 / 5	5 / 5	5 / 15	5 / 15	15 / 5	15 / 5	15 / 15	15 / 15
Publish No Update	10 / 5	10 / 5	20 / 15	20 / 15	20 / 5	20 / 5	30 / 15	30 / 15
No Publish Update	5 / 25	5 / 55	5 / 35	5 / 65	15 / 65	15 / 155	15 / 75	15 / 165
Publish Update	10 / 25	10 / 55	20 / 35	20 / 65	20 / 65	20 / 155	30 / 75	30 / 165
I^2A^2	25 / 25	55 / 55	35 / 35	65 / 65	65 / 65	155 / 155	75 / 75	165 / 165

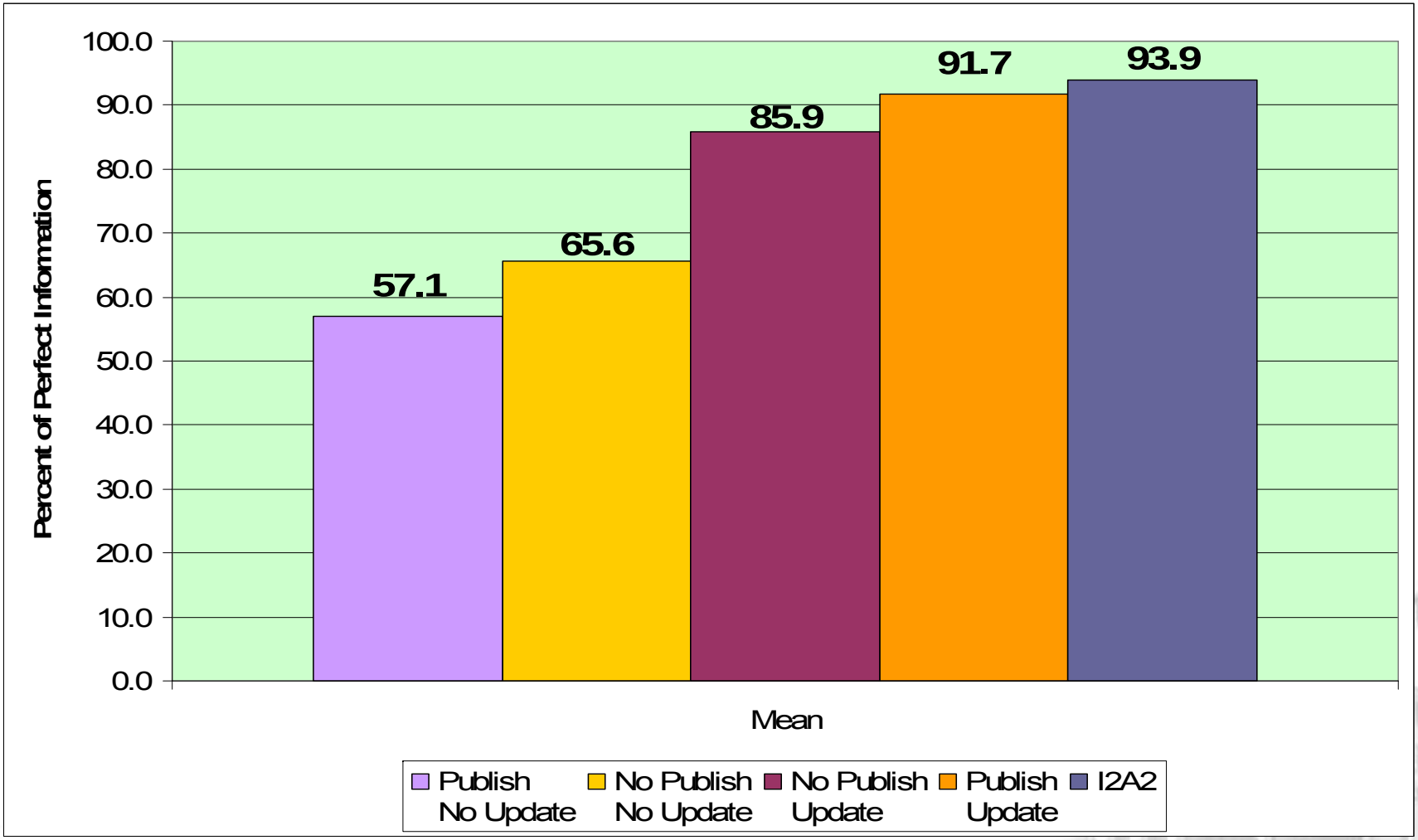
Effects of Competition:
DoD Value as Percent of Perfect Information



