Lectures Notes for Game Theory

**Strategy** – In game theory, a decisions rule that describes the actions a player will take at each decision point.

**Normal Form Game** – A representation of a game indicating the players, their possible strategies, and the payoffs resulting from alternative strategies.

**EXAMPLE 1:**

<table>
<thead>
<tr>
<th>Ace’s Options</th>
<th>Smith’s options</th>
<th>Cut Prices (Ex. Set Price, P_S=$1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maintain Prices (Ex. Set Price, P_A=$1.50)</td>
<td>100 , 60</td>
</tr>
<tr>
<td></td>
<td>Cut Prices (Ex. Set Price, P_A=$1.25)</td>
<td>120 , 20</td>
</tr>
</tbody>
</table>

**EXAMPLE 2: Prisoner’s Dilemma**

<table>
<thead>
<tr>
<th>Gambino’s Options</th>
<th>Capone’s options</th>
<th>Confess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don’t Confess</td>
<td>2 years , 2 years</td>
<td>10 years , 1 year</td>
</tr>
<tr>
<td>Confess</td>
<td>1 year , 10 years</td>
<td>6 years , 6 years</td>
</tr>
</tbody>
</table>

**Dominant Strategy** – A strategy that results in the highest payoff to a player regardless of the opponent’s action.

**Nash Equilibrium** – A condition describing a set of strategies in which no player can improve her payoff by unilaterally changing her own strategy, given the other player’s strategy. (Every player is doing the best they possibly can given the other player’s strategy.)
### EXAMPLE 3: Entry

<table>
<thead>
<tr>
<th>McDonalds’ Options</th>
<th>Burger King’s options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enter Skaneateles</td>
</tr>
<tr>
<td>Enter Skaneateles</td>
<td>-30 , -40</td>
</tr>
<tr>
<td>Don’t Enter Skaneateles</td>
<td>0 , 40</td>
</tr>
</tbody>
</table>

### EXAMPLE 5: Battle of the Sexes

<table>
<thead>
<tr>
<th>Mike’s Options</th>
<th>Stacy’s options</th>
<th>Pittsburgh Steelers’ Ticket</th>
<th>Chicago Bear’s Ticket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh Steelers’ Ticket</td>
<td>10 , 50</td>
<td>0 , 0</td>
<td></td>
</tr>
<tr>
<td>Chicago Bear’s Ticket</td>
<td>0 , 0</td>
<td>30 , 10</td>
<td></td>
</tr>
</tbody>
</table>

### Discussion of First Mover Advantage in the Context of Examples 3, 4, 5:

### EXAMPLE 6: Monitoring Workers

<table>
<thead>
<tr>
<th>Manager’s Options</th>
<th>Worker’s options</th>
<th>Shirk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor</td>
<td>-1 , 1</td>
<td>1 , -1</td>
</tr>
<tr>
<td>Don’t Monitor</td>
<td>1 , -1</td>
<td>-1 , 1</td>
</tr>
</tbody>
</table>

### EXAMPLE 7: A BEAUTIFUL MIND
NASCAR ethic of Hard but Fair. "I'll race clean because I know the rules," one driver explained. "But if you get too greedy, it's payback time." Put another way, even Dale "The Intimidator" Earnhardt won races: They have enough "social capital" to convince competitors they will honor their partnership contracts, even if just for a

But why do some partnerships work while others end in disarray? Again, NASCAR teaches lessons. Frist and Microsoft attract drafting partners for the same reason that

while. In NASCAR, some of this social capital is achieved through agreements struck prior to a race or by radio communication during competition. (NASCAR's utility

cooperation and competition that is necessary for modern victory.

The NASCAR laboratory is a product of simple physics. Unlike other sports, which are largely determined by individual athletic ability or team strength, NASCAR requires its competitors to cooperate in order to win. The forced cooperation is a product of two factors. First, NASCAR imposes engineering restrictions that prevent any driver from attaining a major equipment advantage over rivals. And second, "drafting" allows cooperating cars to go faster. In the 1960s, drivers discovered that if one stock car closely follows another, drafting in its wake, both cars increase speed. The lead car benefits from a drop in air resistance that comes when the slight vacuum at its rear wheels is filled. And the second car speeds up because it's partially protected from the wind. The more cars that are lined up, the faster each car goes. Hence the monotonous rows that develop around the oval track at Daytona.

