Engineering the Acquisitions Process: Better Value Through Mechanism Design

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NOTE: The viewpoints expressed in this presentation are solely those of the authors and do not represent an official government agency position

"Gaming" Success

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- **Kong Ming - Strategic Perspective Manipulation**
  - Fled from the battlefield with a handful of body guards and retreated to Yangping, China
  - Exposed the city, removed the battle flags, hid his guards, and played the lute in view of the approaching army
  - Suspecting a trap, the pursing army of 50,000 turned tail and departed

Moral: Just as Kong Ming defeated an army of 50,000 without fighting, strategic thinking can be used to set terms for government acquisition that is more beneficial for the taxpayer and the security of the nation.

Introduction & Objective

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- Introduce U.S. Department of Defense as a monopsonist
- Discuss limited market competition
- Review Impacts of Better Buying Power (BBP) paradigm
- Identify underlying issues inhibiting true competition and argue more can and needs to be done

Primary Objective:
To introduce the economic game theory concept of mechanism design to help resolve the enduring problem of the high cost of government weapon and aerospace systems

Gov't Monopsony | Cost Growth

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- Industrial Organization
  - In defense and aerospace there is one buyer (the federal government) and five major sellers (prime contractors)
- Government is a weak monopsonist
  - Only buyer with over $500B annual budget
- Cost growth is systemic in NASA & Defense programs
  - Over 80% experience growth (averaged at 50%)

BBP & Will Cost/Should Cost

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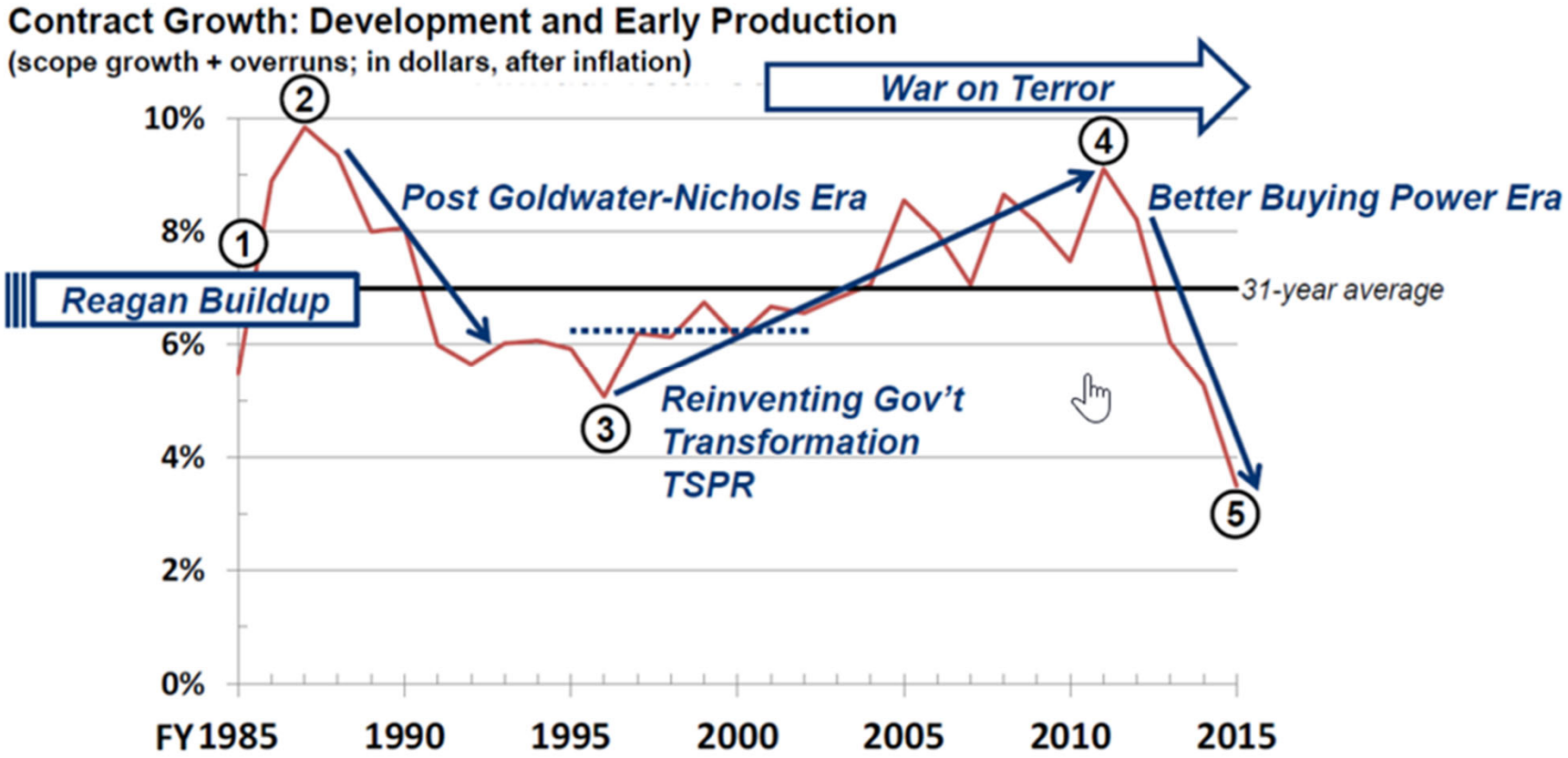
- Better Buying Power (BBP) Initiative implemented in 2010
- Introduced concepts of "Will Cost" and "Should Cost"
  - Will Cost = anticipated costs based on reasonable extrapolation of historic cost trends
    - Program should budget to Will Cost but work toward Should Cost
  - Should Cost = the potential cost of a program if cost savings initiatives are achieved; is specific, actionable, and achievable
    - Should Cost is NOT: "management challenges", increasing risk (moving down the S-curve), or vague
- BBP Success Stories
  - Missile Defense Agency's Terminal High Altitude Area Defense Program (Crowe and Embrey 2016)

