TURKISH AVIATION ACADEMY

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# Aviation Economics & Finance

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# OUTLINE

- Game Theory
- How Airlines Compete
- Baggage Fees: A Game Theoretic Analysis
- Game Theory and Aircraft Manufacturing
- Game Theory: Airbus vs Boeing

# A. **GAME THEORY**

# KEY IDEAS

- Know strategic situation (what is the game?)
- Your competitor is just as smart as you are!
- Think about the response of others
- Nash equilibrium: all participants do the best they can, given the behaviour of competitors.

# GAME THEORY

- Set of tools to analyze situations of *strategic interdependence*, i.e. where A's best decision depends on what B does
- A *game* consists of:
  1. Players: Which decision makers are involved (e.g. Turkcell and Vodafone or THY and Pegasus)
  2. Rules (e.g., simultaneously choose prices or sequantially)
  3. Strategies: What are the options available to each? (e.g., price between 10 and 30)
  4. Outcomes (payoffs): What is the outcome for each player, depending on which strategies are chosen? (e.g., sales minus production costs)
- What will happen if each player pursues his own interests?

# How to represent a game

- Extensive form or game-tree form:
  - useful when decisions are sequential.
- Normal form:
  - useful when decisions are simultaneously taken.
  - Important note: the meaning of "simultaneously"
- Order of moves VERY important to outcome

# EXAMPLE: NORMAL FORM

| Player A \ Player B | L | C | R |
|---|---|---|---|
| **T** | (9,5) | (8,6) | (1,7) |
| **M** | (1,3) | (2,5) | (0,6) |
| **B** | (2,7) | (3,6) | (3,8) |

# DOMINANT AND DOMINATED STRATEGIES

- Dominant strategy: payoff is greater than any other strategy regardless of rival's choice.
  - Rule 1: if there is one, choose it and that's the end of it.
- Dominated strategy: payoff is lower than some other strategy regardless of rival's choice.
  - Rule 2: do not choose dominated strategies.
- Check whether there are dominant and/or dominated strategies in the example above. What can we say based on this?

# EQUILIBRIUM

- Sometimes a game can be “solved” just by looking at dominant and dominated strategies.
- However, there are many games for which this does not work.
- Concept of equilibrium: a rest point of the system.
- **Nash equilibrium:** *Situation such that, given what other players are doing, no player would want to change strategy unilaterally.*

# EQUILIBRIUM

Three equivalent definitions of a (Nash) equilibrium:

An *equilibrium* is a combination of strategies such that

- each player's strategy is a best response to the strategies of the other players
- each player maximizes his payoff, taking as given the others' strategies
- given the strategies of the others, no player has an incentive to deviate

# PRISONER'S DILEMMA

- Output setting (number of flights a day) by two airlines
  - Player: Airlines A and B
  - Action: {2, 4} flights in the morning
  - Here is the pay-off matrix

| B / A | **2** | **4** |
|---|---|---|
| **2** | (450,450) | (375,500) |
| **4** | (500,375) | (400,400) |

# PRISONER'S DILEMMA

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| A \ B | 2 | 4 |
|---|---|---|
| 2 | (450,450) | (375,500) |
| 4 | (500,375) | (400,400) |

