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Engineering the Acquisition Process: Better Value Through Mechanism Design

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GALORATH

Christian Smart, Ph.D., CCEA
Chief Scientist
Galorath Federal

Britt Staley, CCEA



GAMING SUCCESS

Kong Ming – Strategic Thinking

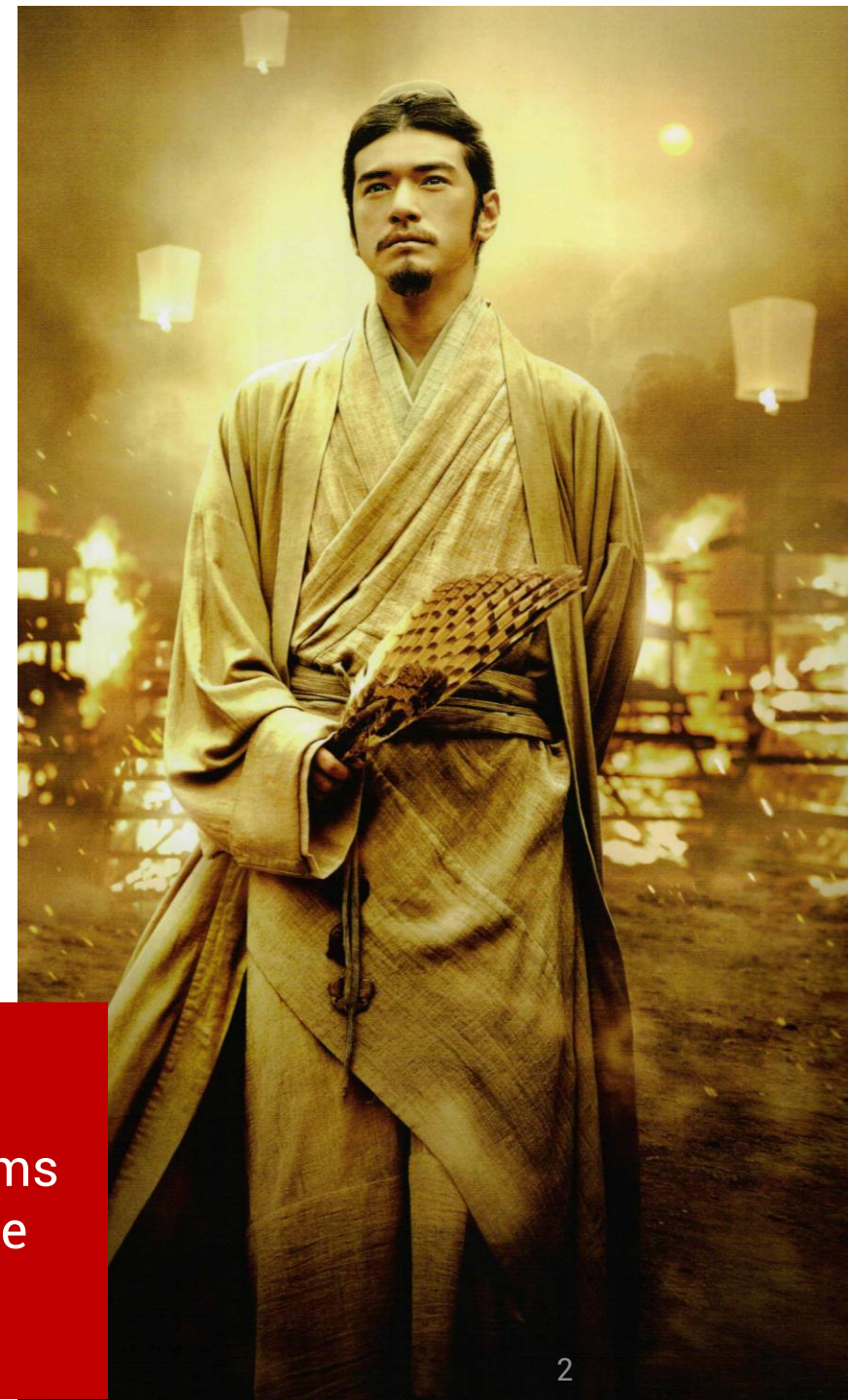
Kong Ming was a Chinese warlord

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 staved off 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.



