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Budgetary Assessments

# The Effects of Competition on Defense Acquisitions: *A Game Theory Approach*

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Former Secretary of Defense Robert Gates:

*“Competition is a major source of productivity in the defense industry, as it is in commercial industry.”*

Former Under Secretary of Defense Ashton Carter:

*“Real competition is the single most powerful tool available to the Department to drive productivity.”*

Weapon Systems Acquisition Reform Act of 2009:

Requires DoD to use acquisition strategies that *“ensure competition, or the option of competition, at both the prime contract level and the subcontract level.”*

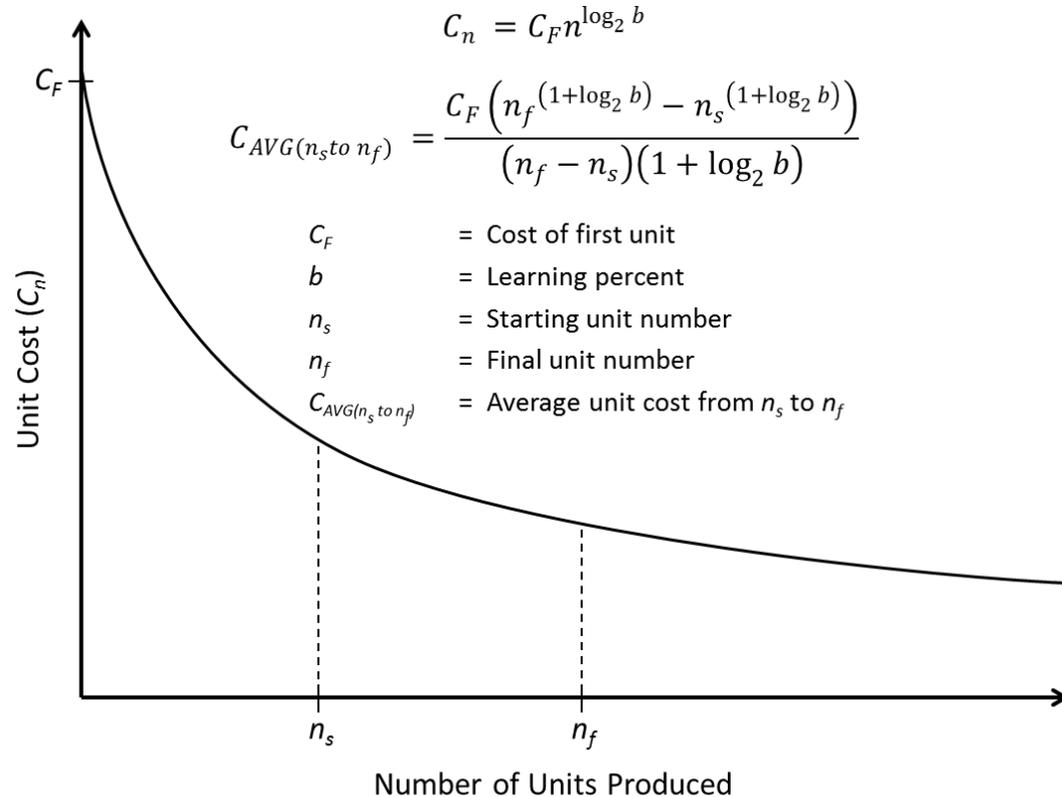
But the “cure” of competition can sometimes be worse than the disease.

- In a traditional free market:
  - Many buyers and sellers
  - Buyers exert control over sellers by patronage
  - As demand falls, prices fall
- Defense is more like a monopsony-duopoly or bi-lateral monopoly
  - Few (if any) other buyers for many of the major weapon systems DoD procures
    - Stealthy aircraft, nuclear submarines, specialized comms equipment
    - Where there are other potential customers (allies and partner nations) quantities are lower and must be approved by U.S. Government
  - Limited number of vendors (primes and subs) capable of producing the systems required
- DoD is not a typical customer
  - Prices are often based on the costs incurred by contractors, not supply and demand
  - As demand falls, unit costs often rise
  - DoD is not just a customer but also a regulator of the industry