BBP Efficacy: Correlation vs. Causation



- Limitations of BBP
  - Tendency to budget to Should Cost
  - BBP continues to be ad hoc
  - Emphasis on competition when market structure limits competition!

Competition: More Apparent than Real

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- DoD emphasizes competition, but it is limited
- In the last 40 years there has been a sea change in the competitive landscape from several dozen companies in the late 1970s to only five major prime contractors today
- This is an oligopoly
- Small number of large firms that have numerous interdependencies sets up the potential for collusion

Market Collusion

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- Interdependency between limited sellers in the market lays the groundwork for potential collusion
- Explicit Collusion – direct conspiring to raise prices; illegal among US firms, but that doesn't mean it never happens!
  - Example: In the 1950s there was explicit collusion among the top executives of GE, Westinghouse, Allis Chalmers, and Federal Pacific in the market for heavy electrical equipment, such as generators used by utility companies
- Tacit Collusion – collusion without overtly conspiring to raise prices; examined here through the lens of game theory

Game Theory

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- The study and modeling of conflict and cooperation between and among decision makers
- Example: "The Prisoner's Dilemma"… but adapted for acquisition, "The Competitor's Dilemma"

		Company B	
		Bid High	**Bid Low**
Company A	**Bid High**	**(3,3)**	**(0,4)**
	Bid Low	**(4,0)**	**(2,2)**

Even though both are *better off* by submitting high bids, there is **always** an incentive to compete

The Iterated Competitor's Dilemma

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- Expectation of single-round is low bids. However, if competition is iterative over time (but finite), strategies evolve to account for current and past interactions.
- Strategies include:
  - Always Cooperate (i.e. bid high)
  - Always defect (i.e. bid low)
  - Grim Trigger
  - Tit-for-Tat
- 1980s – two tournaments held for the Iterated Prisoner's Dilemma; Tit-for-Tat strategy won both.

Is collusion a **learned** behavior?