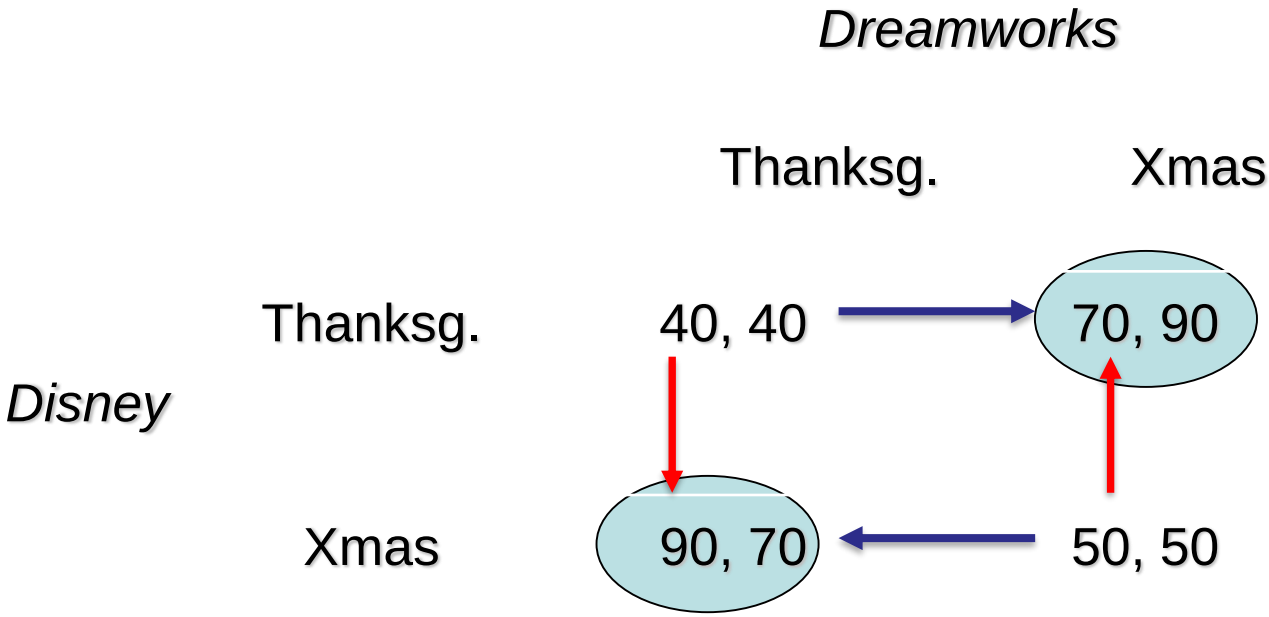
# PRISONER'S DILEMMA

- Dominant strategies: high output (4 flights each).
- Equilibrium payoffs are (400,400), worse than those attained by low output, (450,450).
- Conflict between individual incentives and joint incentives.
- Typical of many business situations.

# EXAMPLE : DISNEY AND DREAMWORKS

- Disney and Dreamworks release new animated movies
- Choice for each: Thanksgiving or Christmas
- Christmas is larger market, but both want to avoid head-to-head competition

# PAYOFF MATRIX MIGHT LOOK LIKE THIS:




Equilibria? Two NE (X,T) and (T,X)

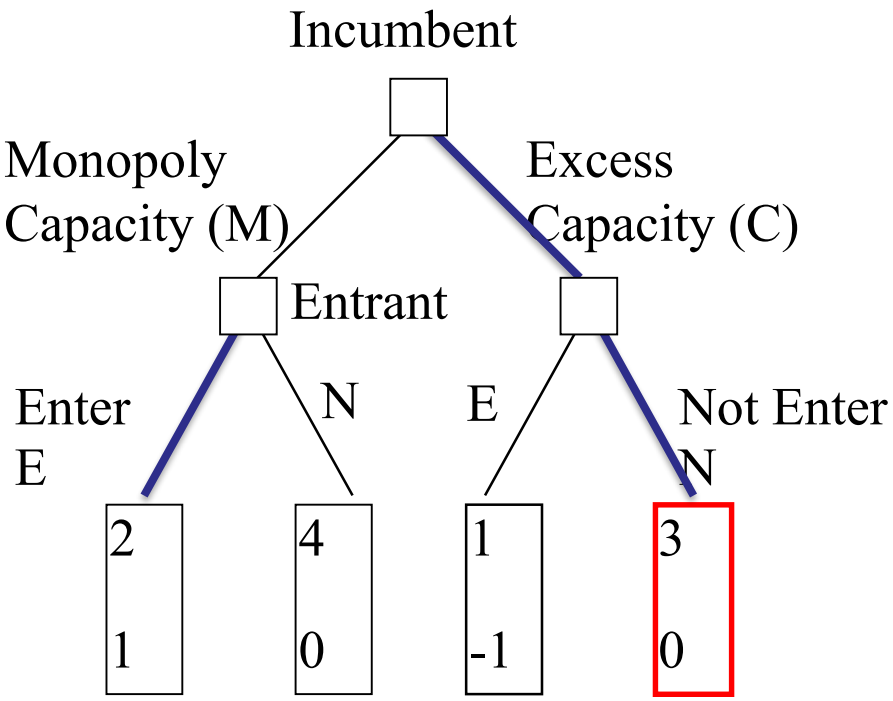
Problem: coordination may be difficult! Illustrates problems with NE.

# Dynamic Games and Subgame Perfection

- In Nash Equilibrium, players take opponents' strategies as given & do not consider the possibility of influencing them
- In games in which a player chooses some actions after observing some of his opponents' actions (dynamic games), the above conjecture is naïve and leads to some absurd Nash equilibria
- Subgame perfection is a refinement that mitigates some of the deficiencies of Nash equilibrium
- An outcome is said to be subgame perfect if it induces a Nash equilibrium in every subgame of the original game.
- Subgame perfect equilibria can be found by backwards induction.