1. Added cost of redundant development work
  - As the only customer for many systems, DoD must pay (directly or indirectly) for two or more contractors to develop the same system
  - Even if a “build to print” approach is used, DoD must still pay for the development of more than one production line
  - Allows for a competition once development work is complete
    - DoD can down-select to a single vendor for production, which effectively ends the competition and grants the winner a monopoly
    - Or can split the award between competing contractors to maintain the prospect of future competition

## 2. Learning curve effect

- A split award means neither contractor receives as many orders and thus neither progresses as far down the learning curve
- Cost of each unit will not decline as much as it would if one company were building everything



### 3. Structure of the competition itself

- Dual-source, winner-take-all, split award, etc.
- Can the additional costs from redundant development work and reduced learning be offset by competitive pressure? It depends...
- Historical analysis is insufficient
  - To calculate the savings from competition, one needs to know what would have happened had competition *not* been used
  - Does not account for differences in the structure of the competition, such as award split and quantity of units being procured

- Use a sole source award for comparison, ranging from zero profit to a maximum assumed profit,  $P_{max}$

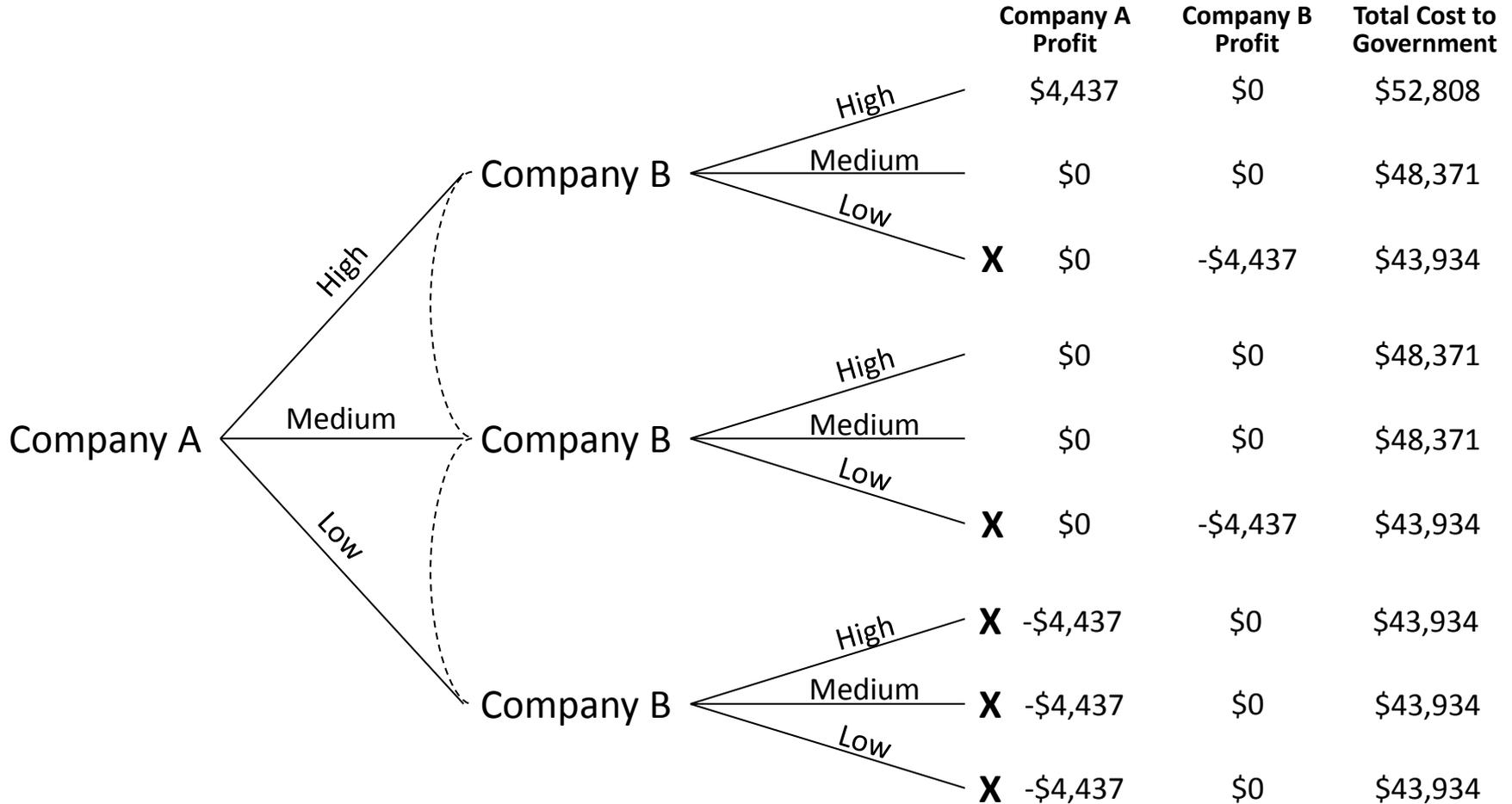
$$\begin{aligned}C_{TOTAL} &= C_{DEV} + Q \times C_{AVG (0 to Q)} \\ &= \$2,000 + 100 \times \left( \frac{\$1,000 \times 100^{(1+\log_2 0.85)}}{100 \times (1+\log_2 0.85)} \right) = \$46,372\end{aligned}$$