Uncertain Demand
Game Theoretic Approach

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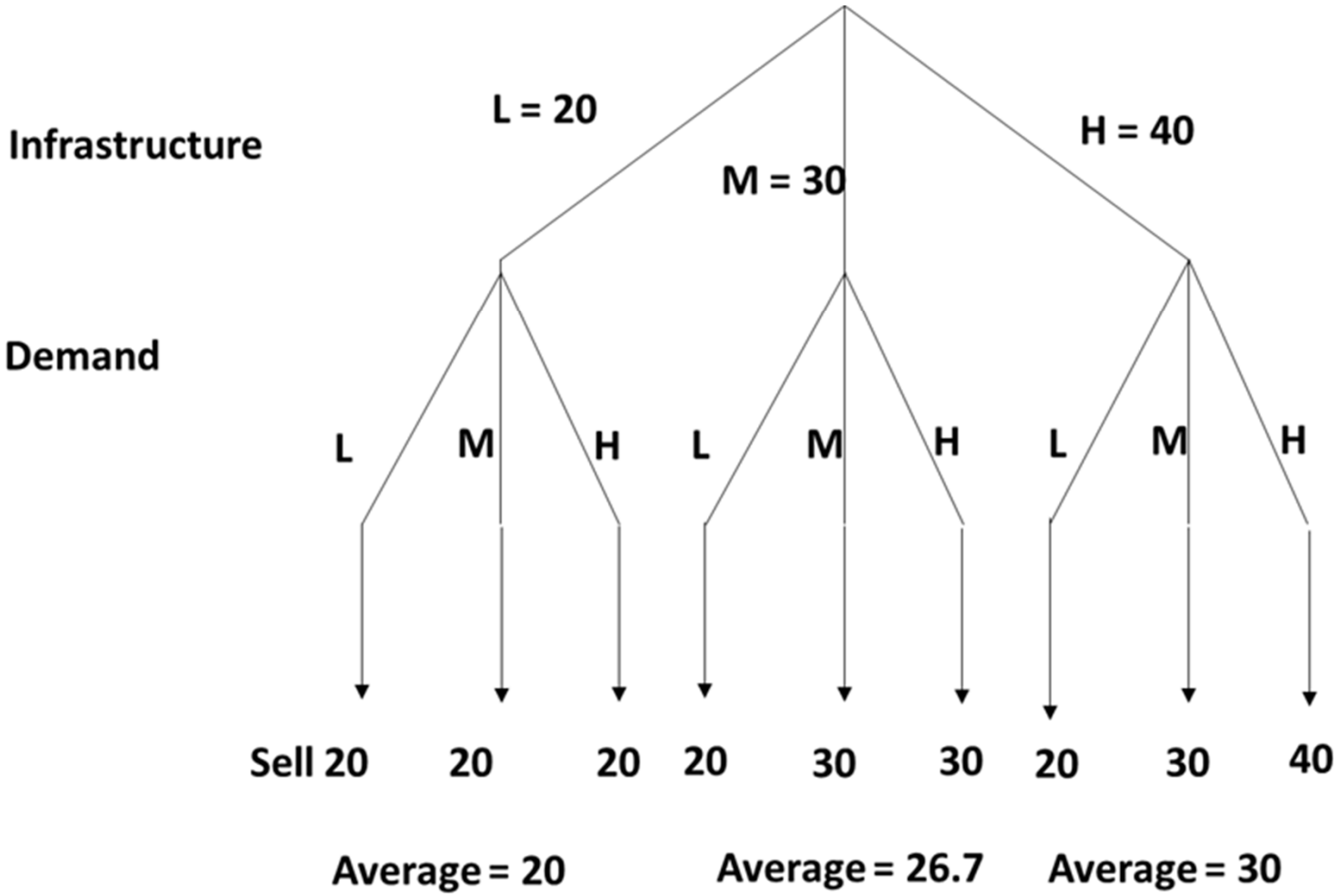
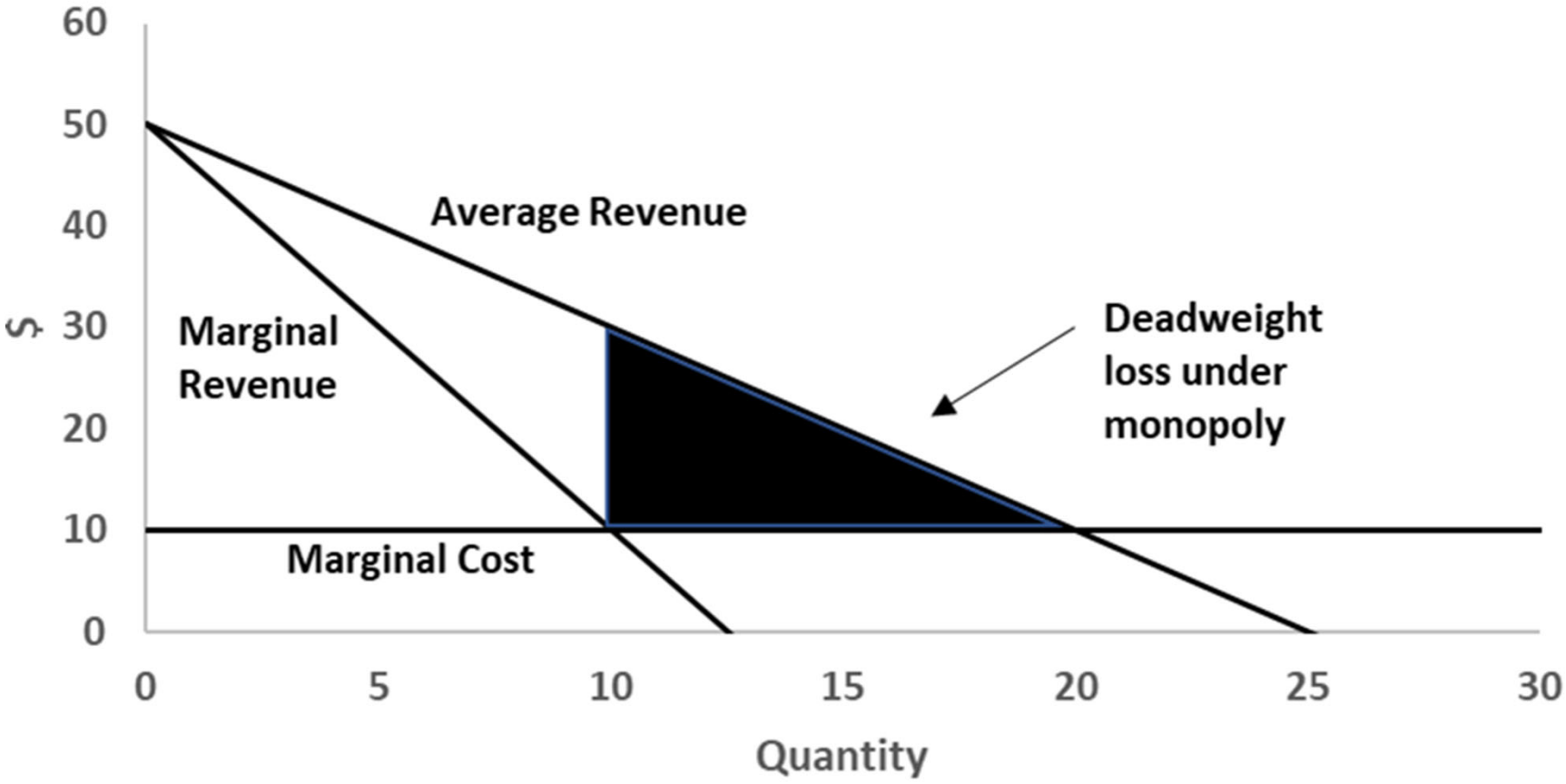


