# AOPL Business Conference

## Oil Pipeline Economics

September 15, 2011

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# Economics as a Tool of Business

- Fundamentally economics uses the principles that individuals make choices that maximize their welfare to predict human behavior.
- These principles provide a powerful predictive tool.
- However, it is ultimately only one tool in the proverbial tool bag.
- Predictions must be tempered with:
  - Common sense
  - Real world experience
  - Human psychology



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# Discussion Outline

- Part I: Economic Theory of Fixed Cost Production
- Part II: Game Theory
- Part III: Natural Experiment

# Part I
# Economic Theory with High Fixed Costs

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# Price Theory

- Microeconomic theory suggests two different prices will emerge depending upon competitive conditions.
- Monopoly: Price=Marginal Cost=Marginal Revenue
- Perfect Competition: Price=Marginal Cost=Demand
- In reality, most prices are somewhere in between.



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# What is “Marginal”

- Marginal means the amount of something (e.g. cost) caused by the last unit.
- For the engineers: marginal is the first derivative.
- It is roughly equivalent to variable cost.
- Marginal is important because it allows us to think about costs and revenues associated with the last unit produced



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# Marginal Versus Average Cost

- At a conceptual level costs can be thought of as: C (q)=cq+F, where c is a cost factor, q is the quantity, and F is a fixed cost.
- Marginal cost is given by MC=c (because the F drops out when you take the first derivative).
- Average Cost is given by AC=Cq\q+F\q or AC=C+F\Q
- Therefore if F is small MC>AC
- HOWEVER, if F is large AC>MC



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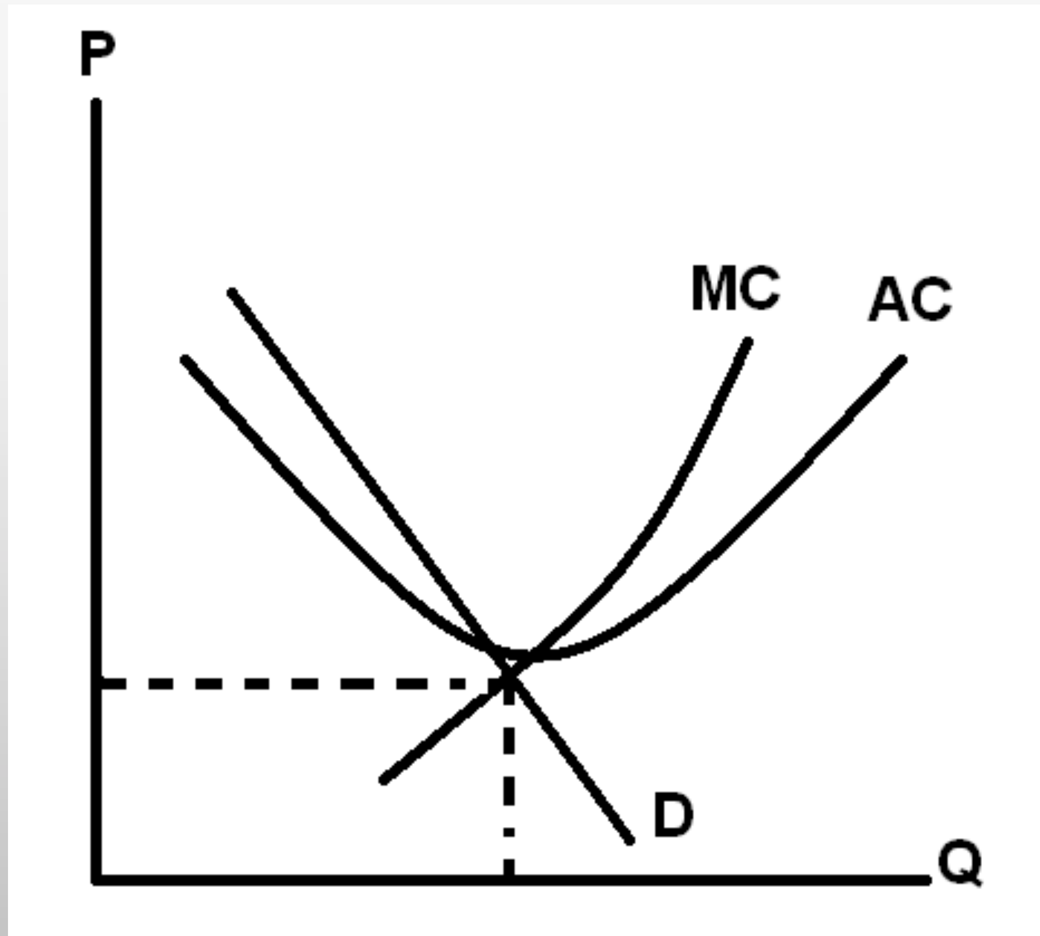
# Marginal Versus Average Cost (cont.)



