

# Game Theory

*A CI Analysis Tool for  
Anticipating Competitor Actions*

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AWARE



## Game Theory - An Introduction

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# Session Overview

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- Game Theory
  - What it is and how to use it
  - Game theory examples - the Prisoner's Dilemma
  - Case studies - showing game theory in practice
- PARTS analysis
  - How this links to game theory
  - The value net
- Toys “R” Us vs. the Warehouse clubs
  - A strategic example

# Game Theory and Business

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- *“Business is a game - the greatest game in the world if you know how to play it”*
  - Thomas Watson, IBM Founder
- *“Game theory forces you to see a business situation over many periods from two perspectives: yours and your competitor’s.”*
  - Judy Lewent – CFO, Merck (Harvard Business Review, Jan-Feb 1994)
- *“At Bell Atlantic, we’ve found that the lessons of game theory give us a wider view of our business situation and provide us a more nimble approach to corporate planning. We call this system, quite simply, the ‘manage the business’ process.”*
  - Raymond Smith, Bell Atlantic Chairman (Fortune, Sep. 1996)

# What is a Game?

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- A Game consists of
  - at least two players
  - a set of strategies for each player
  - a preference held by each player over possible outcomes
- Player is general entity
  - individual, company, nation, protocol, animal, etc.
  - In business: everyone who has an effect on what you can earn
- Strategies
  - actions available to each player. The strategy chosen may depend on what the players know, and how they think.
- Outcome / Payoffs
  - The reward / penalty determined by the players' preferred strategies. Can be financial, % share, % growth or even chance of survival

# What is Game Theory?

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- The formal analysis of strategic behavior looking at the relationships between inter-dependent agents. Game theory focuses on the interplay of competition and cooperation.

## In essence

- Decision Theory
  - You are self-interested and selfish.
- Game Theory
  - So is everyone else.
    - Your best decision depends on what others do, and what they do may depend on what they think that you will do....

# Game Theory - Background

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- Concepts can be traced back 2000 years
  - Game theory in the Talmud
  - 1838: Augustine Cournot writing on duopoly behavior
- **The theory of games and economic behaviour**
  - **John von Neuman, Oskar Morgenstern, 1944**
- 1950-1953: John Nash introduces the Nash Equilibrium concept
- 1960s:
  - Reinhard Selten further develops the Nash equilibrium concept.
  - John Harsanyi looks at the role of information in games and Bayesian games.
  - Thomas Schelling investigates the use of game theory in the study of conflict
  - Robert Aumann studies non-cooperative and repeated games and introduces the concept of “common knowledge” to the subject.
- 1970s: Nash equilibrium concept further refined. Concept of an “evolutionary stable strategy” (ESS) developed by biologist, John Maynard Smith & George Price in 1973

# Game Theory - Background

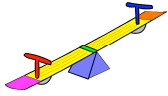
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- 1994: John Nash, Reinhard Selten and John Harsanyi awarded Economics Nobel Prize “for their pioneering analysis of equilibria in the theory of non-cooperative games”.
- 2005: Thomas Schelling and Robert Aumann awarded Economics Nobel Prize “for having enhanced our understanding of conflict and cooperation through game-theory analysis”

# Game Classifications

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## Symmetric versus Asymmetric



Business games are likely to be asymmetric, with the participants playing different strategies, and where there will be different payoffs / outcomes.

## Zero sum and non-zero sum



The total value for all strategic combinations add up to zero in a zero-sum game. Many (most) business games are non-zero sum.

## Simultaneous versus sequential



Many business games are sequential - where one participant makes the first move.

## Perfect versus imperfect information



Most business games involve imperfect information as participants are unlikely to know all the strategies, moves and payoffs of other participant (sometimes called Bayesian games)

## Co-operative versus non-cooperative



Many business games will be non-cooperative although cooperation may take place in some situations and may result in the best result.