Monopolistic Inefficiencies



Mechanism Design

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- Structuring (*"engineering"*) the game (*"acquisition process"*) to achieve desired results
- **In Action:** Government already does this via the multi-year procurement process
- But What about:
  - The "Invisible Hand"
  - Information Asymmetry
- **Revelation Principle** – that any mechanism is equivalent to an incentive-compatible mechanism by which agents reveal their private information to the planner (Laffont and Martimort, 2002)

Contractor Profit Vs. Government Surplus

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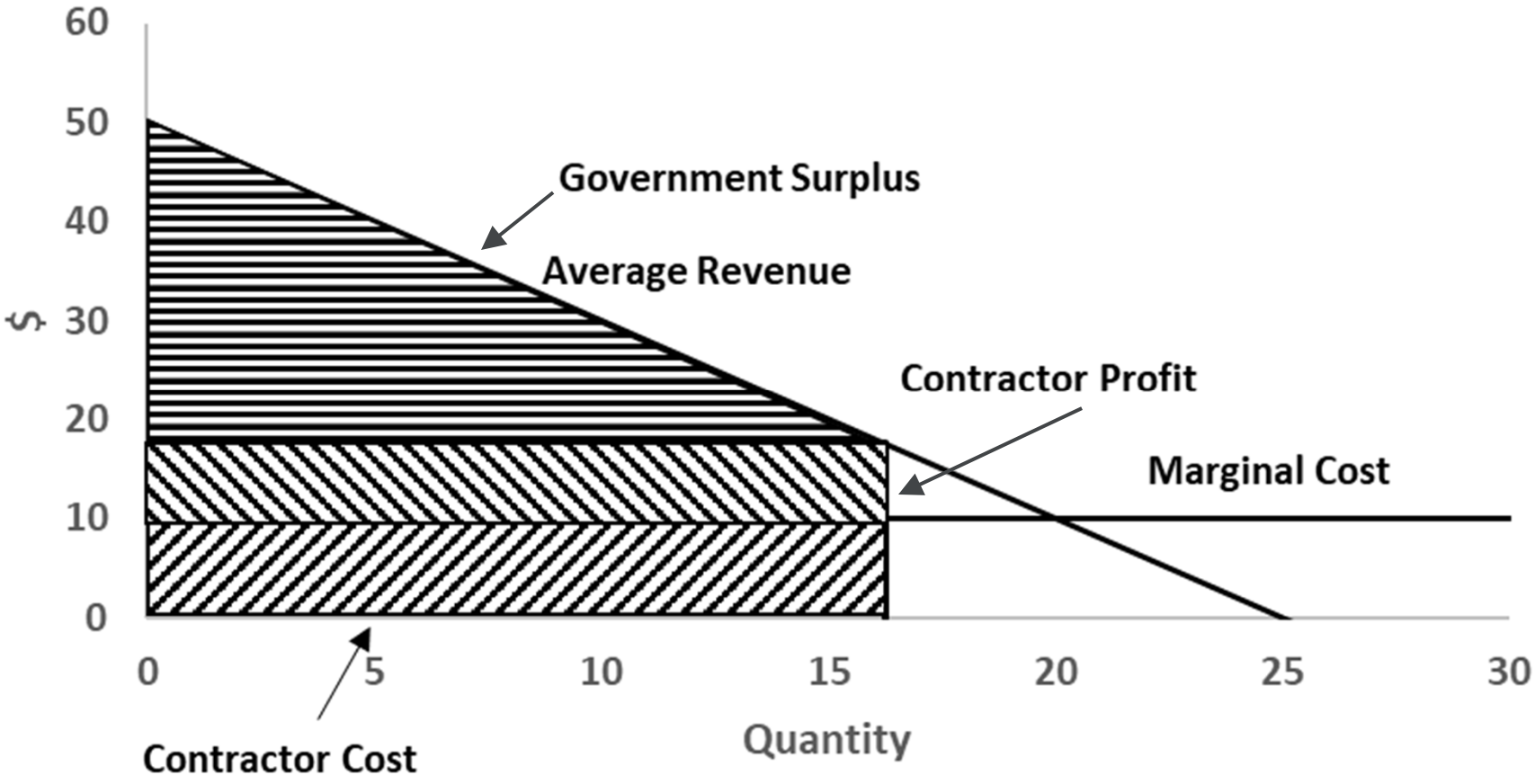
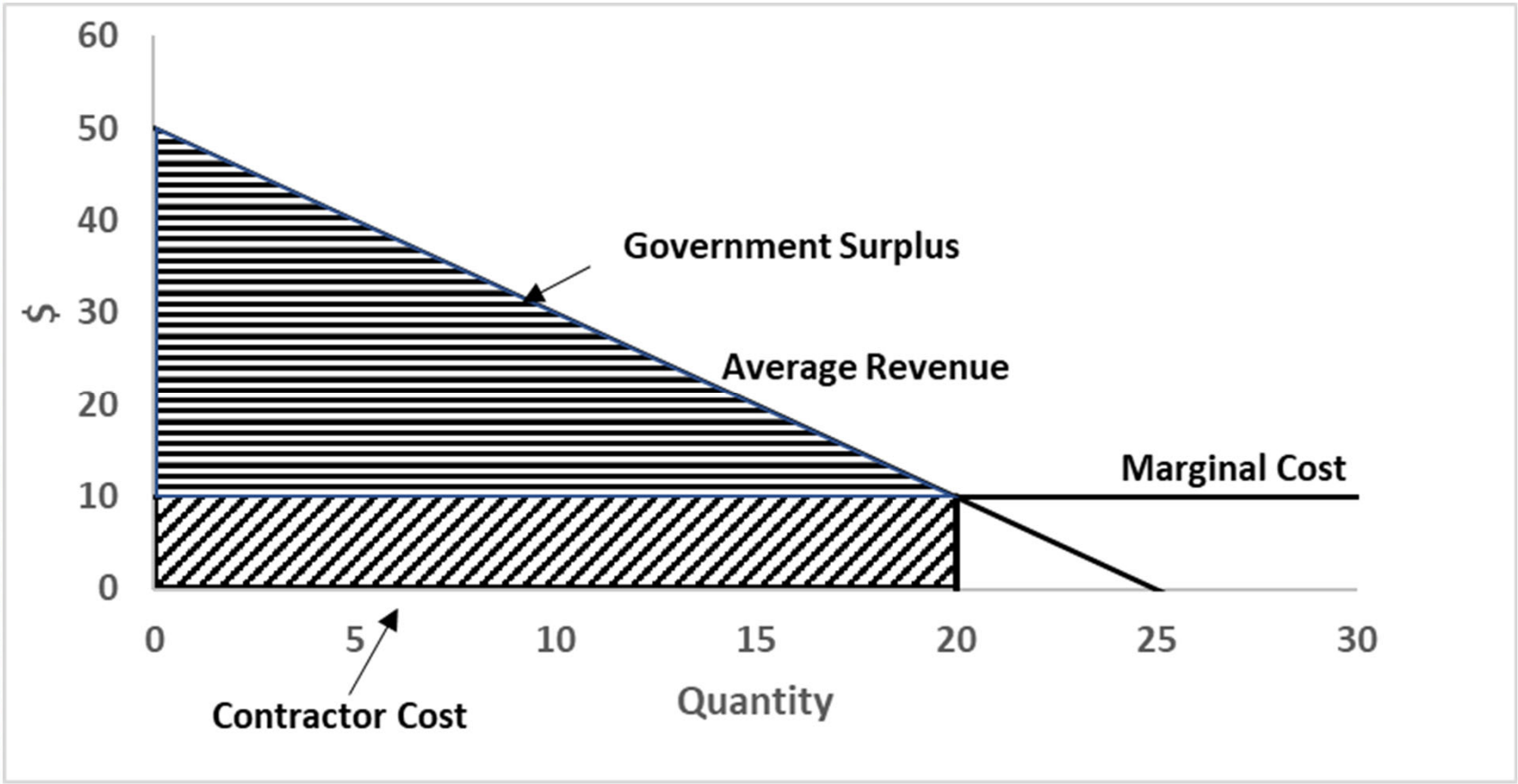