OBJECTIVES

Introduce the economic concept of mechanism design to resolve the enduring problem of high cost of weapon and aerospace systems.

1

Better Buying Power

Review the most recent attempt by the Department of Defense to reduce costs

2

Monopsony

US government is the sole buyer in a \$500 Billion+ annual defense market but is a weak negotiator

3

Limited Competition

The prime contractor market is an oligopoly in development and a monopoly in production

4

Mechanism Design

Show how one particular mechanism can reduce costs in production

BETTER BUYING POWER

THE HYPE

01

"Hype"

Initiated in 2010 - do more without spending more; focus on will cost and should cost

03

Should Cost

Potential cost of a program if cost savings initiatives are achieved; is specific, actionable, and achievable

02

Will Cost

Anticipated costs based on reasonable extrapolation of historic cost trends

04

Some Successes

One example is the Missile Defense Agency's THAAD interceptor program, saved \$1 million per interceptor

DID BBP WORK?

CORRELATION VS. CAUSATION

➤ Cost growth decrease under BBP, but driver may have been reductions in defense spending for most of the Obama Administration – 60% correlation between changes in cost growth and defense spending, with defense spending leading changes in cost growth – see graph.

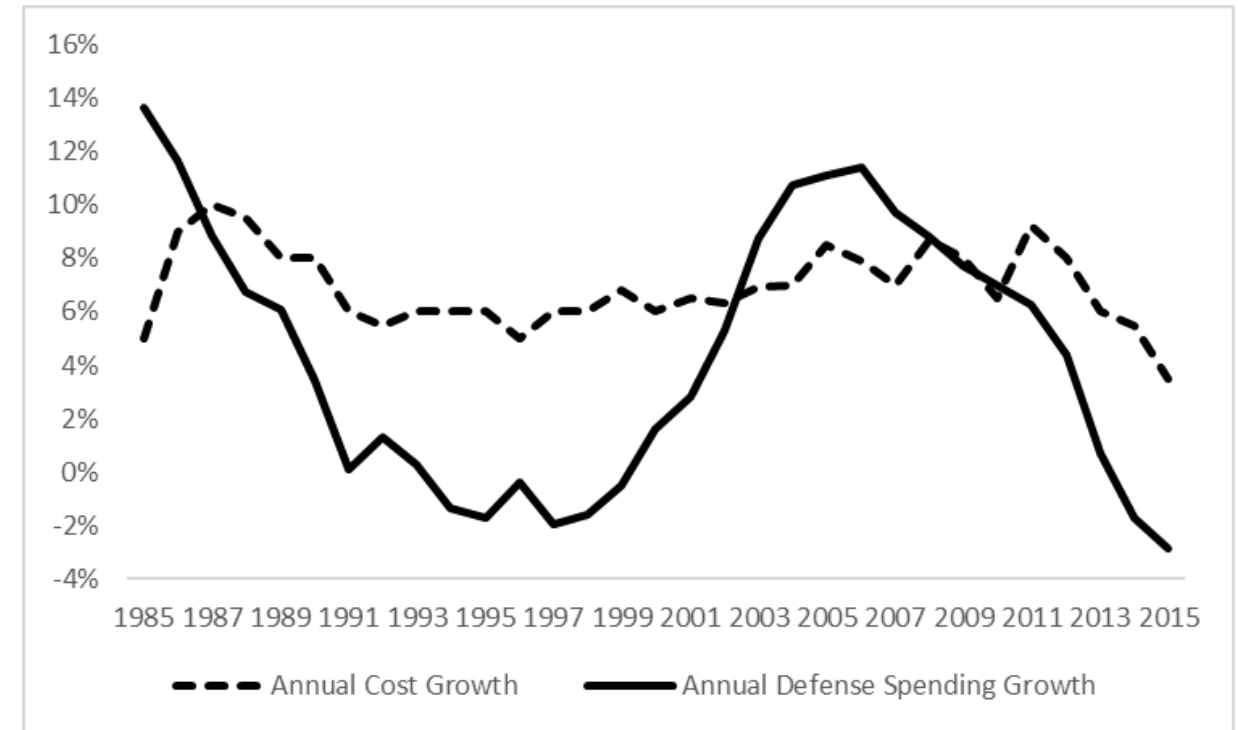
SHOULD COST IS TEMPTING

➤ Management is often tempted to budget to the should cost, rather than the will cost, that money has plenty of uses elsewhere

