UNIT EC449

GAMES FOR PUBLIC SERVICE MANAGERS

STRATEGIC MANAGEMENT

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Introduction

The essence of Game theory is that there is interdependence when making strategic decisions, i.e. what one player does affects and may have been affected by other players.

In a game we need to know

- Who the players are.

There may be possibilities for bargaining. It may also be that 'coalitions' form.

- The historic, social, cultural and legal conventions of the game.

Some players may try and 'bend' these. However, Schelling (1960) showed that many situations have 'focal points', this is where players reach solutions based upon social convention. Thus, knowing how these beliefs and assumptions are formed is an important element of understanding what a 'best strategy' is.

- The type of game being played

Games can be simple (e.g. tic-tac-toe) or complex (e.g. life). Games are sometimes zero-sum games if what one player wins the other loses, but most games involve non-zero sums. Games can involve simultaneous decision-making or sequential decision-making. They can be 'one-shot', be 'multiple-shot' but have a finite length or a 'game' can be played infinitely.

If interaction between players arises

- *only once or*
- *frequently but the environment is so dynamic that each interaction constitutes a different game, or*
- *infinitely*

then a game may be reduced to a matrix or 'normal' form.

Alternatively, if the game has finite length then the game may be analysed using a game tree (called an 'extensive form' game). Here the solution is derived by 'looking forward and reasoning back' ('backward induction').

Here I will only deal with normal form games.

- The feasible set of Strategies

The instruments used to obtain the pay offs and the way final decisions are made.

> *In a one-shot game players make* ***choices. I****n 'supergames' players have a series of choices, usually one at each stage and then make choices. In essence the supergame player is working with a series of 'if then' statements, possibly using backward induction. Such a method of reason and action is called a strategy in game theory.*

- The Pay offs

These are measured in (cardinal) units of satisfaction (utility), e.g. profit, market share, votes, amount of investment, or some qualitative measure.

- Instrumental Rationality

An important assumption often made in game theory is that players are instrumentally rational., that is, given their objectives they choose the most efficient way of achieving them. Game theorists are actively assessing the outcomes based on other behaviour assumptions.

- Common Knowledge

Most games involve Common Knowledge. This is a situation where information or knowledge is known by all players and all players know not only that all the other players know this information but also all the players know that all the other players know this information and so on ad infinitum.

- Information structures*.*

In a game with complete information all players know their own pay offs, the pay offs of their rivals and their rivals choices (strategies). However, complete information need not be ***perfect****. In simultaneous decision games players cannot know their rival's move beforehand. There can also be uncertainty in games of complete information, as long as everyone is aware of the probability distributions attached to various states of nature (e.g., how each country might assess the chances of a missile being launched by chance).*

Anything less than complete information is incomplete information. Thus, in a two player game one player may possess private information about (e.g., about their own work effort or payoffs) while others can only imperfectly estimate that information based upon their own payoffs (e.g., company profits) or the informed group's actions (e.g., a strike).

Behavioural Rules

"Game theory looks for behavioural rules which can solve games by embodying the weakest notion of rationality consistent with finding a solution." (B. Lyons in Hargreaves-Heap *et al*, 1992, p.98). Consider the following:

1. ***Dominant strategy****: the strategy which yields the optimal pay off irrespective of what its rival(s) is (are) doing.*

In ***Figures 1a and 1b****, dominant strategies show optimal solutions for the game. (Note that in all the figures the left hand side figure in the parentheses is the pay off for the player noted at the side of the matrix whilst the right hand side figure is the pay off for the player on the top).*

One of Dixit and Nalebuff's rules for game theory is

"If you have a dominant strategy use it" (1991, p.66).

Figure 1a. Foreign Investment in a local economy.

Local Authority \ Private Firm	Invest in A	Invest in B
Active	(20, 10)	(-5, 5)
Non-Active	(5, 8)	(-8, 5)

Figure 1b. A Housing Association Merger

H.A 1 \ H.A 2	Alliance	No Alliance
Alliance	(3, 4)	(2, 2)
No Alliance	(1, 3)	(4, 2)

Note that it is possible to distinguish between strong and weak dominance. 1a and b are examples of strong dominance. Consider 1c. In this example, player 1 will never play down whilst player 2 will never play right. This is suboptimal. They will play left, up thought they would be better playing down, left. The reason for this inefficient outcome is the possibility of defection by one of the players.