# Example: Subgame Perfection

dioxide industry:




Nash Equilibria: {M, [ E,E ] } , {C, ( E,N ) }

Subgame Perfect Equilibrium: {C, ( E,N ) }

# Dynamic Games and Subgame Perfection

- A repeated game is simply a game made up of a finite or indefinite repetition of a one-shot game.
- The equilibrium of a repeated game may be very different from the repetition of the equilibrium of the one-shot game. Reasons:
  - Learning about competitors
  - Influencing their learning/expectations
  - achieving a "co-operative solution"
- How repetition can make co-operation an equilibrium: tit-for-tat, grim strategies, etc.

# Repeated Games Example: Cartel

- Unique Nash Equilibrium of one shot is (4,4)
- In repeated game: One airline says I will put the number of flights at «cooperative» level as long as my competitor did so if the previous period. If however my competitor deviates from that level, I will punish him.

| A \ B | 2 | 4 |
|---|---|---|
| 2 | (450,450) → | (375,500) ↓ |
| 4 | ↓ (500,375) → | (400,400) |

# COOPERATION CAN BE SUSTAINED IF:

- Cooperation yields the following payoff:

$$450+ 450/(1+r) + 450/(1+r)^2 +\ldots. = 450(r+1)/r$$

- Deviation yields the following payoff

$$500+ 400/(1+r) + 400/(1+r)^2 +\ldots.= 500+ 400/r$$

- Cooperation can be sustained if:

$$r<(450-400)/(500-450)=1,$$

that is if the discount rate is less than 100%.

- In general cooperation can be sustained if

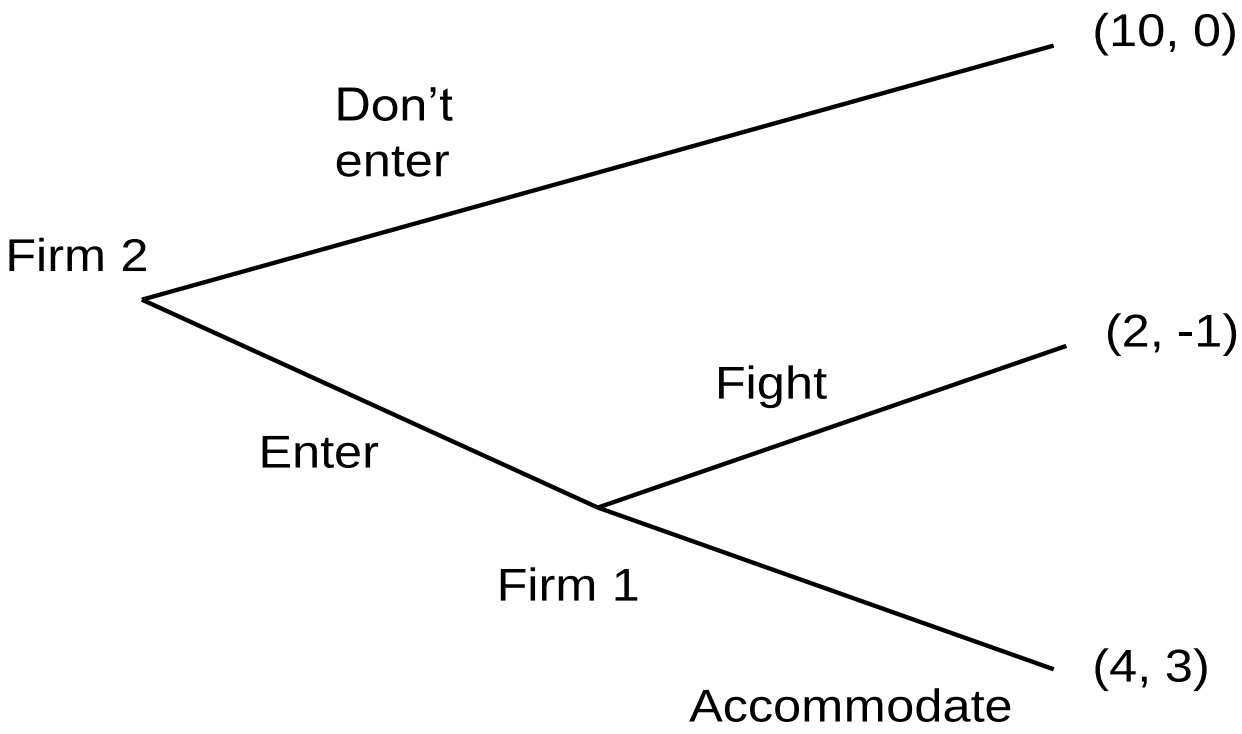
**r<(cartel profit – one shot eq. Profit)/(deviation profit - cartel profit).**