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# Practical Implications for Pipelines

- It is not possible to charge short-run marginal cost since average cost greatly marginal cost.
- Since AC>MC, setting price equal to marginal cost will lead to a loss on average (i.e. bankruptcy).
- Properly applied, cost-of-service simulates average cost



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# Ratemaking Implications

- For a simple pipeline (going from point A to point B) ratemaking is trivial: Rates=COS/Vol.
- The situation becomes more complex for a multi-origin multi-destination pipeline, which must allocate costs.
- Cost allocation should match cost with causation and requires business judgment.
- Economic theory does not provide a definitive formula to allocate cost.
- Economics theory does provide boundaries.

# Ratemaking Boundaries

- A rate should never generate revenue less than variable (technically marginal cost).
- All rates should make some contribution to fixed costs.
- No rate should generate revenue higher than cost to provide service alone.



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# Practical Applications

- Customers with competitive alternatives may pay lower rates than other customers.
- In an oil pipeline context, it is important to carefully assess competition to ensure compliance with anti-discrimination provisions of the ICA.
- Trading rate for volume is always desirable (assuming incremental revenue exceeds variable cost).

# Practical Applications (cont.)

- Customers who pay a higher fraction of the fixed cost may receive different treatment from customers who do not pay as much of the fixed cost.
- They may receive firm(er) transportation.
- They may receive a discount.
- FERC does not permit both
- Chris Barr and Bill Williams discuss this issue in depth in Session 4.

# Part II
# Game Theory

## Strategic Decisions: Actions and Reactions

# Game Theory

- What is game theory?
- How do people behave in strategic situations?
- Making decisions based on available information and the decisions of others
- Provides a rigorous methodology to specify conditions that result in positive economic outcomes

# Carriers And Shippers

- Carriers' Goals
  - Fill up their pipeline capacity
  - Collect tariffs for the transportation services they provide
- Shippers' Goals
  - Ship oil to meet demand(producer: refineries, refiners: terminals/gas stations)
  - Reduce the cost of transportation
- Common Goal
  - Transportation of oil
- "Prisoners Dilemma" provides a classic example of a game where cooperation breaks down.

# Prisoner's Dilemma

| | | Dwight (Bank Robber II) | |
|---|---|---|---|
| | | Silent (Cooperate) | Confess (Defect) |
| Michael (Bank Robber I) | Silent (Cooperate) | 50 , 50 | -100 , 100 |
| | Confess (Defect) | 100 , -100 | 0 , 0 |

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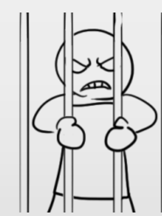
# Prisoner's Dilemma (cont.)

| | | Dwight (Bank Robber II) | |
|---|---|---|---|
| | | Silent (Cooperate) | Confess (Defect) |
| Michael (Bank Robber I) | Silent (Cooperate) |  ,  |  ,  |
| | Confess (Defect) |  ,  |  ,  |



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# Prisoner's Dilemma (cont.)

- The dominant strategy for both robbers is to confess.
- It is a Nash equilibrium.
- Each robber is better off confessing regardless of how the other robber acts.
- No incentive to cooperate
- No ability to punish each other for non-cooperative behavior
- The example is an one shot game. Is this realistic?

# Prisoner's Dilemma – Repeated Game (Finite)

## Bank Robbery #1

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , _100_ |
| | Confess | _100_ , -100 | _0_ , _0_ |

## Bank Robbery #2

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , _100_ |
| | Confess | _100_ , -100 | _0_ , _0_ |

## Bank Robbery #3

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , _100_ |
| | Confess | _100_ , -100 | _0_ , _0_ |



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# Prisoner's Dilemma – Repeated Game (Finite) (cont.)

- The games are solved in reverse order. (induction theory)
- The last game will be played like an one shot game.
- Both robbers' dominant strategy is to confess in the last game.
- The domino effect leads to both robbers confessing in all three games.
- Under what circumstances can cooperation be achieved?