# Some Game Theory Terms

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- **Dominant Strategy:** One strategy is better than another for the player, no matter what strategy competitors play.
  - If there is a dominant strategy, choose it!
  - Sometimes there is no dominant strategy - and instead there are alternative strategies that are equivalent for the players
- **Dominated Strategy:** A strategy that is worse than some other strategy for some or all of the rival's choices.
  - Do not choose dominated strategies!
- **Nash Equilibrium:** A choice of strategies such that given what the other players are doing, no player would want to change strategy unilaterally.
- **Mixed Strategy:** A choice of equivalent strategies that would be played randomly but which would give a better payoff long-term than a pure (single) strategy (for example, because it forces the opponent to guess your next move)

# Illustrating games

- Normal Form

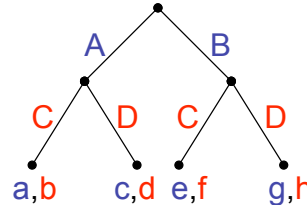
- A “payoff” matrix showing players, payoffs and strategies.
- Presumes that each player acts simultaneously or without knowledge of competitor action

	C	D
A	a,b	c,d
B	e,f	g,h

*A and B are strategies available to player 1 while C and D are strategies available to player 2. a-h are the payoffs resulting from these strategies, with payoffs a,c,e,g available to player 1 and b,d,f,h to player 2*

- Extensive Form

- A “decision tree” with nodes for each player’s choices
- Game can be sequential



*Player 1 moves 1st and chooses strategy A or B. Player 2 then moves choosing a strategy C or D.*

# Applying Game Theory



# The Prisoners' Dilemma

Two suspects are arrested for armed robbery. They are immediately separated.

If convicted, they will get a term of 10 years in prison. However, the evidence is not sufficient to convict them of more than the crime of possessing stolen goods, which carries a sentence of only 1 year.



The suspects are told the following:

- *If you confess and your accomplice does not, you will go free.*
- *If you do not confess and your accomplice does, you will get 10 years in prison.*
- *If you both confess, you will both get 5 years in prison.*



# The Prisoner's Dilemma

*A two-person, non-zero-sum, non-cooperative game with a dominant strategy*

**Prisoner 1**

A Nash Equilibrium

		Prisoner 1	
		Confess	Keep Silent
Prisoner 2	Confess	5,5	0,10
	Keep Silent	10,0	1,1

# The Prisoner's Dilemma

The **dominant** strategy is to confess - even though it results in a 5 year sentence!

The best strategy (keeping silent) can only work if there is total trust and / or complete information

		Prisoner 1	
		Confess	Keep Silent
Prisoner 2	Confess	Lose, Lose	Lose lots Win Lots
	Keep Silent	Win Lots, Lose Lots	Win, Win

# The Prisoner's Dilemma

- Several business equivalents
  - Price wars: one player reduces prices forcing other companies to follow
  - Retail expansion (how many branches of Starbucks do you actually need in one street?)
  - Product enhancements (where companies add features, irrespective of customer needs....)
  - Advertising wars: one company increases advertising....
- Also arms races, drugs in sport....



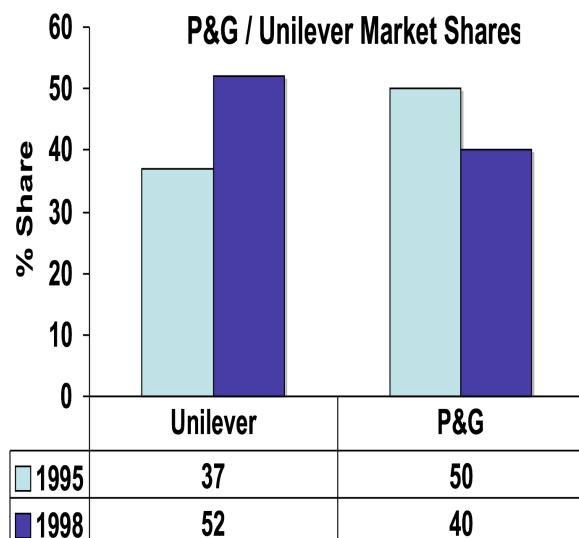
# The Prisoner's Dilemma

- Price Wars - January 2003
  - Ford adds a \$500 direct to consumer rebate on SUVs boosting cash discounts to \$2500 on the Explorer and \$2000 on the Expedition.
  - Earlier in the week GM had offered \$2500 rebates on their SUV models.
- Ford criticised GM's strategy as "yo-yo marketing"
- GM claimed that their actions led to a larger market share and higher profits.
- Despite the discounting, January 2003 sales were reported as weak.