Drafting raises all sorts of delightful game theory possibilities. As long as two racers stay in a partnership, they can catch up with or pass other cars that are not drafting. Partnering doesn't bring home the trophy, though. To win, a racer must defect and pass his opponents, but as David Ronfeldt, the author of the Rand paper explains, when "a racer in a line wants to break out and get ahead he needs at least one partner. If he swings out alone, he is bound to lose momentum" and lose the race, leading to the NASCAR axiom that "it takes two to pass one." So, cars engage in a delicate dance of game theory and false allegiances, forming partnerships at 190 mph to overtake the leader until a betrayal or defection leaves one car falling back while the other partners with a new rival.

The gamesmanship gets even more complicated. When two cars begin drafting, the second driver gains an advantage if he (and all NASCAR drivers are "he") drops back a length or two and then re-enters the draft zone and uses the tiny extra momentum to slingshot past the leader. Additionally, following cars can "fan the tail" of the leader, moving their bumper within inches of the lead car and fanning back and forth to disrupt the airflow over the vehicle. As the aerodynamics scatter, the lead car loses downward grip, and the driver must slacken acceleration to avoid sliding sideways. So lead drivers will slow when they see followers begin to fall back or "mirror" the drivers behind them to prevent attacks.

This tension between cooperation and competition is precisely where Ronfeldt sees applicability to the real world, because it turns out that similar dynamics exist all around us. When Microsoft and Cisco developed partnerships during the '90s with potential competitors such as Intel, Compaq, and Dell, they formed "drafting lines" that weathered the booms and busts that damaged lone drivers like Apple. Sen. Trent Lott's fall from grace and Sen. Bill Frist's ascendance can be explained in part by a series of defections of potential rivals from Lott to Frist that, once started, built a momentum that became impossible for Lott to slow. At the core of these events is a tenet of the emerging science of complexity: Cooperation can sustain a surprisingly high degree of competition, as long as the participants agree to some basic rules.

But why do some partnerships work while others end in disarray? Again, NASCAR teaches lessons. Frist and Microsoft attract drafting partners for the same reason that Dale "The Intimidator" Earnhardt won races: They have enough "social capital" to convince competitors they will honor their partnership contracts, even if just for a while. In NASCAR, some of this social capital is achieved through agreements struck prior to a race or by radio communication during competition. (NASCAR's utility as a laboratory is enhanced by our ability to retroactively review communications and compare them to tapes of the race.) But more frequently it is a product of the NASCAR ethic of Hard but Fair. "I'll race clean because I know the rules," one driver explained. "But if you get too greedy, it's payback time." Put another way, even though we may be rivals in the future, we'll agree to trust each other right now.

NASCAR also serves as an interesting model for what causes certain kinds of aggressive behavior. Economists at the University of Chicago made a surprising discovery when they began examining NASCAR accidents. While they initially assumed that aggressive driving and the attendant crashes occur when racers are eager to pass cars in front of them, it turns out the opposite is true. Drivers are more likely to crash when someone is about to overtake them. In other words, racers become more aggressive not when they think they can win, but when they're afraid they're going to lose.

And so does everyone else. Research suggests that investment bankers are more prone to commit fraud when they feel the competitor at their heels. Students in school cheat not to get the "A," but to avoid the "C." From Indonesian cockfighting to technological change, recklessness stems more from the fear of falling than the excitement of new heights. "Don't be greedy" is how Cisco's CEO explains his strategy for transforming competitors into docile partners. The cooperation of NASCAR, or any other system it turns out, persists only when everyone believes he has the opportunity to win.

These implications may be significant. America stands at an interesting crossroads: The drafting lines that developed in the wake of the Gulf War have fractured. Our

potential impact of future attacks.

Threat Integration Center and passed the USA Patriot Act.

But despite those measures some companies fear the terrorist will always get through. They have turned to the private sector for help on gauging the potential impact of future attacks.
Shortly after September 11 2001, a small group of companies that specialise in assessing risk for the insurance industry launched US terrorism risk models.

These combine technology and data to predict likely terrorist targets and methods of attack, and possible losses to life and property.

They are aimed at the insurance and reinsurance industry, which already uses similar models to assess potential losses from natural catastrophes such as hurricanes and earthquakes.

"Most major commercial insurers and reinsurers are using terrorism modelling today," says Robert Hartwig, chief economist at the Insurance Information Institute.

Risk Management Solutions, one of the companies that sells the models, says its models identified the Citigroup building in New York and Prudential Financial's building in New Jersey as possible targets ahead of the US government's code-orange threat alert for the financial sector last month.