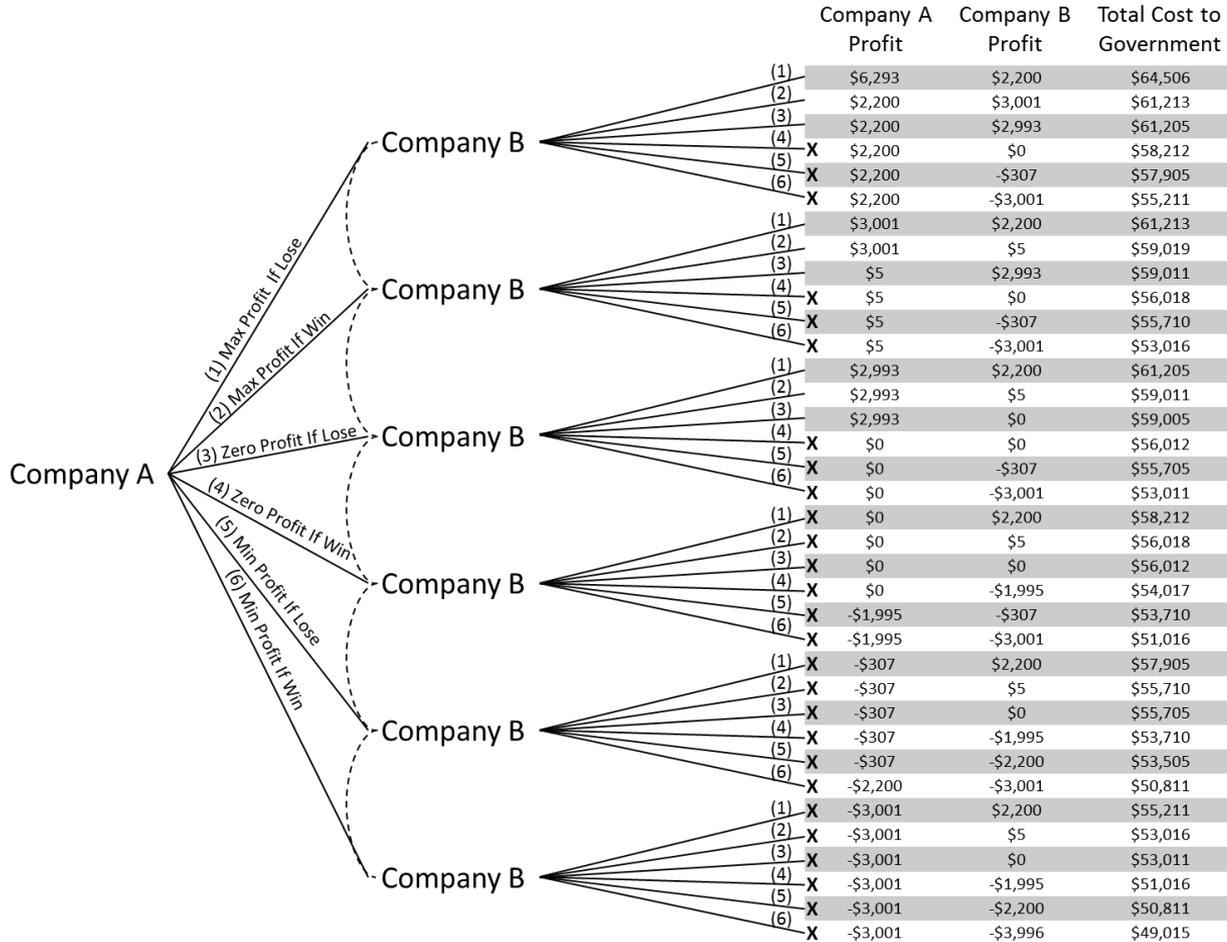
$$\begin{aligned}C_{TOTAL} &= C_{DEV} + Q \times (1 + P_{max}) \times C_{AVG (0 to Q)} \\ &= \$2,000 + 100 \times (1 + 0.1) \times \left( \frac{\$1,000 \times 100^{(1+\log_2 0.85)}}{100 \times (1+\log_2 0.85)} \right) = \$50,809\end{aligned}$$