AD HOC

➤ Better Buying Power achieved some successes, but was ad hoc – could do better with an overarching strategy

Like NASA's Faster-Better-Cheaper policy, BBP was an idea without a plan



INDUSTRIAL ORGANIZATION

IN DEFENSE AND AEROSPACE

GOVERNMENT IS A MONOPSONIST



Weak negotiator – asymmetry of incentives and information
Can push down prices in the short-term, leading to cost growth

PRIME CONTRACTOR MARKET IS AN OLIGOPOLY



Between 1980 and 2000, over six dozen contractors consolidated to the Big Five – Boeing, General Dynamics, Lockheed Martin, Northrop Grumman, and Raytheon .

RESULT IS HIGH COST AND COST GROWTH



Air Force paid \$10,000 for a toilet seat cover in 2018
Average cost growth of development programs has remained 50% since the 1970s



COMPETITION AMONG PRIME CONTRACTORS

DoD EMPHASISES COMPETITION

A key tenet of Better Buying Power was to compete contracts as much as possible but this is more apparent than real

OLIGOPOLY

However there are not enough companies to effectively compete

Five major primes, less in some commodity classes

Data rights not purchased up front, so no competition in production

POTENTIAL FOR COLLUSION

The limited number of competitors sets up the potential for collusion, either explicit or tacit



COLLUSION

INTERDEPENDENCY



Interdependency among prime contractors sets up the potential for collusion

EXPLICIT



Illegal but it happens

In 1950s, senior executives of multiple firms conspired to fix prices in the heavy electrical equipment market

TACIT



Collusion without overtly conspiring to raise prices

Examined here through the lens of game theory



GAME THEORY

THE ECONOMICS OF STRATEGY, CONFLICT, AND COOPERATION

		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.

ECONOMIC DISCIPLINE



Not the theory of checkers or chess

Study of conflict and cooperation between and among decision makers

JOHN NASH



Popularized in the film "A Beautiful Mind," John Nash was awarded the Nobel Prize in Economics in 1994 for his work on game theory

PRISONER'S DILEMMA



Game theory shows how simple competition *always* leads to a lower price

THE ITERATED COMPETITOR'S DILEMMA

Is collusion a learned behavior?

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.