Figure 1c. Weak Dominance.

		FIRM 2 Left	FIRM 2 Right
FIRM 1	Up	(7, 2)	(5, 2)
	Down	(7, 4)	(2, 0)

2. ***Nash equilibrium****: each player does their best given what they assume the other(s) is (are) doing. Named* after the mathematician, John Nash, who discovered the concept in the late 1940s, t*his is a* stable, self-enforcing and generalised equilibrium *concept in Game theory. It arises because not all games have dominant strategies. So again using a Dixit and Nalebuff rule*

> ***"Having exhausted the simple avenues of looking for dominant strategies or ruling out dominated ones, the next thing to do is to look for an equilibrium of the game" (1991, p.77).***

Look again at Figures 1a, 1b and 1c and consider the Nash equilibrium.

The Nash equilibrium is thus a more powerful solution concept.

Problems for Nash Equilibrium

1. A Classic Game: The Prisoner's Dilemma (Due to A.W. Tucker)

In this game 2 prisoners have been brought in for questioning by the police about a serious crime. The police have some information and so can make some charges hold but they need to question the suspects if they are to get the whole picture. The police interview the suspects in separate rooms. The prisoners now find themselves in a dilemma. The game is shown in the matrix below. Both have two choices, to confess or not confess. The pay offs for prisoner 1 are shown in the right of the bracket and those for prisoner 2 on the left. They are negative to reflect years in prison.

Clearly, both prisoners have a **dominant strategy** of confessing; it does not matter what strategy the other prisoner chooses (we can thus say that not confessing is a **dominated strategy)**. Both prisoners will get either 5 years or 6 months in prison for confessing and 10 years or 1 year if they keep quiet. Given the possibility of a 6 month sentence both players find themselves confessing.

Figure 2. The Prisoner’s Dilemma

		PRISONER 2	
		Confession	**No Confession**
PRISONER 1	**Confession**	**(-5, -5)**	**(-0.5,-10)**
	No Confession	**(-10,-0.5)**	**(-1,-1)**

Note

> “there is complete but imperfect information. it is complete because both know the strategies and payoffs available to each other, yet imperfect because decisions have to be made before the other’s choice has been revealed. All of this is common knowledge” (Lyons, *ibid*. p.98)

The implications of the PD are clear enough. Both players act sub-optimally. However, this sits uneasily with the concept of **instrumental rationality**; both players would be better off acting ‘irrationally’ and co-operating with each other. Both would then enjoy a better pay off.

This is not just a parlour game, it has relevance to public services. For example,

- **Why should we collect taxes to pay for emergency services or services such as street lighting?** People want the benefits but do not want to pay. There is a “free-rider” problem, which suggests that defect (non-co-operative) strategies develop. To see this, think about it from the point of view of the individual. Society would be better off if everyone participated in providing public goods and services. However, an individual may reason that if I do not pay then my net pay off is higher than if I do pay. I get the benefits of health care (or whatever) but not the costs. Clearly, if everyone behaves like this then society loses out.

- How can we stop shirking in the work place? If we work in teams then the rewards an individual gets from an extra unit of effort are diluted among our work colleagues. If there are 10 people in a team and one person puts in the extra unit of effort the payoffs (and these can be non –

pecuniary payoffs like satisfaction from seeing the team succeed, as well as monetary rewards) are shared by the other 9. So why make the effort in the first place?

- Why do employers and unions play tough guy strategies? Would a more professional, cooperative approach give higher returns?

- Why do partnerships fail to get off the ground?

Can we Resolve the Prisoner' dilemma?

Changing the Structures of the Pay offs

This solution is relatively straightforward. As most police officers will tell you offenders have learnt to play the Prisoner's Dilemma game over time. They act co-operatively because it is the 'rational' thing to do. Alternatively, they may act 'rationally' because the pay offs have been changed - Prisoner 1 may come from a large family and the implicit threat to injure Prisoner 2 in the event of confession would have to be taken account of in the latter's pay offs!

A Framework of Law

Clearly, an institutional structure enshrined by Statute would help to alleviate the free-rider problems and the emergence of inappropriate behaviour. However, establishing such a solution is easier said than done.