# B. **HOW AIRLINES COMPETE**

# GAMES WITH SEQUENTIAL MOVES

- In many situations, one player moves before the other.
- Example:
  - Firm 1 is a monopolist, making a profit of 10
  - Firm 2 can enter market at a cost of 1, or stay out
  - If firm 2 enters, firm 1 can either
    - **accommodate** entry: both firms get 4 (not including 2's cost of entry)
    - **fight**: firm 1 gets 2, firm 2 gets 0 (not including 2's cost of entry)
- Here, firm 2 moves *before* firm 1. What will happen?

# GAME TREE

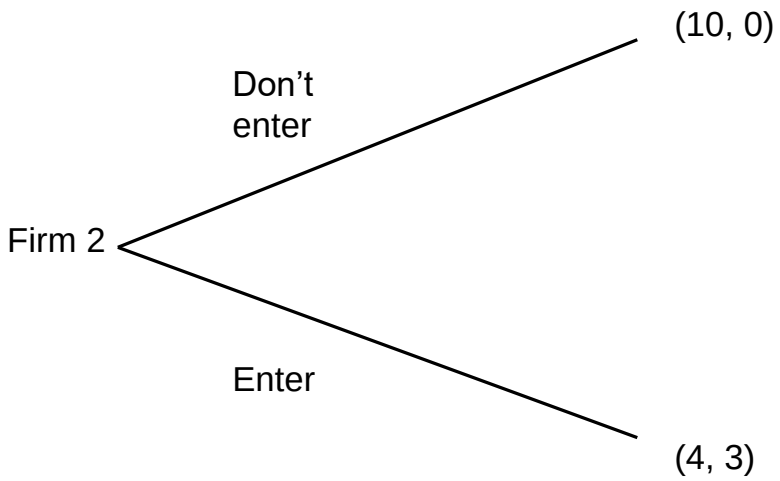


# LOOK AHEAD AND REASON BACK

Firm 2's best strategy depends on what 1 does.

$\Rightarrow$ Look at 1's decision: If 2 enters, …

$\Rightarrow$ 2's simplified tree:



# GAME THEORY IN PRACTICE

- Formal games capture essentials of strategic interaction
- In practice,
  - not set up model and solve;
  - rather, gain insight into the strategic interaction
  - What kind of game best describes the situation?
- Put yourself in the shoes of others you interact with! If they don't do what you expect them to,
  - don't assume they're irrational, instead
  - try to understand how they perceive the game

# AN EXAMPLE WITH DIFFERENT SCENARIOS

- American and Southwest compete on the route between L.A. and Las Vegas.
- Assumptions:
  - Each airline's marginal cost of a passenger is 60
  - Airlines offer a homogeneous good => customers buy from firm with the lowest price
  - Total market demand given by $Q = 240 - P$,

    where $P = \min\{p_A, p_S\}$
  - If both firms have same lowest price: demand split equally
  - Each firm has unlimited capacity

# 1. COLLUSION:

## FIRMS MAXIMIZE TOTAL PROFITS

- Remember how to compute the monopoly price?

$$\max_{p}(p - c)Q$$

- Answer: $p_A = p_S = 150$

  $\Rightarrow q_A = q_S = 45$

  $\Rightarrow \pi_A = \pi_S = 45(150 - 60) = 4050$

- Problem: strong incentive to undercut your competitor!
- At e.g. $p_S = 149$, Southwest gets <u>all</u> of the business
  - $\pi_S = q_S(p_S - MC) = (240 - 149)(149 - 60) = 91*89 = 8{,}099 > 4050$
- Cooperation is unstable

# 2. Independent decisions: Nash equilibrium

- What will happen if each "player" independently pursues his own interests?
- What is American's profit-maximizing price (= best response) if it expects Southwest to choose $p_S$?
  - If $p_S > 60$, choose $p_A = p_S$ – "1 cent"
  - If $p_S = 60$, choose $p_A \geq 60$
- Define Southwest's best response to $p_A$ similarly
- What is the Nash equilibrium?