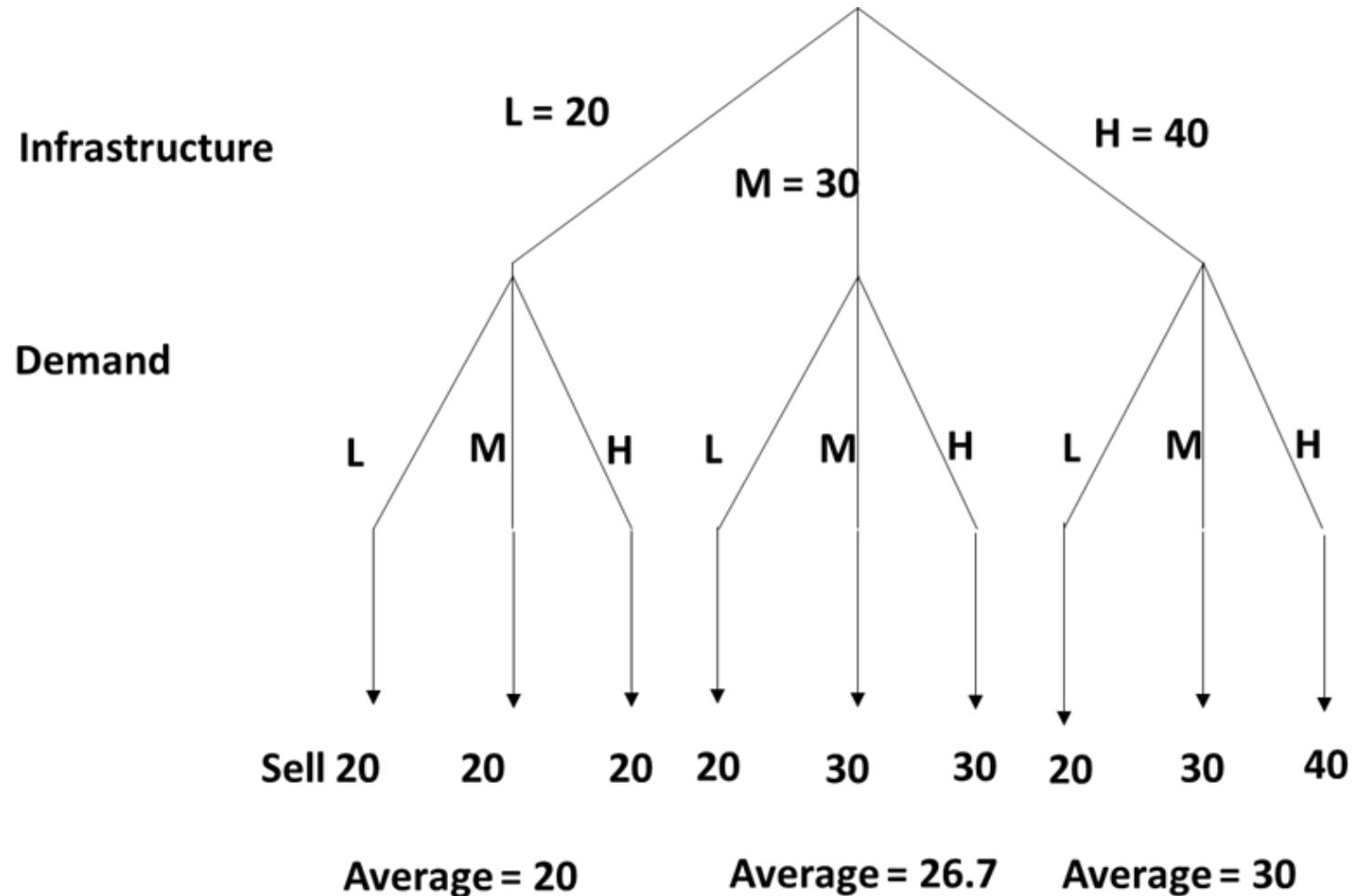
Strategies include:

- Always Cooperate (i.e. bid high)
- Always defect (i.e. bid low)
- Grim Trigger
- Tit-for-Tat