Andrew Coburn, director of terrorism research at RMS, says the company can pinpoint possible targets because it believes terrorists make rational decisions.

"Their methods and targeting are very systematic," he says.

RMS uses game theory - analytical tools designed to observe interactions among people - in its models. It argues that, as security increases around prime targets, rational terrorists will seek out softer targets.

Industry participants, however, say the predictive abilities of the models are limited, given the difficulty of foreshadowing human behaviour.

"The probability side can't be relied on as it is with natural hazards," says Ryan Ogaard, global practice leader of the modelling unit at Guy Carpenter, a reinsurance specialist.

Still, the information the models contain is considered valuable for assessing the impact of any attack, in part because modelling companies have collated extensive data for their catastrophe risk models.

"We've already built databases of commercial buildings and residences and the people in them for the whole country," says Jack Seaquist, terrorism product manager at AIR Worldwide.

The development of the models has attracted the interest of the US government, which is using some of them in its Department of Homeland Security, according to Dennis Kuzak, senior vice-president at Eqecat.

"We are in fact helping the US government get a better handle on potential risks," he says, adding that this is an "unexpected" use of the model.

How extensively the models will be used in the future remains unclear.

Much depends on the fate of the Terrorism Risk Insurance Act, which was passed in 2002 to provide federal help for any insurance losses sustained as a result of a terrorism attack.

Under the act, the Treasury Department is obliged to cap insurers' liability and reimburse them for some losses.

The act has enabled insurers comfortably to extend coverage to businesses, which are increasingly demanding terrorism insurance.

More than 46 per cent of US businesses bought insurance to cover terrorism risks in the second quarter - nearly double the rate during the same period a year before, according to Marsh, an insurance services group.

The government has not yet decided whether it will extend the act. If it does not, some market participants believe the terrorism risk models could become an increasingly valuable means of underwriting terrorism insurance.

But trade associations for the insurance industry say the inability of the models accurately to assess the frequency of terrorist attacks means they are not a reliable indicator of pricing the risk of catastrophic attacks.

"From a severity standpoint, the total loss from a terrorist event... could well exceed the capacity available in the insurance industry," the associations said in a submission to a congressional hearing on the act earlier this year.

Others argue that, if the terror risk act is not extended, interest in the models might diminish because insurance companies could be reluctant to provide terrorism coverage at all.

Meanwhile, the accuracy of the models' predictions remains in doubt.

"But hopefully we'll never see them tested," says the Insurance Information Institute's Mr Hartwig.
The Imperfect Science of Release Dates

By Josh Rottenberg Published November 9, 2003

On Dec. 25, which this year happens to be a Thursday, five new movies will be released in theaters -- six, if you count a new Disney IMAX film called "Young Black Stallion." As with the Fourth of July and Thanksgiving, there is a special cachet to opening a film on Christmas Day. It announces to the audience that this is not just any movie but a cinematic event. It infuses a studio's marketing campaign with the warm, "It's a Wonderful Life" feelings most people have at that time of year. And, as Robert Harper, vice chairman of 20th Century Fox, points out, "Everyone knows when Christmas is." In theory, with kids out of school and parents off work, almost any type of movie can be released successfully around the Christmas holiday. It's hard to imagine a film with less yuletide cheer than "The Exorcist," and yet on Dec. 26, 1973, audiences flocked to watch Linda Blair projectile-vomit on a priest. The great paradox of holiday programming, in fact, is that the only kind of movie that never opens on Christmas is a movie about Christmas. Interest in Santa and Rudolph and all the rest falls off a cliff as soon as the holiday is over, so films with Christmas themes -- this year's prime examples being the Will Ferrell movie "Elf" and the black comedy "Bad Santa" -- typically open in November and are pulled from theaters on Dec. 26.

The casual moviegoer rarely ponders why a particularly bubbly romantic comedy, serial-killer thriller, literary costume drama or animated talking-farm-animals movie opens on the day it does. Movies come; movies go; movies wind up on video. To those responsible for putting those films on the screen, however, nothing about the timing of their releases is arbitrary.

Christmas Day marks the traditional climax of Hollywood's year-end prestige season, during which the studios roll out their most artistically respectable films, the show ponies believed to be contenders for awards and critics' 10-best lists. In some cases, a movie with awards ambitions will be released for just a one-week, New York and Los Angeles run in December to qualify for Oscar consideration and then put back on the shelf until January or February. All five of last year's Academy Award nominees for best picture opened in December, three of them ("The Pianist," "The Hours" and "Chicago") on Christmas weekend.