# THE "BERTRAND TRAP"

- If American charges $P_A > MC$, Southwest will undercut slightly
- if Southwest charges $P_S > MC$, American will undercut slightly
- If American charges a $P_A = MC$, Southwest's best responses is to charge $P_S = MC$ or a higher price; profit is zero either way
- *Only equilibrium: both firms charge a price equal to MC = 60. Profits are zero*

# THE BERTRAND TRAP IN PRACTICE

- Example: Iberia Airlines' purchase of new planes in 2003 – a "Bertrand trap" with one buyer and two sellers
  - Iberia negotiated for months with Boeing and Airbus over an order of 100+ new planes
  - Iberia played Boeing and Airbus off against one another, getting each to make new "final" offers
  - Eventually gave the order to Airbus

# BERTRAND TRAP

- Extreme outcome, but it's always possible for firms to fall into the "Bertrand trap" temporarily.
- With fixed costs, firms make losses when P=MC
  - E.g. airline industry
- Also known as "Bertrand paradox":
  - 1 firm = monopoly, 2 firms = perfect competition
  - E.g. supermarket industry, express mail industry

# 3. Scenario: Price Competition with Differentiated Products

- Or "differentiated Bertrand market"
- Demand:
  - American's demand: $Q_A = 120 - p_A + \frac{1}{2} p_S$
  - Southwest's demand: $Q_S = 120 - p_S + \frac{1}{2} p_A$
  - In what sense differentiated?
- American's best response to Southwest's price?

  $\Rightarrow$ Find price that maximizes American's profit:

  $$\pi_A = (p_A - 60)(120 - p_A + \tfrac{1}{2} p_S)$$

  $\Rightarrow$ Take derivative with respect to $p_A$, set to zero:

  $$120 - p_A + \tfrac{1}{2} p_S - (p_A - 60) = 180 + \tfrac{1}{2} p_S - 2 p_A = 0$$

# PRICE EQUILIBRIUM

$\Rightarrow$ American's best response: $p_A = 90 + \frac{1}{4} p_S$

$\Rightarrow$ Similarly, Southwest's best response is $p_S = 90 + \frac{1}{4} p_A$

- Price equilibrium = solution to those two equations

  $p_A = p_S = 120$

  – Check: why no incentive to undercut at these prices?

- Each firm's profit is

  $(120 - 60)(120 - 120 + \frac{1}{2} * 120) = 60 * 60 = 3{,}600$

- Product differentiation reduces strength of price competition!
- What would happen if both firms invest in advertising to increase customer loyalty?

# 4. SCENARIO: PRICE COMPETITION WITH CAPACITY CONSTRAINTS

- Go back to initial scenario with homogeneous goods; demand is
$$Q = 240 - p$$
- Now assume each airline has only one plane with capacity of 60
- If $p_A = p_S = 120$, then $Q = 120$, and both firms' planes are exactly filled; each gets profit of $(120 - 60)60 = 3{,}600$
- Would either firm want to cut price?
- Would either firm want to *raise* price?
  - E.g. if $p_A = 121$, then assume 60 customers fly Southwest first, so American's demand is $(240 - 60) - 121 = 59$
  - Profit $= (121 - 60)59 = 3{,}599 < 3{,}600$
- $p_A = p_S = 120$ is a Nash equilibrium!

# CONCLUSION SO FAR

- Price competition (rivalry) most intense when products are homogeneous and firms have excess capacity
- Factors that reduce rivalry:
  1. Product differentiation
     - Similar: switching costs
  2. Capacity constraints
  3. Firms' ability to collude on prices