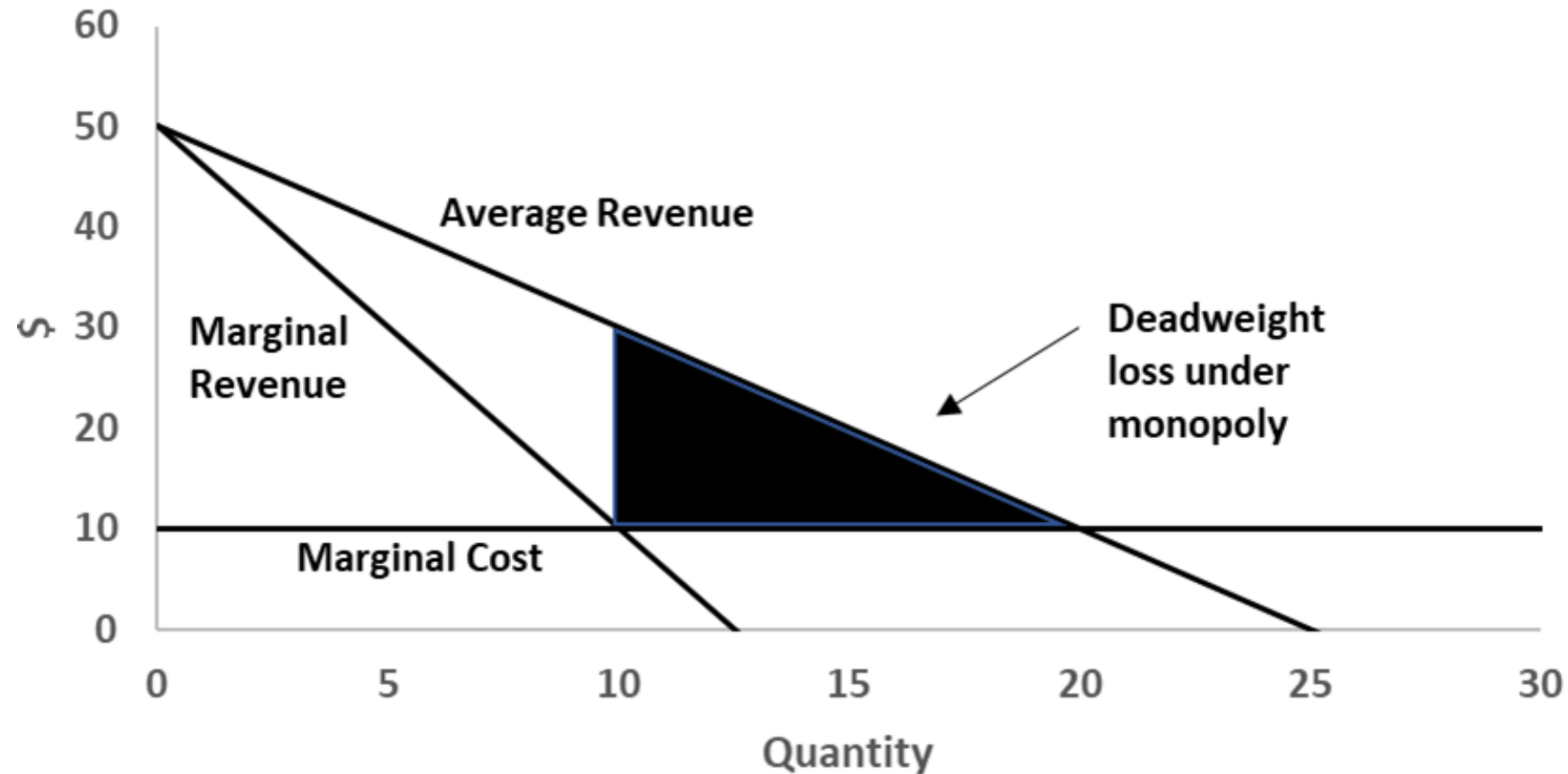
1980s – two tournaments held for the Iterated Prisoner's Dilemma; Tit-for-Tat strategy won both