This year, the pictures opening on Dec. 25 run the gamut of sizes, styles and genres. There's a Civil War drama, adapted from a best-selling novel (Miramax's "Cold Mountain"); a Steve Martin family comedy (Fox's "Cheaper by the Dozen"); a live-action fairy tale (Universal's "Peter Pan"); a Ben Affleck thriller (Paramount's "Paycheck"); and, from the director Robert Altman, a small ensemble film set in the ballet world (Sony Classics' "The Company"). (As of this writing, Touchstone's western "The Alamo," and Warner Brothers' David Mamet film, "Spartan," have already moved off Christmas Day.) The diversity of this slate did not come about by chance. The first principle of scheduling any film's release date is to avoid going directly against a similar movie. Studios realize that a standoff between films aimed at the same demographic -- kids, women, "urban" teenagers -- splits the vote, in effect, and hurts both films. "No one is interested in going head to head in this business," Harper says. "Someone is almost always going to give. It's just a question of who.

Given the stakes involved, film companies generally disclose their future release dates well in advance, giving everyone time to minimize the chance of collision. But at the end of the year, with so many films vying for coveted berths, some jostling is inevitable. As Jeff Blake, vice chairman of Sony Pictures Entertainment, notes, "There are only four weekends in December, so you're always going to be bumping into other movies."

Last December featured one of the most dramatic games of chicken in recent memory, when two films starring Leonardo DiCaprio were both slated to open on Christmas weekend. Ultimately, Miramax blinked first, moving the release of Martin Scorsese's "Gangs of New York" five days earlier and ceding the holiday to the other DiCaprio film, DreamWorks' "Catch Me If You Can." "We didn't think about moving," says Terry Press, the head of marketing for DreamWorks. "We had been there first, and 'Catch Me If You Can' was perfect for that date." This year, DreamWorks chose to schedule a somber psychological drama, "House of Sand and Fog," for the day after Christmas, deferring a bit to Miramax. "I don't want our reviews to run on the same day as 'Cold Mountain,'" Press says.

Taking into account the competitive field in December, Warner Brothers Pictures made the rather unusual decision to schedule its biggest release, the sweeping historical epic "The Last Samurai," for the first weekend of the month, usually considered the most sluggish point in the holiday season. "I'm willing to take my chances," says Dan Fellman, the studio's president of theatrical distribution. "One, the marketplace isn't as crowded then, and two, an early date gives our movie a chance to grow." The fact that the movie stars Tom Cruise certainly offsets some of the risk. Given the number of goliaths lumbering around in December, you might imagine that smaller films would scamper to safer ground. For independent film companies, though, with the marketing boost they can get from awards nominations and appearances on year-end Top 10 lists, releasing a movie during the Christmas season can seem appealing, even necessary. Still, as always with art-house films, the key to success is counterprogramming.

"When we opened 'Orlando' opposite 'Jurassic Park' on Memorial Day weekend, we played in very few theaters, but it was, like, house-record business," says Michael Barker, co-president of Sony Pictures Classics. Art-house movies almost never factor into a major studio's release strategy, though. As one distribution executive says, "It would be like somebody in the television business with 'Friends' looking at the schedule and saying, 'Gee, there's a fabulous show on the Discovery Channel this week.'" Conventional wisdom holds that while the field may be more crowded at the end of the year, the entire market expands then, and films released at that time tend to hold up better over consecutive weekends. "As long as you don't have too many movies competing for exactly the same audience," says Chuck Viane, head of distribution at Buena Vista, "success over the holidays is easier to achieve." It's no surprise, then, that all of the studios have already begun sketching out their plans for next Christmas. (Universal has even staked out Dec. 14, 2005, for its remake of "King Kong.") Of course, no film's success can be taken for granted, not even at Christmas. There are plenty of examples of highly anticipated December releases that turned into holiday turkeys -- "Angela's Ashes" and "A Civil Action," to name just two. Tom Ortenberg, head of distribution at Lions Gate, says that in the end, all of the calculations about demographics and distribution patterns come down to this: "There is never a bad time to release a good film -- and there is never a good time to release a bad film."

Josh Rottenberg writes frequently about entertainment. He last wrote for the magazine about the actor Jack Black.