# C. BAGGAGE FEES: A GAME THEORETIC ANALYSIS

# AIRLINE INDUSTRY

- Characteristics
  - High Fixed Cost
  - Huge Fuel costs
  - Debt Intensive

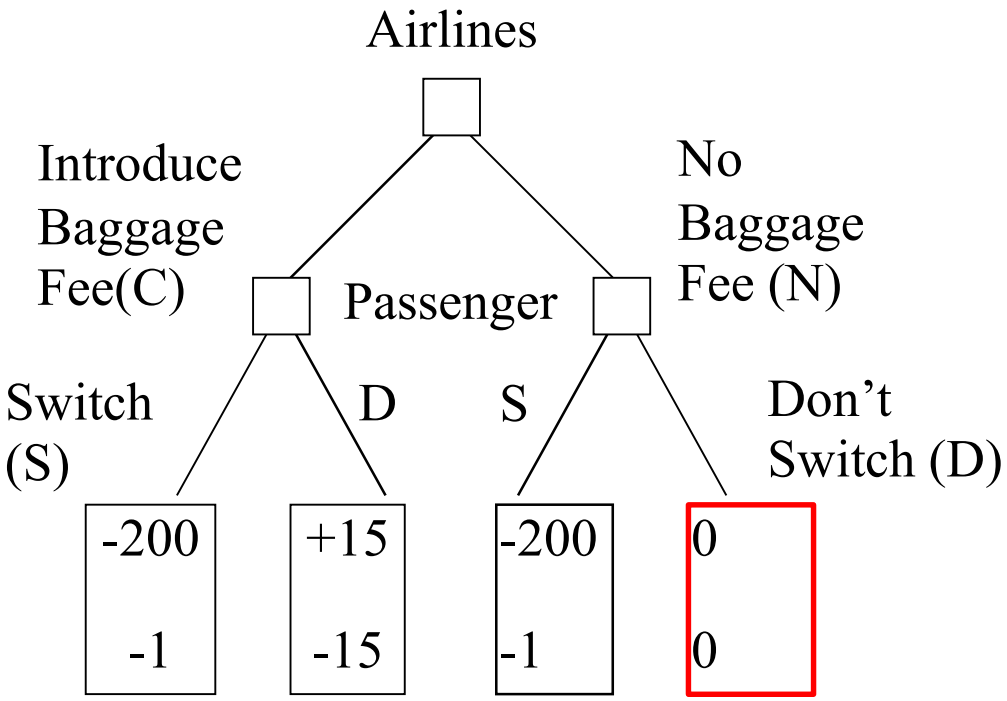
- Need for Additional Source of Revenue

# BAGGAGE FEE REVENUE OF AIRLINES 2009-2008

| 2Q 2009 Rank | Airline | 2nd Quarter 2008 | 3rd Quarter 2008 | 4th Quarter 2008 | 1st Quarter 2009 | 2nd Quarter 2009 | Percent Change 2Q 2008-2Q 2009 (%) |
|---|---|---|---|---|---|---|---|
| 1 | American | 37,101 | 94,075 | 113,856 | 108,117 | 118,442 | 219.2 |
| 2 | Delta | 42,861 | 47,489 | 60,542 | 102,838 | 118,356 | 176.1 |
| 3 | US Airways | 17,917 | 67,928 | 93,759 | 94,227 | 104,138 | 481.2 |
| 4 | United | 19,721 | 42,283 | 58,771 | 59,102 | 67,412 | 241.8 |
| 5 | Northwest | 15,685 | 32,695 | 63,578 | 59,787 | 67,186 | 328.3 |
| 6 | Continental | 16,361 | 21,180 | 49,287 | 55,616 | 63,157 | 286.0 |
| 7 | AirTran | 6,099 | 7,867 | 12,749 | 30,881 | 40,535 | 564.6 |
| 8 | Spirit | N/A | N/A | N/A | N/A | 16,178 | N/A |
| 9 | Frontier | 1,245 | 2,928 | 10,018 | 12,456 | 13,463 | 981.4 |
| 10 | JetBlue | 7,275 | 12,119 | 11,504 | 12,603 | 12,353 | 69.8 |
| | **Industry Total** | **178,214** | **350,061** | **498,568** | **566,328** | **669,572** | **275.7** |

# SEQUENTIAL (LOOK FORWARD REASON-BACK ANALYSIS)

dioxide industry:



# TWO-STAGE GAME: STAGE 1

| Passenger / Airline | Buys from AA | Switches to another airline |
|---|---|---|
| **Include baggage fee in fare** | (+15,-15) | (-200,-1) |
| **Exclude baggage fee from fare** | (0,0) | (-200,-1) |

# TWO-STAGE GAME: STAGE 2

| Passenger / Airline | Travel | Cancel | Don't Fly |
|---|---|---|---|
| **Charge** | (+15,-15) | (+100,-100) | (+200,-200) |
| **Don't Charge** | (0,0) | (+100,-100) | (+200,-200) |

# D. GAME THEORY AND AIRCRAFT MANUFACTURING

# STRUCTURE OF THE SINGLE AISLE AIRCRAFT MANUFACTURER'S GAMES

# E. **GAME THEORY: AIRBUS VS BOEING**

# AIRBUS AND BOEING GAME

- Boeing and Airbus have to decide whether to invest in the development of a Super Jumbo for long distance travel;
- if they both develop successfully the new plane, their profits will drop by 50 millions a year;
- if only one develop the Super Jumbo, it will make 80 millions a year in additional profits, whereas the profits of the other firm will drop by 30 millions a year;
- if no firm develops the plane, nothing changes.

# Matrix Representation of Airbus-Boeing Game

| Boeing \ Airbus | Develop | Do not develop |
|---|---|---|
| **Develop** | (-50,-50) | (80,-30) |
| **Do not develop** | (-30,80) | (0,0) |

# DEVELOPPER'S DILEMMA

- There are no dominant strategies for both
- If only one of the players decides to develop, he will reap superior profits from the unchallenged future market dominance.
- If both players go ahead, the product is likely to generate losses for both players.
- If neither goes ahead, a profitable market remains untapped.