Loeb-Magat Mechanism



Baron-Myerson Mechanism

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- For the sake of simplicity we assume that the fixed cost are known and that the only uncertainty is about the marginal cost
- The contractor knows the marginal cost but the government does not (information asymmetry)
- However the government knows the upper and lower bounds, so the uncertainty is modeled as a uniform distribution

Optimal Policy

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- Requirements
  - Contractor does not lose money (profit is nonnegative)
  - The firm maximizes its profit by revealing its true marginal cost so there is no incentive for the contractor to misrepresent its cost
  - The price paid by the government to the contractor is on the demand curve

WT"F"– What the (Distribution) Function

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- We use the following notation:

  θ : Marginal cost of the contractor

  f : Probability density function of the contractor's marginal cost, we assume uniform from θ_0 to θ_1

  F : Cumulative distribution function of the contractor's marginal cost

  s : Subsidy paid to the contractor, can be positive or negative

  p : Price paid to the contractor

  q : Quantity supplied by the contractor

  k : Contractor's fixed cost

  V : Demand function

  π : Contractor profit

Optimal Policy - Results

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- The government's objective function is

$$\int_{\theta_0}^{\theta_1} \left(V\big(q(\theta)\big) - \left(\theta + \frac{F(\theta)}{f(\theta)} \right) q(\theta) - k \right) f(\theta) d\theta - \pi(\theta_1)$$

- This is optimized by setting the price paid to the contractor by being on the demand curve, so the price is