- Uses game theory to model how companies would bid in a competition
- Takes into account development costs and learning curve effect
- Models how companies would be incentivized to bid depending on:
  - Number of rounds of competition
  - Split in award between contractors (or winner-take-all)
  - Quantity of units procured
- Assumed parameters can also be varied separately for each company
  - First unit cost
  - Learning percent
  - Max/min profit
  - Initial development cost
  - Total quantity of units procured

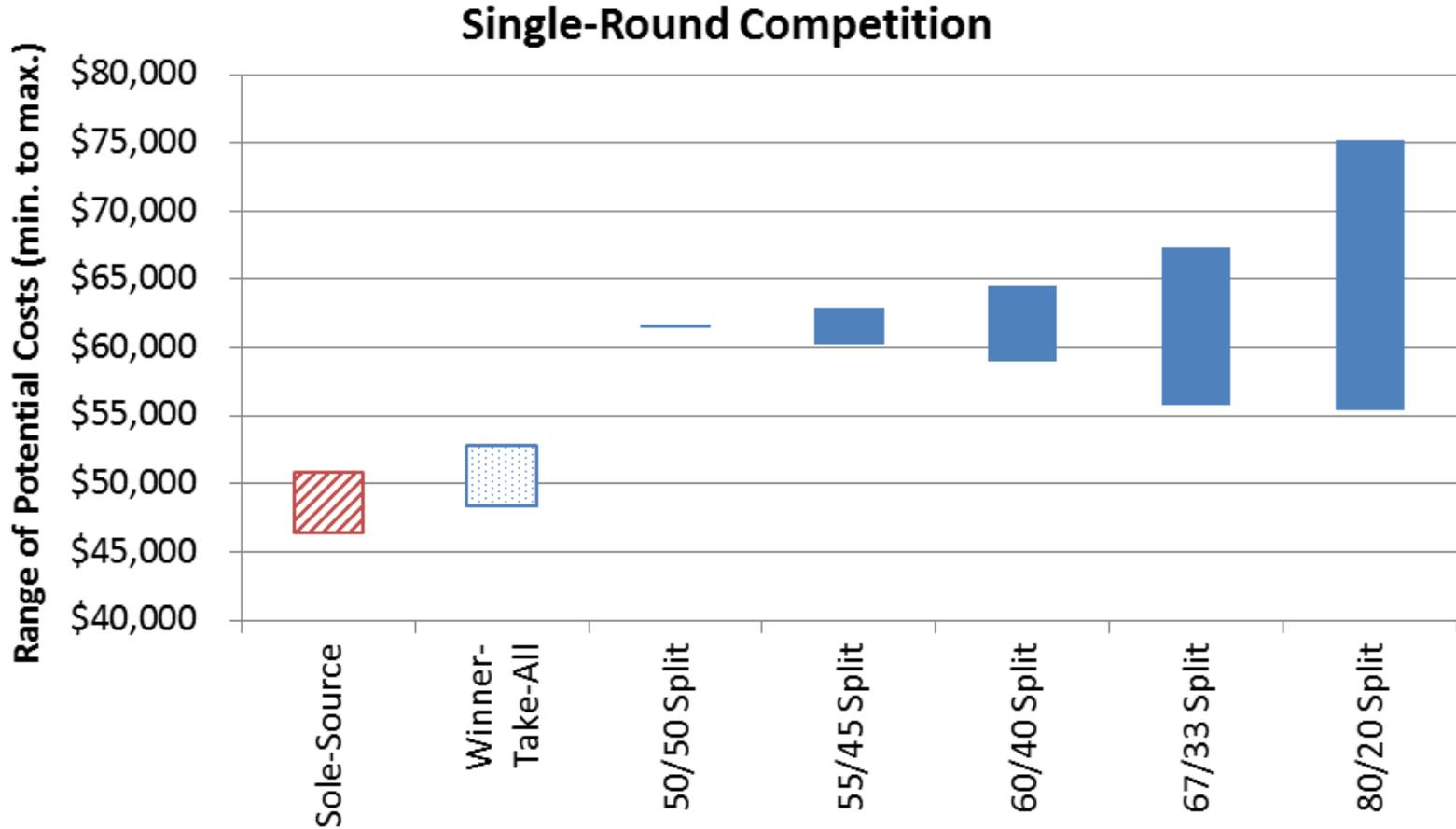
First Unit Cost ( $C_f$ )	Learning Percent (b)	Maximum Profit ( $P_{max}$ )	Minimum Profit ( $P_{min}$ )	Total Quantity of Units Procured (Q)	Initial Development Cost ( $C_{DEV}$ )
\$1,000	85%	10%	-10%	100	\$2,000