# SUPERJUMBO GAME OF AIRBUS-BOEING

| Airbus / Boeing | **Develop** | **Do not develop** |
|---|---|---|
| **Develop** | **(high risk,risk)** Cooperatively Boeing 400+ monopoly market too small?) | **(risk,loss)** Market too small, dominance Boeing |
| **Do not develop** | **(loss,risk)** Dominance Airbus market too small? | **(profit,loss)** 400+ monopoly unchallenged |

# PRICES, PROFITS AND THE NUMBER OF FIRMS

- Suppose N firms instead of two. Can generalize previous results:
  - If firms can perfectly collude: monopoly price, profits fall with N
  - With homogeneous goods: monopoly if N = 1, but price = MC and zero profits if $N \geq 2$
  - With product differentiation, prices and profits decrease gradually with N

# TWO MAIN DETERMINANTS OF PROFITABILITY

1. The industry
   - How profitable is the industry in general?

2. The firm and its position in the industry
   - Does the firm we're focusing on have a competitive advantage or disadvantage in this industry?

# First, define the relevant market/industry

- Seems easy at the surface, e.g. airline or auto industry…
- …but can be tricky in practice:
  - Airlines: all of U.S., or e.g. L.A.-Vegas?
  - Automobiles: all cars, or minivans vs. SUVs vs. Luxury sedans
  - Particularly tricky: geographical boundaries
- In the end, a question of
  - cross-price elasticities of demand, and/or
  - substitutability on supply side

# First, define the relevant market/industry

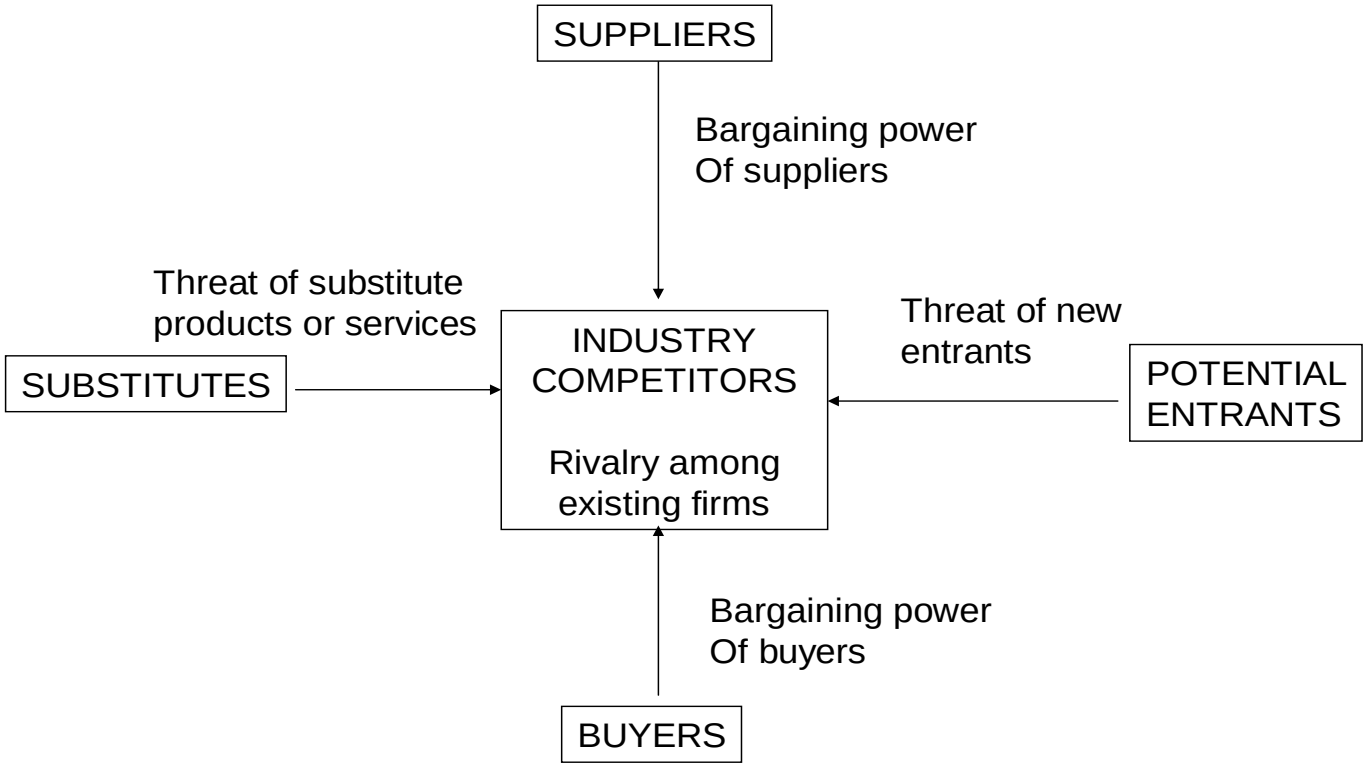
- No single "right" definition, just pick what seems most appropriate
- Once market is defined:
  - Competitors of firm A = firms in the same industry
  - Substitutes for A = goods produced outside industry