$$\theta + \frac{F(\theta)}{f(\theta)}$$

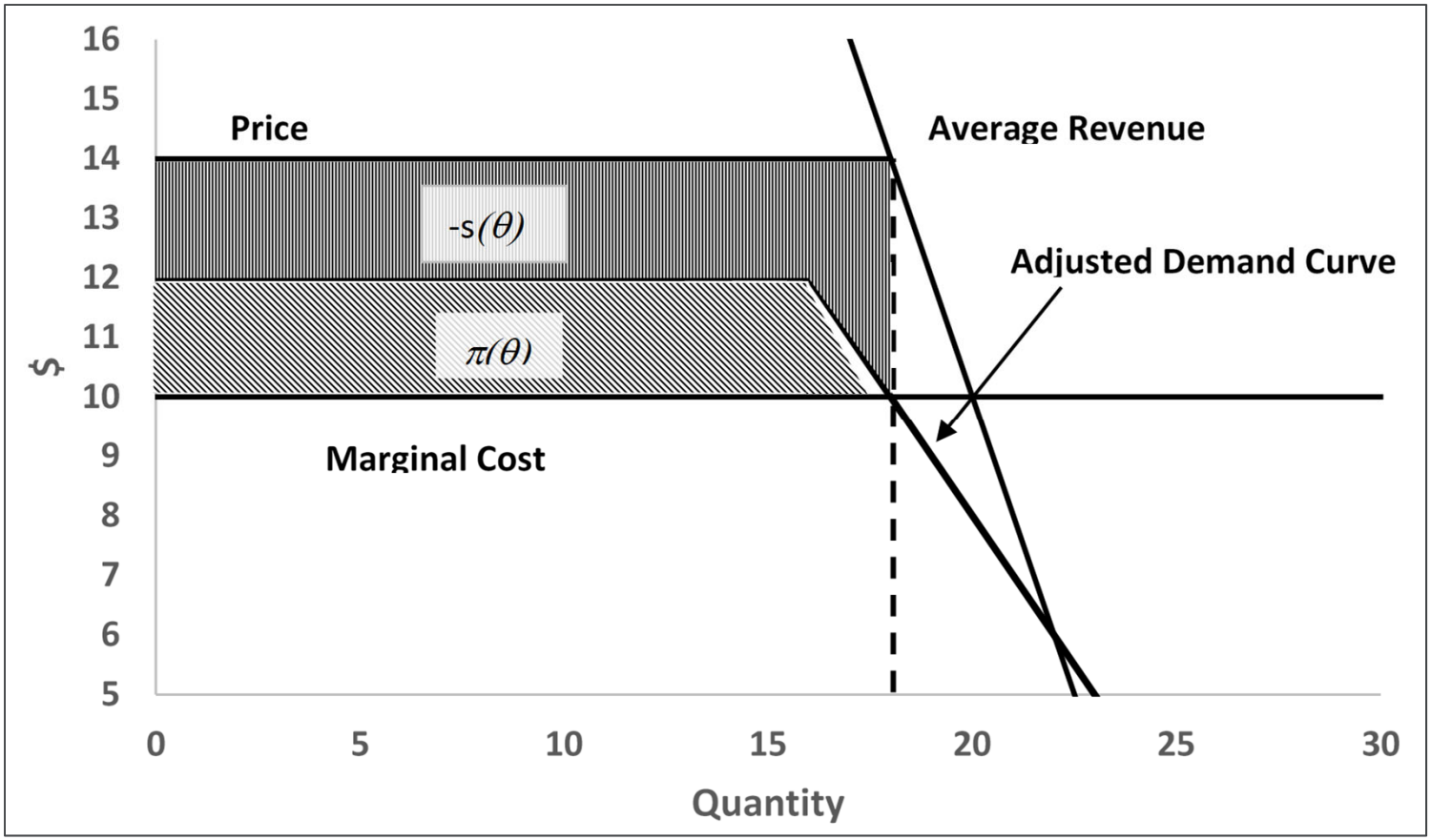
- The subsidy is

$$s(\theta) = \theta q(\theta) + k - p(\theta) q(\theta) + \int_{\theta}^{\theta_1} q\big(\tilde{\theta}\big) d\tilde{\theta}$$

- Thus the contractor's net profit is

$$\int_{\theta}^{\theta_1} q\big(\tilde{\theta}\big) d\tilde{\theta}$$

Baron-Myerson Example



Mechanism	Quantity	Profit	Profit/Unit
None	10	$200.00	$20.00
Loeb-Magat	20	$400.00	$20.00
Baron-Myerson	18	$33.00	$1.83

Conclusion

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- Costs in the Department of Defense are high
- Efforts to date have focused on ad hoc efficiencies
- Longer term the following should be addressed
  - Antitrust
  - Data rights will enable competition in production
- Shorter term need to think strategically
  - Mechanism design is a promising approach to increase quantity and reduce monopoly profits in production

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BACK-UP SLIDES

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