ECON20005 Notes

Week 1

Decision Theory

- Decision theory applies to single agent problems (i.e. where an agent's decision doesn't influence the payoffs and decisions of other agents).
- An agent chooses a since action x and receives the payoff $u(x)$
- If x is continuous, calculus can be used to mamise $u(x)$. If x is discrete, then decision trees can be used to maximise $u(x)$.

Payoffs

- A *payoff* indicates how much a player values a certain outcome
- If outcomes are random, the *expected payoff* is the weighted average of the payoffs associated with each possible outcome.

Decision Trees

- Decision trees can be solved using *backward induction* (also called *rollback*)

Decision Theory vs Game Theory

- In decision theory, an agent's actions *do not* affect the payoffs of other agents
- In game theory an agent's actions *do* affect the payoffs of other agents
- Therefore, in a game theory situation, each agent needs to anticipate the strategies of other players.

Elements of a Game

- Players (who influences the game)
- Actions (actions available to each party)
- Timing (who acts when)
- Information (perfect vs imperfect information. symmetric vs asymmetric information)
- Payoffs

Information

- Perfect Information
    - All players have all information to determine the sequence of future outcomes and payoffs from all possible strategies (e.g. chess)
    - All past actions of all players are fully observable by all players (i.e. the 'state' of the game is fully observable at all times)
- Imperfect Information
    - Not perfect information (e.g. simultaneous penalty kicks, stock market)

    - This is when players do not know the strategies that other players will follow
    - Simultaneous games are, by definition, games of imperfect information.
    - Nature always creates imperfect information
- Asymmetric Information
    - When one player has information that another player does not (e.g. poker)

Zero Sum Games

- Game where one player's benefit is another player's loss
- The total payoff of all players is constant (NOT that the total payoff is zero)
- Non zero-sum games are situations where players' interactions do not yield perfectly offsetting payoffs
- To prove that a game is non zero-sum, it's only necessary to find 2 sets of strategies where the total payoff across all players is not equal.

Key Assumptions

- Assumptions of rationality
    - Players aim to maximise their payoffs
    - Players can perfectly calculate payoffs
    - Players flawlessly follow the best strategy
- Assumptions of common knowledge
    - Each player knows the rules of the game
    - Each player knows that each player knows the rules
    - Each player knows that each player knows that each player knows the rules.
    - Each player knows that … etc.
- Although we assume perfect rationality, we acknowledge that in the real world people aren't always perfectly rational. It's valuable to think of optimal decision making as a benchmark that can help illustrate departures from rational behaviour

Equilibrium of a Game

- A strategy of a player is a complete plan of action that specifies the action the player will take in every possible situation they could face.
- In equilibrium, each player chooses the strategy that is the best response to the strategies of other players, and no player has an incentive to change their strategy.
- The type of equilibrium depends on the type of game (i.e. simultaneous vs sequential, perfect vs imperfect information)

Conflict vs. Cooperation

- In some games, players benefit from cooperation.
- In some games, there is a mixture of both cooperation and conflict (e.g. with international trade, cooperation leads to overall gains, but conflict determines how those gains should be divided)

Repeated vs One Shot Games

- In one shot games, there is limited information about other players, and no possibility to punish non-cooperative behaviour
- Repeated interactions provide the possibility to learn about other players, and to build a reputation and to punish non-cooperative behaviour

Week 2

Strategy vs Action

- A strategy describes the actions that a player's will take at all possible decision nodes
- A player's strategy should contain one element for each of their decision nodes.
- An action is an individual decision of a player

Sequential Games

- Played by two or more players over two or more periods (e.g. chess)
- Sequential games are generally represented using game trees (also called extensive form games).
- Game trees reveal each player's actions, the timing of their actions, and the resulting payoffs.
- Game trees are the joint decision trees for all players in a game

Solving Sequential Games

- A subgame is a portion of a larger game, starting at a non-initial node of the larger game.
- Using backward induction, you start at the final subgames and work backwards to the initial node, selecting the movement that maximises the relevant player's payoff at each node.
- An equilibrium found using backward induction is called a *Subgame Perfect Nash Equilibrium (SPNE).* <u>An SPNE is a set of strategies</u> that are optimal in every subgame, no matter whether that subgame is on or off the equilibrium path of play.
- An SPNE predicts stable outcomes since no player wants to deviate from their equilibrium strategies

First/Second Mover Advantage

- In some games, the order in which players move can give put them in a better or worse position.
- A first mover advantage can stem from a player's ability to commit to a certain course of action. A good commitment often requires you to commit to a future action that you would not normally want to take in order to influence the choices of your opponents.
- Second mover advantage stems from having the ability to adapt.
- The first-mover advantage for a given player is based on the timing of their moves relative to other players.

Uncertainty

- Uncertainty and random events can be introduced by nodes in a game tree that correspond to moves by “Nature”.