- Two competitors with virtually identical products (form, fit, function approach)
- Both companies have perfect information about their own costs, such as first unit cost and learning percent, as well as their competitor's underlying costs
- Companies bid in secret so that one does not know how the other is bidding in the current round, but do know how their competitor bid in previous rounds
- Companies try to maximize net profit from all rounds of competition
- Each company has a limited set of six price points to select from in each round, determined dynamically in each round for each company
- Unit cost is assumed not to vary with production rate or economies of scale, will tend to make competition look more favorable (lower cost) than it should
- Learning percent assumed constant throughout the production run
- Company A wins all ties
- Uses iterated elimination of strictly dominated strategies

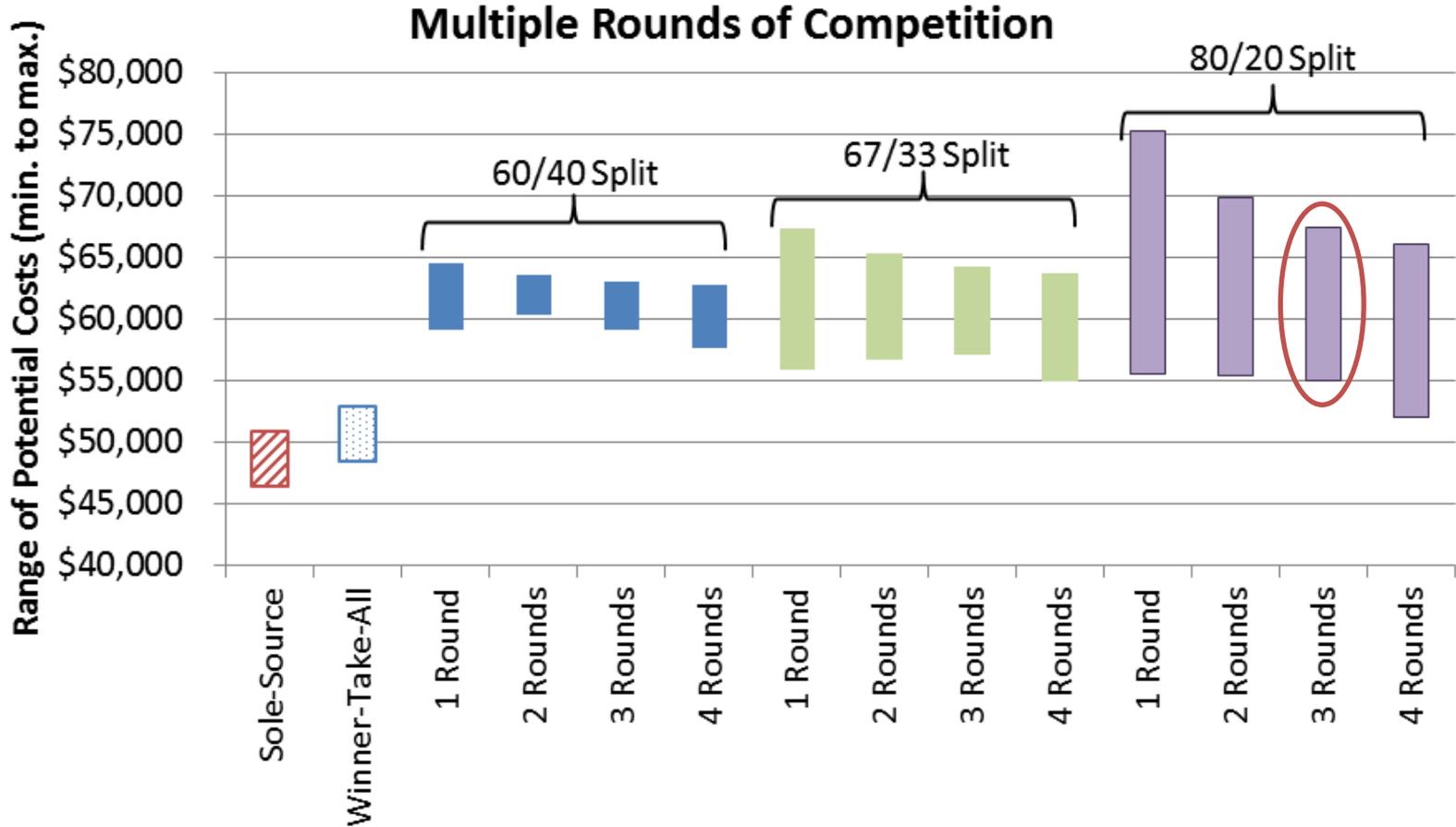




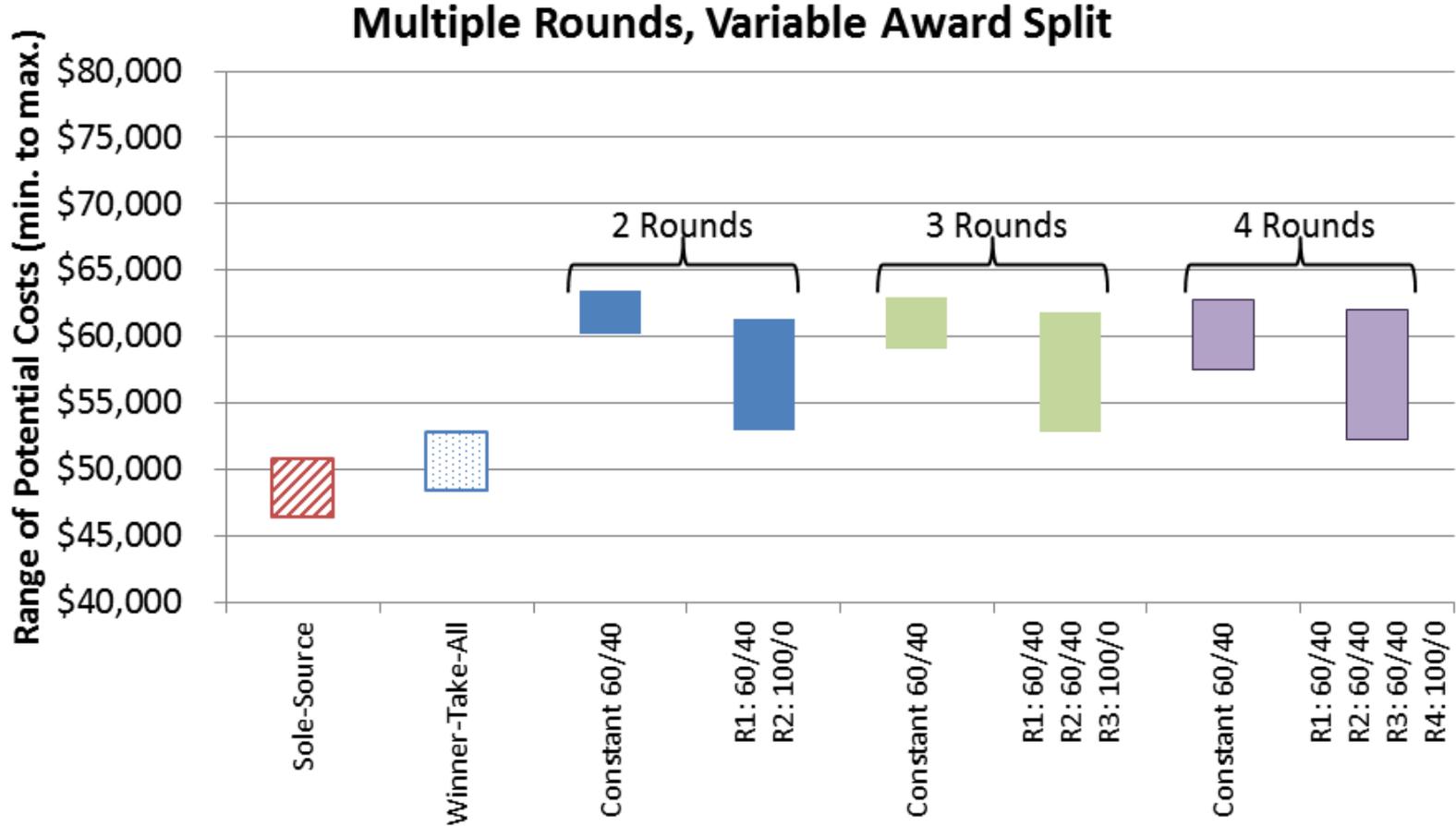
- Only 9 of 36 outcomes are non-dominated
- Each company only bids options 1, 2, or 3
- Total Cost could range from \$59,005 to \$64,506
- Compares to range from sole source award of \$46,372 to \$50,809