A very famous example, known as 'The Tragedy of the Commons', illustrates this point. The existence of Common land led farmers to graze livestock free of charge but this ultimately led to overgrazing and disaster for all. To overcome this situation the Government passed laws to enclose the land, establishing property rights for some but not others.

It is possible to translate this example to the seas and population problems.

The Framework of Law has been influential in bringing about partnerships in health, housing and social services as well is in economic development via initiatives such as City Challenge and the Single Regeneration Budget. In these instances funding will only be provided if joint working occurs.

Managerial Mechanisms

To establish partnerships we need to ensure that there are lead agencies. In the private sector, those strategic alliances that work best are those where majority ownership lies with one partner. This is also true in public sector partnerships. However, it is important that trust has been built up among the partners.

Punishments

To increase benefits to all participants need to have an incentive if they are to signal a willingness to participate. This can be done by the use of **punishment** systems that offer some protection to people who are willing to act co-operatively. One punishment strategy is a **Trigger strategy** whereby defection from the co-operative route is punished with a low price strategy thereafter. This is a severe punishment mechanism but note that there will be an incentive to defect in one period. If this occurs then society would only be marginally better off.

An alternative strategy is **'Tit-for tat' (TFT).** Robert Axelrod held a tournament in which he invited game theorists to submit a computer program that would resolve the Prisoner's Dilemma. The winner was TFT submitted by Anatole Rappaport. This program

- Acted co-operatively in the first round.
- In subsequent rounds, it adopted its opponent strategy from the previous round.

In the tournament each program
- Competed head-to-head against another
- Competed against itself
- Competed against another that was randomly selected by a computer.

We play the game below based on the following matrix. C represents co-operation and D defection.

		Player 2: C	Player 2: D
Player 1	C	(100, 100)	(-10, 140)
	D	(140, -10)	(0, 0)

	Firm 1 Tit for Tat	Firm 2 Dominant Strategy
Round 1	C -10	D 140
Round 2	D 0	D 0
↓	↓	↓
Round 9	D 0	D 0
Round 10	D 0	D 0

Total Profits	- 10	140

	Firm 1 Tit for Tat		Firm 3 Tit for Tat	
Round 1	C	100	C	100
Round 2	C	100	C	100
↓	↓		↓	
Round 9	C	100	C	100
Round 10	C	100	C	100
Total Profits		1000		1000

	Firm 2 Dominant Strategy		Firm 3 Dominant Strategy	
Round 1	D	0	D	0
Round 2	D	0	D	0
↓	↓		↓	
Round 9	D	0	D	0
Round 10	D	0	D	0
Total Profits		0		0

My suspicions are that if I played this game in the classroom, there would be a greater determination for players to co-operate because the payoffs for (Defection, Defection) are zero. It would be interesting to see whether pay offs of (90, 90) for (Defection, Defection) would induce more defection. Nevertheless, the rationality assumption in game theory suggests that (Defection, Defection) is the Nash Equilibrium for the game.

Generally TFT works because it is

- Nice – a TFT acts co-operatively and is never the first to defect.

- Provocable – they punish defection quickly.

- Forgiving – a TFT will reward players that act co-operatively again by reciprocation.

However, TFT works poorly when

- In a head-to-head contest with a dominant strategy player (as we have already seen)

- Facing a TFT player and some exogenous shock occurs. In this case the swift punishment leads to lower payoffs for both players.

The following illustrates a situation where a **Tit for 2 Tats** is better than TFT. In other words we recognise that players make ‘mistakes’.

	Firm 1 Tit for Tat		Firm 2 Tit for Tat	
Round 1	C	100	C	100
Round 2	C	100	C	100
Round 3	Nature D	140	C	- 10
Round 4	C	- 10	D	140
Round 5	D	140	C	- 10
Round 6	C	- 10	D	140
Round 7	D	0	Nature D	0
Round 8	D	0	D	0
Round 9	D	0	D	0
Round 10	D	0	D	0
Total Profits		460		460

	Firm 1 Tit for 2 Tats		Firm 2 Tit for 2 Tats	
Round 1	C	100	C	100
Round 2	C	100	C	100
Round 3	Nature D	140	C	- 10
Round 4	C	100	C	100
Round 5	C	100	C	100
Round 6	C	100	C	100
Round 7	C	- 10	Nature D	140
Round 8	C	100	C	100
Round 9	C	100	C	100
Round 10	C	100	C	100
Total Profits		930		930

Axelrod (1984) suggests that we need to

- Teach people to care about each other
- Improve recognition abilities and
- Teach reciprocity

However, note Axelrod is not an altruist. For Axelrod the foundation of co-operation is not really trust but the durability of a relationship in which we can elicit co-operation through the use of punishment for defection.