# MAP THE KEY RELATIONSHIPS:

# PORTER'S FIVE FORCES (1980)

- Questions addressed:
  - What's going on in the industry in general?
  - How "attractive" is the industry?
  - How much value created can the firms in the industry appropriate as profits?
  - And how much goes to suppliers and buyers instead?
  - Identify "forces" that reduce profitability
- Focus on average firm, not on any particular one
- Snapshot of industry at particular point in time

# FIVE FORCES


SUPPLIERS
Bargaining power
Of suppliers
Threat of substitute
products or services
SUBSTITUTES
INDUSTRY
COMPETITORS
Rivalry among
existing firms
Threat of new
entrants
POTENTIAL
ENTRANTS
Bargaining power
Of buyers
BUYERS

# THREE STEPS OF CONDUCTING A USEFUL 5-FORCES ANALYSIS

1. Identify the players: who are the relevant competitors, suppliers, buyers, substitutes, entrants?

2. How much are industry profits threatened by these forces? E.g., is buyers' bargaining power high or low?

3. What are the underlying economic reasons?
   - Need to get to this level for 5-forces analysis to be useful for strategic decision making

# INTERNAL RIVALRY

- To what extent are profits dissipated by firms' competition for buyers/suppliers?
- We just saw what that depends on:
  1. Market structure
  2. Strength of price competition
- Also: non-price competition
  - advertising/marketing, R&D

  $\Rightarrow$ higher fixed costs

  $\Rightarrow$ pressure to gain market share

# SUBSTITUTES

- Good Y is a substitute for X if having Y decreases customers' demand (lowers the willingness to pay) for X.
- Key question: To what extent does competition from substitute products erode the profitability of a typical firm in the industry?
- Substitutes can be completely different products:
  - Eyeglasses and laser surgery
  - Airlines and video-conferencing
  - Express mail and electronic file transfer
- Main point: don't forget to think about these!

# BUYERS

- Key question: To what extent do purchase prices in this market differ from those that would prevail in a perfectly competitive buyer's market?
- Buyer power tends to be higher if:
  - Large share of buyers' cost
  - Large share of sales of firms in industry
  - Industry's product is not critical input for buyers, easy to substitute
  - Little rivalry in buyer industry
  - Buyers can credibly threaten to backward-integrate.

# SUPPLIERS

- Key question: To what extent do input prices deviate from those that would prevail in perfectly competitive input markets?
- Supplier power tends to be higher if:
  - Input is a critical component of production, difficult to substitute
  - Small share of costs of firms in industry
  - Small volumes relative to other customers of the supplier
  - Little rivalry in supplier industry
  - Suppliers can credibly threaten to forward-integrate.

# ENTRY

- Average profits can't be high if it's easy to enter
- But distinguish barriers to entry from attractiveness of market, focus on barriers here.
- Two kinds of barriers to entry:
  1. Impediments to imitation: reasons why entrants cannot imitate incumbents, e.g. patents
  2. First-mover advantages: reasons why it is not *economical* for entrants to imitate incumbents
     - Is there enough business to pick up for a late mover to recoup costs of entry and make a profit?

# WHERE RELEVANT, A 6TH (POSITIVE) FORCE: COMPLEMENTS

- Good Y is a complement for X if having (a higher quality version of) Y increases customers' demand for X.
- Examples:
  - Intel and Microsoft
  - Desktop printers and digital cameras
  - Video game consoles (e.g. Nintendo) and video games
  - Airlines what????
- Want to keep substitutes (competitors) out, want to bring complement(or)s in!

# EXAMPLES FOR LAST POINT:

1. Anecdotal: some industries are concentrated but apparently very competitive, e.g. supermarkets, express mail
2. Deregulation in industries often followed by wave of mergers, e.g. U.S. airline industry
3. Case study:

# END OF MODULE 12