UNCERTAIN DEMAND

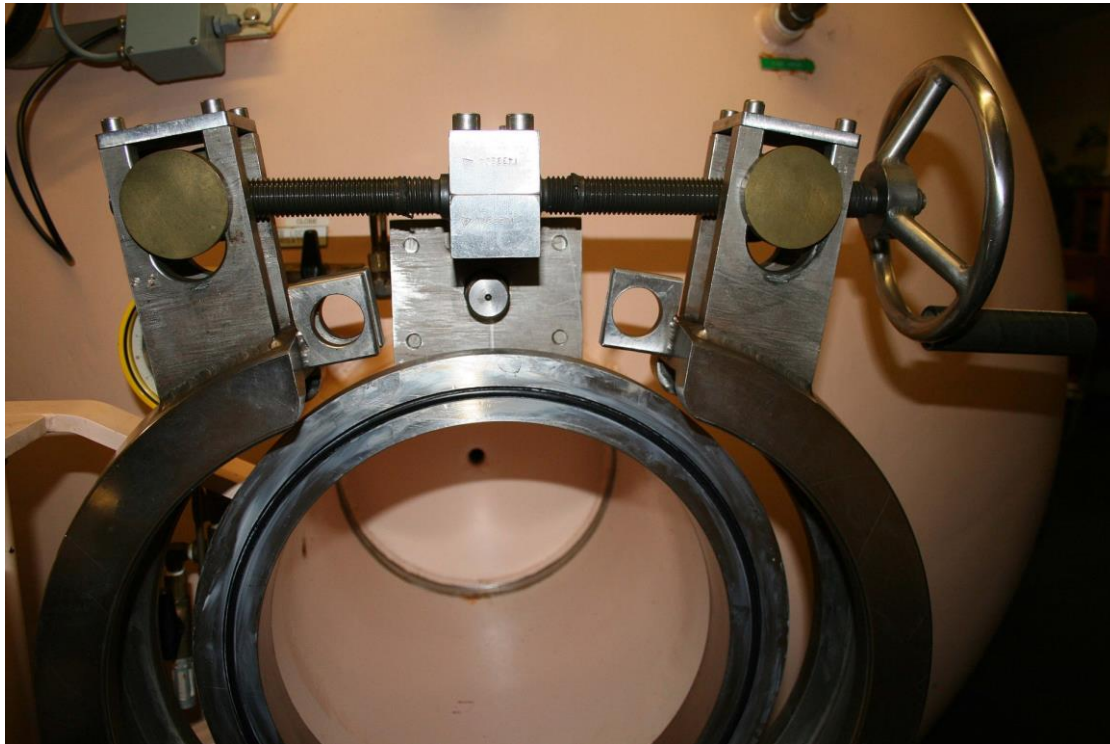
GAME-THEORETIC APPROACH



MONOPOLISTIC INEFFICIENCIES



MECHANISM DESIGN



**STRUCTURING ("ENGINEERING") THE GAME
("ACQUISITION PROCESS") TO ACHIEVE DESIRED
RESULTS**

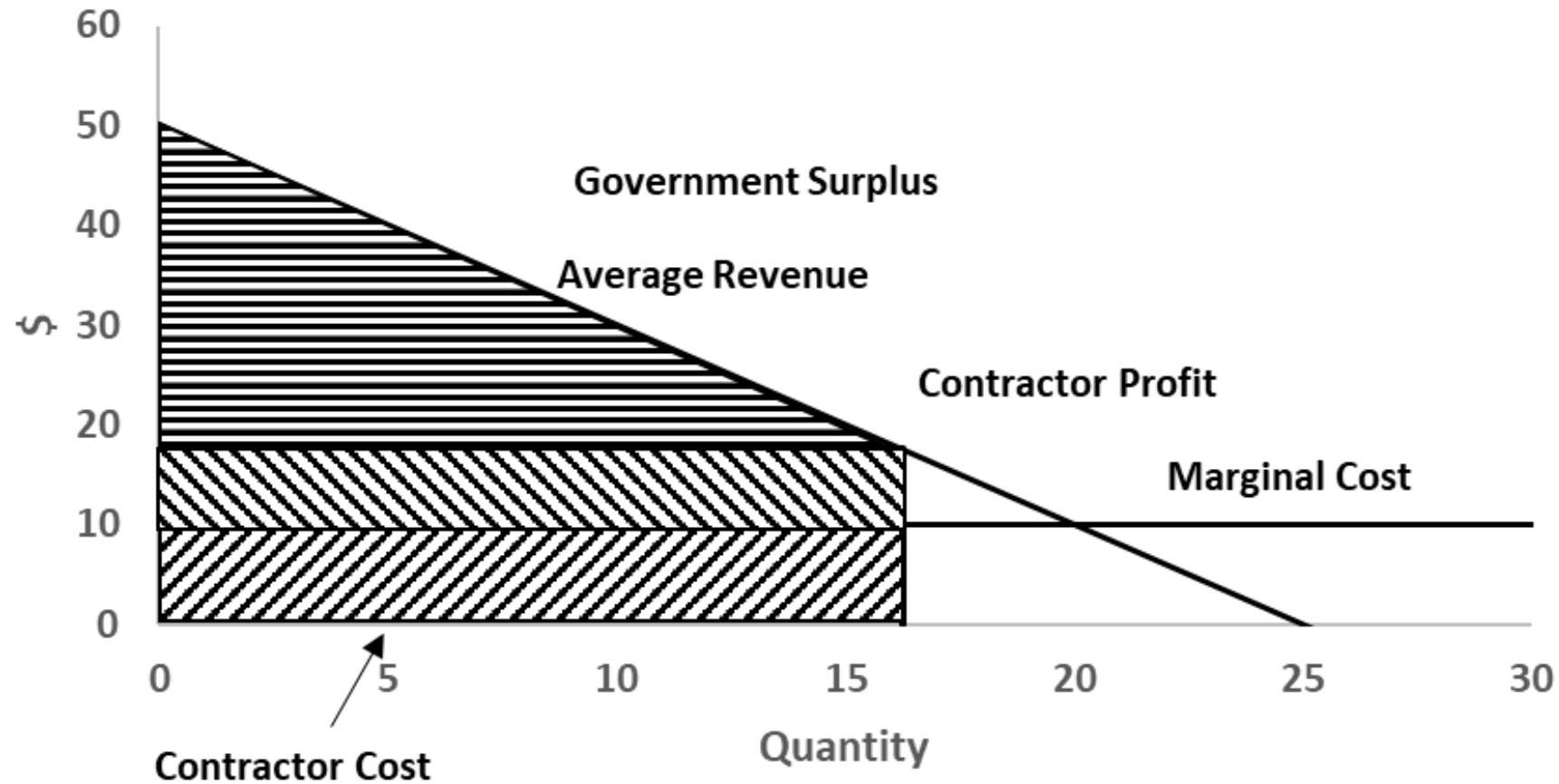
IN ACTION

Government does this to some extent – multiyear procurement
Much more can be done – issues of information asymmetry

