Lecture 3: Sequential-Move Games

Primary reference: Dixit and Skeath, *Games of Strategy*, Ch. 3.
Games Without Dominant Strategies

- Many games do not have dominant strategies.
- Choices are often not discrete.
- Even if choices are discrete, a player’s best response may depend on the other player’s strategy.
- Example: Football
Neither side has a dominant strategy.

- If offense plays “Run,” the defense is best off playing “Counter Run.” If offense plays “Pass,” the defense is best off playing “Counter Pass.”
- Offense is best off playing “Pass” except against a blitz.
“Blitz” is never optimal for the defense here—we say it is *dominated*.

Dominated strategies can be eliminated from the game in looking for solutions—your opponent will not play one.
With “Blitz” eliminated, “Pass” is a dominant strategy for the offense and “Counter Pass” is dominant for the defense.

Then finding the Nash equilibrium is easy.
Fred and Barney live in the stone age. Each typically hunts rabbits by himself. One day they talk and realize that if they pool their efforts, they could catch big game like stag or bison and have more food to eat. They tentatively agree to hunt big game the next day. But...before parting, they never agree which type of big game to hunt.
The hunting grounds for stag and bison are far apart and in opposite directions. What do Fred and Barney choose to do?

<table>
<thead>
<tr>
<th></th>
<th>Stag</th>
<th>Bison</th>
<th>Rabbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fred</td>
<td>3,3</td>
<td>0,0</td>
<td>0,1</td>
</tr>
<tr>
<td>Barney</td>
<td>0,0</td>
<td>3,3</td>
<td>0,1</td>
</tr>
<tr>
<td>Rabbit</td>
<td>1,0</td>
<td>1,0</td>
<td>1,1</td>
</tr>
</tbody>
</table>
There are no dominant or dominated strategies.

There are three pure strategy Nash equilibria.
Will the players arrive at an equilibrium, and which one?

- They cannot communicate, so they must each predict what the other player will do.
- Are any of these choices more prominent?
- If one choice is obviously more prominent to both players, it can become a *focal point* and emerge as the outcome.
Here Fred and Barney have a strong preference for Bison.

Bison seems like a more obvious choice but there are still the same three equilibria.
The original formulation of the “stag hunt game” is from J-J Rousseau.

This colorful modification comes from Dixit and Nalebuff, “The Art of Strategy.”

Thomas Schelling (nobel prize winner) taught much of what we know about focal points.
Mystery Game

- A game of coordination.
- Prize: 5 final exam points.
- Who wants to play?
Other Examples of Coordination Games

- Research joint ventures.
- Chicken (brinksmanship): the war of attrition.
- Standards: DVD or DIVX?
DVD vs. DIVX

- DVD introduced in early 1997 by a consortium including Toshiba, Sony, Matsushita, Philips, others.
- Superior to VCR quality.
- By spring 1997, several studios released a handful of movies in DVD format. Summer hardware sales exceeded expectations, but the consortium hoped that Christmas 1997 would be when DVD took off.
- In fall 1997, Circuit City introduced DIVX, which was partially incompatible with DVD. They hoped to own the entire market.
- Consumers didn’t know which format would win, so the Christmas 1997 season was a bust...for both DVD and DIVX and everyone else (a short-term coordination failure that eventually gave way to convergence to DVD).
- This is also an entry story...
Sequential-move games - Boulton & Watt as incumbent monopolists

- James Watt invents a substantial improvement to the steam engine in 1765, the separate condenser.
- Watt secures a 14-year patent for the separate condenser in 1769, gets a 17-year extension in 1775, so the patent runs until 1800.
- Watt’s patent also claimed to cover devices using the forcing power of steam, but these claims were far weaker.
- Boulton & Watt faced many entrants who imitated the separate condenser during the 1780s and 1790s, including Edward Bull and the Hornblower brothers.
- Boulton & Watt also faced entry by Richard Trevithick in the 1790s. Trevithick did not imitate the separate condenser but did use the forcing pressure of steam.
If you are a potential entrant, do you enter?
If you are Boulton & Watt, do you litigate if entry occurs?
Solving Sequential-move games

- Think forward, reason backwards.
- Start with Boulton & Watt’s decision to litigate conditional on entry, find their best response.
- Then, conditional on that best response, consider Bull’s decision of whether to enter.
- This yields a sequentially rational, or subgame perfect, equilibrium.
Boulton & Watt are better off litigating, as not litigating would encourage other firms to quit paying royalties.
Bull earns a positive payoff even expecting litigation, so entry is a best response.

Equilibrium is entry followed by litigation.
High-pressure technology (using the forcing pressure of steam) was immature and not much of a threat to business.
Boulton & Watt’s Decision

- Losing a lawsuit might jeopardize the integrity of the patent versus low-pressure producers.
If Boulton & Watt were to sue, Trevithick’s payoff is worse than if he doesn’t enter.

However, it is not in Boulton & Watt’s interest to sue, so Trevithick can enter unmolested.
Could Boulton & Watt Prevent Entry By Bluffing?

▸ They tried.
▸ In 1782, Boulton & Watt took out an advertisement in the Bristol newspaper threatening to sue all entrants, including those using high-pressure steam.
▸ Can such bluffs preclude entry? That is, is it an equilibrium for Boulton and Watt to ”sue if entry occurs” and for Trevithick to stay out?
▸ Actually, that can be a Nash equilibrium, but not a subgame perfect equilibrium. If Trevithick believes Boulton & Watt will sue, it is in his best interest not to enter. Since he never enters, Boulton & Watt never make an irrational decision.
▸ Moreover, this Nash equilibrium is not very believable. Hence, subgame perfection is our solution criterion in sequential games.
▸ When games are repeated, it is possible to build a reputation for aggression and to thereby preclude entry...more on this later.
Subgame Perfection

- However, this Nash equilibrium (Don’t Enter, Litigate if Entry) is not very believable. It required Trevithick to expect irrational behavior from Boulton & Watt.
- Hence, subgame perfection is our solution criterion in sequential games.
- When games are repeated, it is possible to build a reputation for aggression and to thereby preclude entry...more on this later.
- Footnote: Boulton & Watt filed (and eventually won) lawsuits against Bull and Jabez Hornblower for imitation of the separate condenser. They never sued Trevithick. High-pressure steam came to dominate steam technology several decades later.