Sample Simulation Outcome:
DoD Value as Percent of Perfect Information



Mean Simulation Results



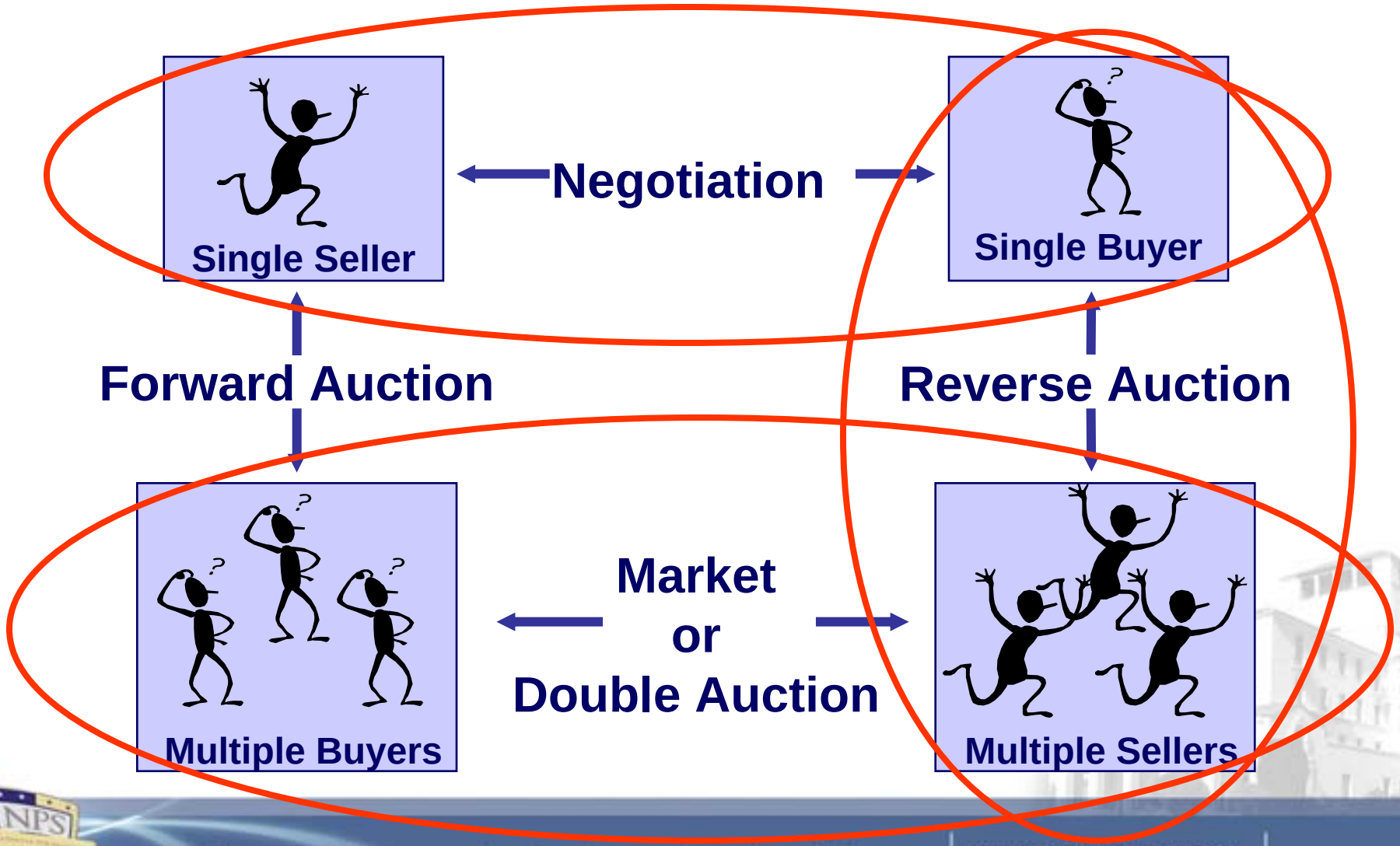
Selected Simulation Results

- 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



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

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

(After: Brown and Ray, 2007)

Federal Reverse Auctions: Competition

Government Agency	Number of Awards	Ave # of Sellers Bidding	Ave # of Bids per Auction	Ave # of "No bids" per Auction	Ave. No. of Sellers Notified	Ave. Savings in Dollars
FEDERAL GOVERNMENT	**18,401**	**5.9**	**13.6**	**44.6**	**836.5**	**$8,178.44**
Department of Defense	**5,932**	**4.7**	**10.2**	**55.7**	**1,012.9**	**$5,181.24**
Department of the Army	3,101	4.1	8.9	59.6	1048.2	$4,361.21
Department of Air Force	316	3.7	8.7	58.8	1027.7	$14,695.88
Department of the Navy	1,710	5.7	11.9	48.3	971.5	$3,696.98
Other DoD Agencies	805	4.8	12.1	55	958.8	$7,758.06

FedBid Results FY2002 – FY2007

Revenue Equivalence

Auction	Strategy	Outcome
English	Bid Up to True Value	Highest Bidder Wins at 2nd Price
Dutch	Trade-Off Between Risk and Return	Guess 2nd Price No Bid Above Value
First-Price Sealed-Bid	Trade-Off Between Risk and Return	Guess 2nd Price No Bid Above Value
Second-Price Sealed-Bid	Bid True Value	Highest Bidder Wins at 2nd Price

Binomial Distribution

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

Draws	5	10	20	40	80	160
1 STD	±.220	±.155	±.109	±.077	±.055	±.039
+ 1 STD	.820	.755	.709	.677	.655	.639
-1 STD	.380	.445	.491	.523	.545	.561