Source: Wall Street Journal, Jan 31, 2003

# The Prisoner's Dilemma

- Soap Wars: Procter & Gamble and Unilever are engaged in a long running "soap war", each company trying to capture a larger proportion of the detergent market
  - Within the UK, the two market leading soap powder brands are Ariel from P&G and Persil from Unilever.
  - In 1998 Unilever launched Persil in tablet form at the same time that P&G test-marketed Ariel tablets
  - In early 1999 P&G launched Ariel tablets



# The Prisoner's Dilemma

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## Soap Wars

		Unilever's Strategies	
		Launch Tablet	Don't Launch Tablet
Procter & Gamble's Strategies	Launch Tablet	<b>+4%, +4%</b>	<b>+12%, -4%</b>
	Don't Launch Tablet	<b>-4%, +12%</b>	<b>+8%, +8%</b>

Note: Figures for % growth are illustrative

# The Prisoner's Dilemma

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- Tobacco Advertising
  - 1960s: Tobacco heavily advertised
  - 1964: US Surgeon General issues official warning that cigarette smoking may be hazardous.
    - Companies worried about liabilities
  - 1970: Companies strike an agreement to carry a warning label and **to cease TV advertising in exchange for immunity from federal lawsuits**

# The Prisoner's Dilemma

## Tobacco Industry

Each firm earns \$4bn from its customers. Advertising costs \$1bn but captures \$2bn from competitors.

		Company 2 Profits	
		Advertise	Don't Advertise
Company 1 Profits	Advertise	\$3bn, \$3bn	\$5bn, \$2bn
	Don't Advertise	\$2bn, \$5bn	\$4bn, \$4bn

**What actually happened: Following the 1970 agreement advertising decreased by \$61m. Profits rose by \$91m**

## More Games

- The Prisoner's Dilemma is just one category of game
- Other common games include:
  - Chicken
  - Hawk-Dove
  - Stag Hunt (a game of co-operation)
  - Rock-Paper-Scissors
- Games can include 3 or more players, and several moves

# Another Game

- Two competitors with almost identical products.
  - Can charge \$2, \$4 or \$5.00.
  - 10,000 customers - of which 4000 are price sensitive and pick the lowest price, while 6000 choose on a random basis.
- **What is the best price to charge?**

		Product 2		
		\$2	\$4	\$5
Product 1	\$2	\$10k, \$10k	\$14k, \$12k	\$14k, \$15k
	\$4	\$12k, \$14k	\$20, \$20k	\$28k, \$15k
	\$5	\$15k, \$14k	\$15, \$28k	\$25k, \$25k

# Another Game

- Eliminate dominated strategies until you get the best strategy - if possible.
  - This will be a *Nash* equilibrium
  - Sometimes there is no dominant strategy or there may be more than one equilibrium point
- Check each cell and ask: “Is this the best strategy irrespective of what the other player does?”

		Product 2		
		\$2	\$4	\$5
Product 1	\$2	<del>\$10k,</del> <del>\$10k</del>	<del>\$14k,</del> <del>\$12k</del>	<del>\$14k,</del> <del>\$15k</del>
	\$4	<del>\$12k,</del> <del>\$14k</del>	\$20, \$20k	<del>\$28k,</del> \$15k
	\$5	<del>\$15k,</del> <del>\$14k</del>	\$15, \$28k	<del>\$25k,</del> <del>\$25k</del>

# Applying Game Theory to CI

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- Industry / Market Analysis
  - PARTS analysis
  - The Value Net
- Strategic Analysis