2. Multiple equilibria in one-shot games

Figure 3 shows the Battle of the Sexes game so called because it recognises potential difficulties between individuals in relationships. The matrix shows the strategies and pay offs for two individuals sitting at work wondering what to do in the evening. Both want to be together, though they have slightly different preferences as to what they want to do. Being apart is the worst outcome and this is given zero points. As to the co-ordinated activity that may take place, 'getting your own way' yields more than 'giving in' and is rewarded with 2 rather than one point.

		Her	
		Knitting	**Sumo**
Him	**Knitting**	**(2, 1)**	**(0, 0)**
	Sumo	**(0, 0)**	**(1, 2)**

Figure 3: The Battle of the Sexes Game

There are two Nash equilibrium in pure strategies. How might the problem be resolved?

- The existence of hierarchy (one of them is dominant and the other acquiescent)
- A commitment is made by one of the players (She buys tickets for the Sumo)
- Convention, whether historical, legal, cultural or social may have a role to play
- The players may arrive at some 'focal point' based on any of the above.
- They play **mixed strategies**. This is also a Nash equilibrium in that a situation exists in which each agent chooses the optimal frequency with which to play their strategy given the frequency choices of the other agent. Thus, the probability that each chooses the 'getting their own way' strategy is 2/3, whilst there is a 1/3 chance of 'giving in'.

There is some disagreement among authors as to whether a rational player would find this pay off acceptable. However, mixing strategies may be one way of resolving coordination difficulties in 'Battle of the Sexes ' type games.

The Battle of the Sexes Game has implications in any coordination issue. In the public services, mergers between Housing Associations might be seen as beneficial but there may be a dispute over the method of implementation. Similarly, multi-agency approaches to problems are commonplace in the public services. However, establishing an appropriate solution is rather more difficult. The game might also be characterised by wage bargaining or the allocation of scarce funds between parties.

I've included an example from the private sector (taken from John Kay's Book) showing the importance of co-ordination in a standards game. Again there may well be parallels with situations you've come against in respect of installing particular IT systems. It could also be that public service providers agree on the need for partnership activity but not on its form.

		Consumer 2	
		Buy VHS	**Buy Betamax**
Customer 1	**Buy VHS**	**(Best, Good)**	**(Bad, Bad)**
	Buy Betamax	**(Bad, Bad)**	**(Good, Best)**

Figure 3a: A Simple 'Battle of the Sexes' Standards Game

Here there are 2 possible outcomes each buy VHS or each buy Betamax. However, one consumer does not optimise their payoffs.

What is required is

1. Hierarchy - govts often attempt to establish a particular standard.
2. Commitment. This means
   - rapid achievement of an installed base, e.g. Sky won against BSB in spite of EC sponsored technology
   - Credibility of the supplier, e.g. JVC offered an open licensing policy to win the VHS/Betamax game.

How Useful is Game Theory?

- It allows us to study the logic of the situation in a scientific manner
- it provides a model of complex strategic interactions
- There may be many stages in each game
- We may have to show credibility, weigh risks, face players who have information bias, recognise the time dimension.
- Game theory makes us recognise interdependence

However,

- It makes some awkward assumptions about the instrumental rationality of players who are more interested in ends rather than means. Means are only of relevance in so far as they lead to maximising ends. Rationality may take different forms however, depending on the assumptions we make about human behaviour. And, players may come from different social and cultural backgrounds and have different histories. These may all affect the outcome of games. (Interested students should consider the issue of **Rationalizable Strategies**. For an introduction see B. Lyons in Hargreaves-Heap et al (1990. pps 103-104).

- Because of the possibility of multiple equilibria the 'art' of strategic decision making is vitally important.

Selected Reading

Axelrod R (1984) *The Evolution of Co-ope*ration, Basic Books, New York.

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