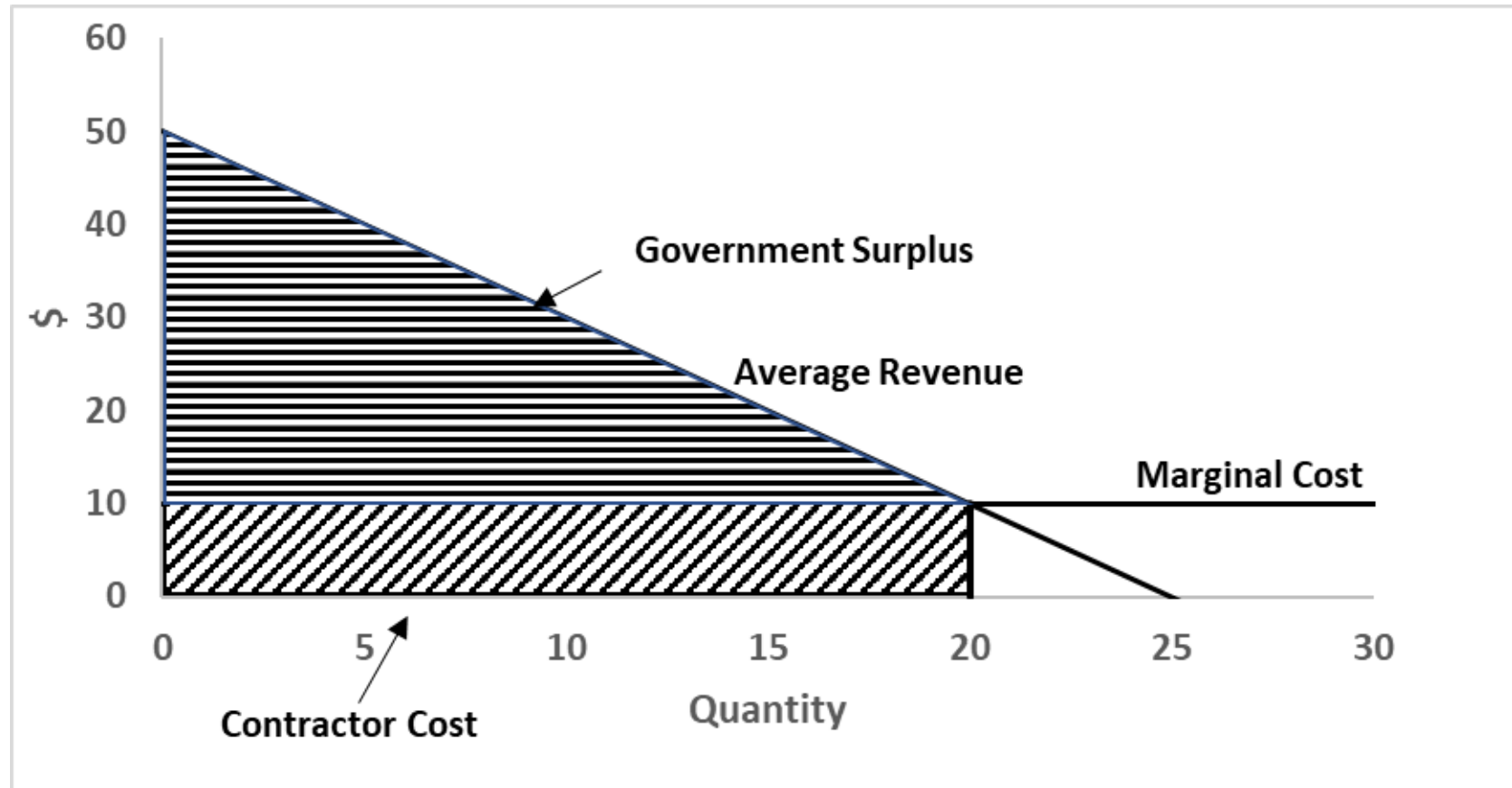
REVELATION PRINCIPLE

Any mechanism is equivalent to an incentive-compatible
mechanism by which agents reveal their private information to
the planner

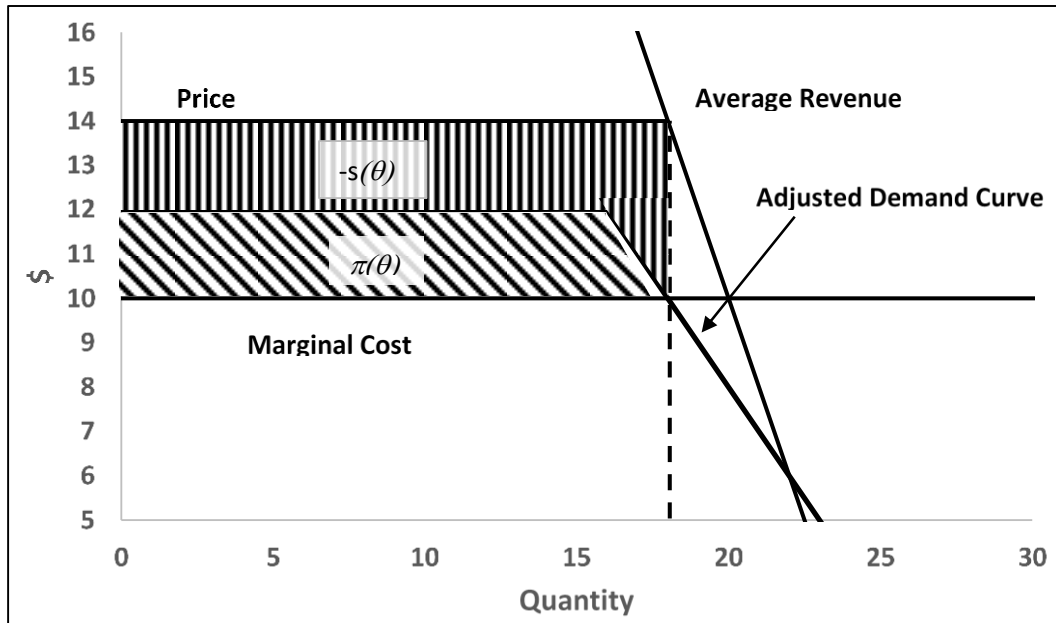
CONTRACTOR PROFIT VS. GOVERNMENT SURPLUS



LOEB-MAGAT MECHANISM



BARON-MYERSON MECHANISM



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



ASSUMPTIONS

Fixed cost known, variable cost uncertain but government can bound the variable cost

Contractor knows variable cost (asymmetry)



REQUIREMENTS

Contractor does not lose money

Revelation principle

Price is on the demand curve



RESULTS

Government can yield significant savings by using strategy

THE MATH

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

THE MATH PART 2

- The objective function is

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

- 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

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

- Thus the contractor's net profit is

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

CONCLUSION

01

Costs in the Department of Defense are high

02

Efforts to date have focused on ad hoc efficiencies

03

Longer term the following should be addressed

- Antitrust
- Data rights will enable competition in production

04

Shorter term need to think strategically

Mechanism design is a promising approach to increase quantity and reduce monopoly profits in production