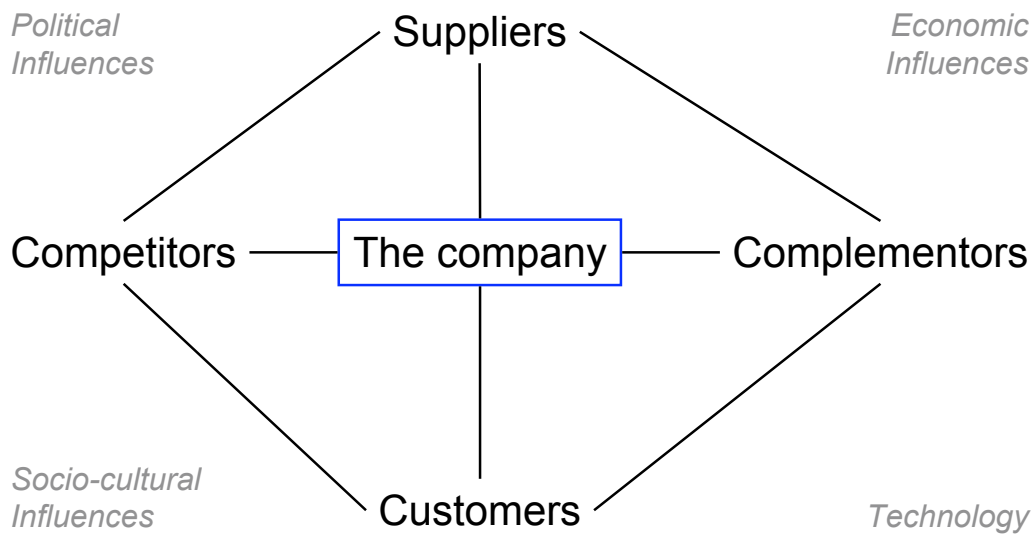


## PARTS Analysis

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- Who are the *Players*?
- What is their *Added Value*?
  - The added value is what each player brings to the game. I.e. the size of the pie with the player minus the size of the pie without the player.
  - Many companies have lower added value than they think
    - How many people missed Arthur Andersen when it went into bankruptcy.
- What are the *Rules* in the industry?
  - The way business in the industry gets done.
- What are the *Tactics* used to gain advantage?
  - How the players create value in the game, within the rules. What are the strategies used by each player?
- What is the *Scope* of the game?
  - How does the game fit in with the external environment? What are the boundaries to the game (I.e. industry or market)?

# The “Value Net”



Based on Brandenberger & Nalebuff's model

## Using PARTS Analysis

1. Use the Value Net to define the players impacting your (and your competitor's) organisation.
2. Are these the same? If not what are the differences?
3. Determine the added value for each organisation?
  - What impact would it have on the overall pie if one of you disappeared. Would it make a difference? This is the added value!
4. Examine the scope of the game i.e. the industries and markets within which each player operates. If these are not the same, then the player with the larger scope may have additional added value.
5. Consider the rules of how business is done within the industry / market, and also how the players communicate with each other within this industry and market (i.e. the tactics)? Could changes to this, or the scope lead to a rise in added value? If so, for whom - you or a competitor?
6. **Consider tactics / strategies that would increase your added value within the game!**

## Another Case Study: Toys “R” Us in 1990

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- Toys “R” Us: 650 stores in the USA, with a 32%+ market share. Range of toys with keen pricing gives competitive advantage. Average margins = 30% above cost price.
  - Competitive Landscape in the early 1990s
    - Standard toy & department stores
      - Do not compete with Toys "R" Us on price (50% markups)
    - General discounters (Wal-Mart, Target)
      - Cannot compete with Toys "R" Us on selection (9% markups)
      - Toys exhibit high product differentiation
    - Specialized discounters (only Toys "R" Us)
    - Warehouse clubs (Costco, Pace)
      - Introduced in the 1980s. By 1992, 450 stores.
      - Margins are 9-12% above cost price
      - By 1989, about 200 items in competition
- Cause of concern for Toys “R” Us!***

## Toys “R” Us (continued)

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Toys "R" Us strived to change the game:

- **The Players:** Toys “R” Us; The toy manufacturers; The warehouse clubs.
- **The tactics / strategies:** Each player makes a strategic decision - sequentially.
  - 1) Warehouse clubs: Entry toy market or decide not to compete.
  - 2) Toys “R” Us: possible competitive responses: price war, boycott manufacturers; accept the new game and status quo.
  - 3) Toy manufacturers: Only have to make a move if Toys “R” Us chooses a boycott. Their choices: “cooperate” with boycott and stop selling to warehouse clubs or continue to sell
- Uncertainties include demand for toys; potential profits; government restrictions on anti-competitive practices....