# Prisoner's Dilemma – Repeated Game (Indefinite)

## Bank Robbery #1...

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , 100 |
| | Confess | 100 , -100 | 0 , 0 |

## Bank Robbery #2...

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , 100 |
| | Confess | 100 , -100 | 0 , 0 |

## Bank Robbery #N

| | | Dwight | |
|---|---|---|---|
| | | Silent | Confess |
| Michael | Silent | 50 , 50 | -100 , 100 |
| | Confess | 100 , -100 | 0 , 0 |

# Prisoner’s Dilemma – Repeated Game (Indefinite) (cont.)

- Discounting future payoffs (δ)
  - If $\delta \leq 50\%$ for both robbers, cooperation can be achieved
- Cooperation can be reinforced
  - Deviation from cooperation will result in punishment (credible threat)
- Myopic robbers will not cooperate.

# Practical Implications for Pipelines

- Importance of long term relationships to lessen incentive to deviate from cooperation
  - Commitment from shippers for new pipeline construction
  - Term contracts for stability of throughput in exchange for incentive discounted tariff rates
- Short term gains may not benefit the pipeline in the long run



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# Free Rider Game 1

| | | Dwight | |
|---|---|---|---|
| | | Contribute | Free Ride |
| Michael | Contribute | 50 , 50 | -100 , 100 |
| | Free Ride | 100 , -100 | 0 , 0 |

# Free Rider Game 2

| | | Dwight | |
|---|---|---|---|
| | | Contribute | Free Ride |
| Michael | Contribute | 50 , 50 | 1, 99 |
| | Free Ride | 99, 1 | 0 , 0 |



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# Implications of the Free Rider Game

- With certain payoff structures the project won't get built (everyone free rides).
- This is the same outcome as the Prisoner's Dilemma
- If the payoff structure is altered sometimes the project will be built and sometimes it will not be built.
  - In the example above it will be built approximately 4% of the time.
- To ensure the project is built the payoffs must be altered such that contributing becomes the dominant strategy.



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# Free Rider Game 3

| | | Dwight | |
|---|---|---|---|
| | | Contribute | Free Ride |
| Michael | Contribute | 50 , 50 | 75, 25 |
| | Free Ride | 25 , 75 | 0 , 0 |

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# Part III: Natural Experiments

Using Statistics to Inform Decisions (and avoiding their misuse)

# Correlation Does Not Equal Causation

- It is inappropriate to infer that because two events occur together one event caused the other.
- Examples:
  - Roosters crowing and the sun rising
  - Price of gasoline rising in 1998 and increasing concentration in the oil industry.
  - Going to Yale and earning a higher salary.

# Inferring Causation: Controlled Experiment

- A controlled experiment is the "Gold Standard" for inferring causation.
- Example:
  - Some roosters placed outside;
  - Some roosters placed in a barn without sunlight;
  - Some roosters exposed to artificial sunlight at a time other than morning.
- Evaluate results to determine if sun rising causes crowing.
- In many cases controlled experiments are impractical.

# Inferring Causation: Linear Regression

- With sufficient observations (at least >50 ideally >250) it may be possible to infer causation using some form of Linear Regression.
- However a Linear Regression MUST include all variables that impact the "Dependent" variable.
- Examples:
  - Price of Gasoline=Concentration of Oil Industry
  - Wages=Graduated from Yale

# Linear Regression: Omitted Variable Bias

- If variables are omitted the results will be biased.
- For example, omission of  a "crude price" variable biases the concentration variable.
- In the Yale example, the omission of variables such as "parents income" biases the Yale variable.

# Solutions to the Problem of Omitted Variable Bias

- A common solution involves adding variables.
- For example, in the gasoline equation we might add: 1) crude price; 2) population; 3) GDP
- To the Yale equation we might add:
  1) Parents Income; 2) High School Grades
- Ensuring you have all relevant variables is the key limitation to this approach.

# Using Natural Experiments

- Ensuring you have all variables is ultimately impossible; you don't know if you have variable you don't know about.
- A controlled experiment would be ideal.
- In most cases (e.g. oil pipeline contexts) a controlled experiment is unlikely to work.
- Sometimes a "natural experiment" will work.
- For example, we might compare the incomes of Yale Graduates with students who got into Yale but went to a state school.

# Further Examples of Natural Experiments

- Analyzing the price of gasoline in a city where oil industry concentration increased, compared to a city where concentration did not increase.

- Analyzing the impact of elections of crime.

- Analyzing the impact oil pipeline expansions on the price of gasoline.

# Value of Natural Experiments as an Analytical Tool

- The statistics are relatively straightforward.
- The insights they provide can be powerful.
- They require a deep understanding of institutional and commercial realities of the industry being analyzed.