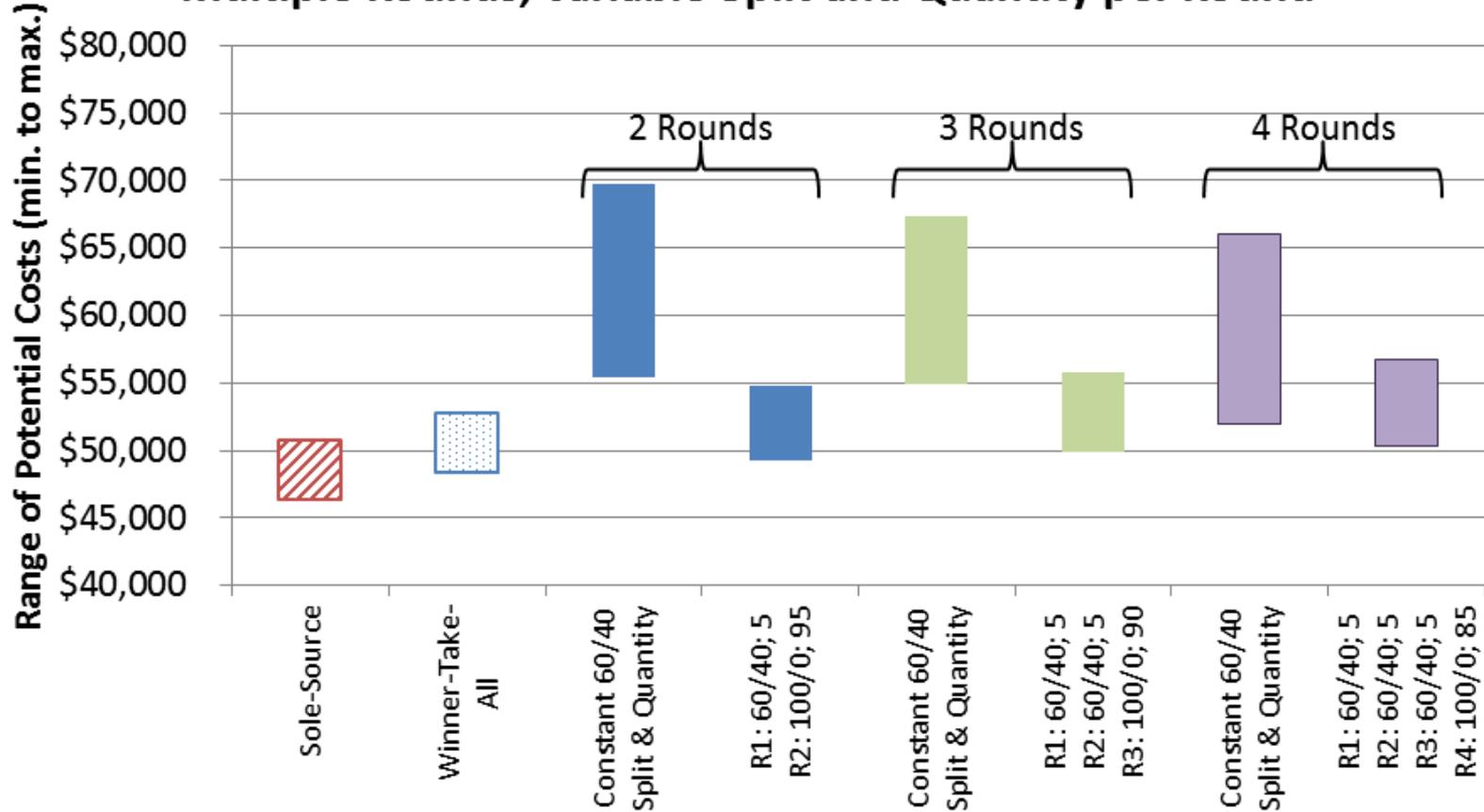
- Same principles and assumptions apply
- Calculates become longer and more complex
  - Single round: 36 possible outcomes, <1 second
  - Two rounds: 1,296 possible outcomes, ~1-2 seconds
  - Three rounds: 46,656 possible outcomes, ~1-5 minutes
  - Four rounds: 1,679,616 possible outcomes, ~1 hour
  - Five rounds: 60,466,176 possible outcomes, multiple days







## Multiple Rounds, Variable Split and Quantity per Round



- A higher learning percent tends to make competition more favorable in multi-round competitions
- Higher development cost or lower first unit cost will make competition less attractive
  - Higher ratio means a greater share of total cost due to development work—more difficult to recoup through competition
  - Higher ratio also means production work, the source of any potential savings from competition, is a smaller share of total cost
- As the total quantity of units procured rises, more costs are shifted into production and competition is more attractive

- Long-term O&S costs
  - Can be higher if two different sets of equipment must be maintained
  - Competition for maintenance work could promote efficiency and lower costs
- Industrial base
  - Awarding a sole-source or winner-take-all contract could permanently knock competitors out of the marketplace
  - Would reduce overall industrial capacity and limit future competition
- Operational risks
  - Being dependent on a single system or subsystem creates operational risks if a design flaw is uncovered
- Innovation
  - Sustained competition over multiple rounds can induce contractors to continue innovating their designs and manufacturing processes
  - Cannot always be measured or modeled

- Competition has an intuitive appeal but does not always drive down costs
- Certain competition structures can actually drive up acquisition costs by incentivizing contractors to bid higher
- Key questions for designing an acquisition strategy:
  - What is the best way to structure a competition to better incentivize contractors and reduce costs?
  - When can competition be ruled out as a viable option for reducing costs?
- Answer depends on program specific factors
- The model presented provides a way to explore different structures and to help inform sound acquisition strategies