# Toys "R" Us (continued)

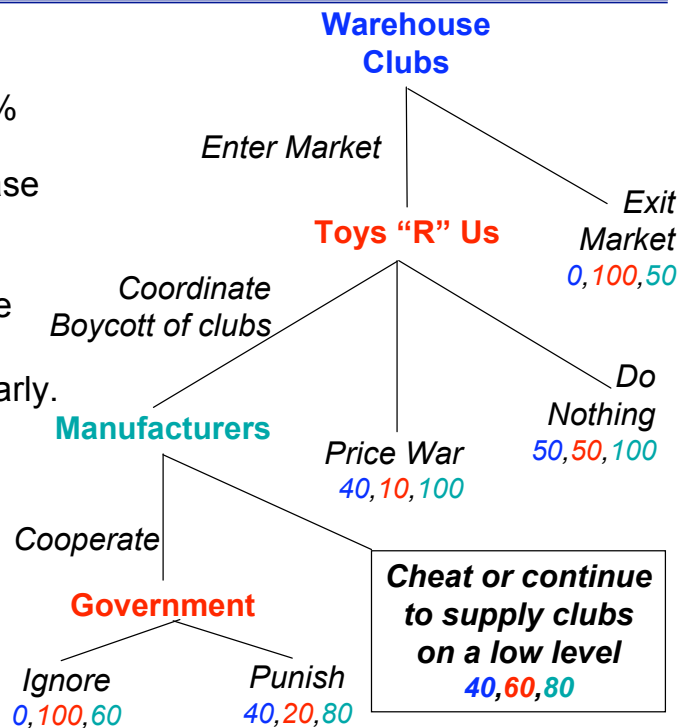
## Payoffs:

If the warehouse clubs exit then Toys "R" Us wins - payoff = 100% vs. 0 for clubs and 50% for the manufacturers (who fail to increase supplier power).

A price war will hurt Toys "R" Us more than the clubs - so estimate 40% clubs, 10% Toys "R" Us.

Can estimate other payoffs similarly.

**Manufacturers agreed to Toys "R" Us's deal. The warehouse clubs toy sales fell. Pre-agreement growth was 50% per year. After agreement it fell to 10% per year.**



## Using Game Theory to Analyse Strategy

- Define the strategic issue
  - What decision are you trying to make: pricing, capacity changes, market entry, etc.?
  - How is this decision related to other strategic decisions being made in the market?
- Who are the players?
  - Do not just consider your competitors - but all the relevant players.
  - Look for win-win opportunities - not just win-lose. Look for cooperation possibilities - enabling you to work with another player to maximise your success chances.
- Determine the structure of the game?
  - Will decisions be made simultaneously, or sequentially over time? (If the latter, who will lead and who will follow, and how many moves will there be?)
  - Can any agreements be enforced?



# Using Game Theory to Analyse Strategy

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- What potential actions can each player take?
  - Generate a list of these - for all players, from their perspective, not yours!
  - What will the impact be for these actions on your strategy?
  - What are the other player's strategic objectives (I.e. what are the payoffs)?
  - Which (if any) players' interests conflict?
  - Are some players better informed?
- Create a payoff diagram or decision tree to examine the steps and what the best options are likely to be.

# The benefits of Game Theory

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- Game theory models do not need to be exact. The aim is to make managers consider the impact of decisions
- Game theory forces managers to consider the other player's moves
- Unlike chess, business games do not have fixed rules, players and potential moves
  - Game theory allows for the examination of ideas that can lead to new rules or by changing the scope of the game - essentially to create a new game.  
e.g. customer switching can lead to an emphasis on price, and result in price wars. Companies can change the game through loyalty programmes, etc. that create added value for customers and decrease tendency to switch
  - **Being a grandmaster chess player is no good if everybody else now wants to play poker! Aim to be the first to change the game by monitoring the competitive environment for change opportunities!**

# Summary - Keep one step ahead

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# Summary - How to win!

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# Thank You

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