Chapter 1 : What is Game Theory?

Game theory is concerned with how rational individuals make decisions when they are mutually interdependent. In recent years this theory has been increasingly applied to various branches of economics. Often this synthesis has significantly improved our understanding of economic issues and led to important new insights being developed. In many instances the application of game theory has transformed the way economists think about both microeconomic and macroeconomic problems. This is evidenced by the frequent use of the adjective "new" when game theory is applied to different branches of economics. For example, it is now common for economists to refer to New Industrial and New International Economics. Both of these areas have developed as game theory has been applied to traditional disciplines within economics. Also, while not uniquely defined by their use of game theory, much of New Classical and New Keynesian Macroeconomics have incorporated game theoretical analysis. Indeed so widespread is the use of game theory in economics that it is difficult to find an area where such an approach has not yielded new insights and challenged traditional theory. The aim of this book is to provide an introduction to basic game theory concepts and to illustrate how these have been applied to a diverse range of economic issues. In the first section of this chapter we discuss the broad characteristics of game theory. These, in turn, delimit the range of economic issues for which game theoretical analysis is applicable. In the second section we provide an outline of subsequent chapters.

1.1. Basic Assumptions of Game Theory.

As stated above game theory is concerned with how rational individuals make decisions when they are interdependent. To understand this definition more fully we discuss what is meant by of individualism, rationality and mutual interdependence.

a. Individualism.

It is usual to distinguish two separate branches of game theory. These are cooperative and non-cooperative game theory. Strictly speaking the previous definition of game theory only applies to non-cooperative game theory. In non-cooperative game theory the individuals, or players, in a game are unable to enter into binding and enforceable agreements with one another. Due to this assumption non-cooperative game theory is inherently individualistic. In contrast cooperative game theory analyses situations where such agreements are possible. The focus of cooperative game theory is therefore on how groups of individuals committed to each other formulate rational decisions. This distinction does not mean that non-cooperative game theory precludes individuals working together. However, it does state that this will only happen if individuals perceive such cooperation to be in their own self interest. From this perspective individuals work together not because they have to, but because they voluntarily choose to do so. This individualistic approach is clearly consistent with the dominant emphasis within neoclassical economics. For this reason it is non-cooperative game theory that has had the greatest impact within mainstream economics.

Given this prominence we restrict ourselves in this book to economic applications of non-cooperative game theory. Nonetheless it should be realised that in many cases we consider the cooperative and non-cooperative approaches are not clearly distinguished. For example, in many instances complex organisations such as firms, governments and indeed countries are considered to act as individual decision makers. Clearly this is an extreme simplification and one that ignores how decisions are formulated within these institutions. The value of such a simplification is to make the resulting models more tractable. As in other areas the skill of the economist is to select the level of aggregation most appropriate for the problem being analysed.

b. Rationality.

The second characteristic of game theory is that individuals are assumed to be instrumentally rational. This means that individuals are assumed to act in their own self interest. This presupposes that individuals are able to determine, at least probabilistically, the outcome of their actions, and have preferences over these outcomes. As with individualism this characteristic dominates neoclassical economics and its justification has been attempted in a number of ways.

The first justification is to argue that individuals are indeed rational. However, given the complexity of many decisions, and the amount of information that often needs to be analysed, this seems unrealistic. Indeed evidence from many experimental studies suggests that individuals are
not fully rational but instead seek solve complex decisions by adopting simplistic rules that are generally sub-optimal. A second justification for rationality is that due to some process of natural selection the economy eventually converges on the fully rational outcome. From this perspective the assumption of rationality is consistent with focusing on the long run equilibrium of the economy. For example, it is argued that if firms sub-optimise then the competitive process will eventually force them to leave the industry. The result of this is that in long run equilibrium all remaining firms must be optimising and fully rational. One problem with this argument, however, is that although such an evolutionary process may be considered relevant for competition between firms, it is not always clear how it applies in other contexts. For example, there seems to be no evolutionary process whereby rational consumers can eliminate non-rational consumers. Without such a process of selection the economy will not necessarily converge on the rational outcome. The final justification for rationality is that it is not intended to describe how individuals actually solve complex decisions, but rather it is only assumed that individuals act as if they were fully rational. Once again the assumption of rationality is used to make the resulting models more tractable. As noted by Friedman (1953) all theories must involve some simplification, as none can include all the possible features of reality. According to this positive methodology the assumption of rationality should not be dismissed merely because it is believed to be unrealistic. This is because all simplifying assumptions are necessarily unrealistic. Instead rationality should only be rejected if the results based on this assumption are found to be unhelpful. This will be true if the theory either gives rise to no relevant predictions or these predictions are falsified by empirical evidence. With this methodology a theory should be judged on its usefulness rather than on the supposed realism of its assumptions. In this book it is argued that game theory based on rationality can be extremely useful in helping us understand a diverse range of economic issues. This, however, does not imply that departures from complete rationality will not also provide useful insights and predictions. Indeed a major theme of this book is that minor departures from full rationality are often required in order to derive meaningful results from game theory, and that further research incorporating these modifications is warranted. An alternative justification for analysing models that incorporate departures from full rationality is that as economists we may not only be interested in finding useful theories, but also interested in discovering theories that are true. If this is our aim then the positivist methodology fails. If a theory's assumptions are falsified then these need to be modified so that they conform to reality. As discussed in this book this is an ongoing process in the development of game theory and its application to economics.

c. Mutual Interdependence.

The final characteristic of game theory is that it considers situations where individuals are mutually interdependent. In this situation the welfare of any one individual in a game is, at least partially, determined by the actions of other players in the game. Significantly with mutual interdependence individuals may now have the incentive to act strategically. With strategic decision making individuals seek to anticipate the effect their own actions will have on the behaviour of others. Given this expectation each individual then determines their optimal response in order to achieve the most desirable outcome. In contrast to individualism and rationality this characteristic of mutual interdependence is less prominent within neoclassical economics. For example, in General Equilibrium Theory all agents are assumed to be atomistic. This ensures that the actions of agents taken in isolation have no effect on market outcomes or the welfare of others. This is assumed true for both firms and consumers. With this, and other assumptions it can be demonstrated that the competitive equilibrium is Pareto efficient. This means that no one individual can be made better off without making someone else worse off. In contrast once interdependence is introduced, so that an individual's welfare depends on the actions of others, there is the possibility of market failure and Pareto inefficiency. In this situation at least one individual can be made better off without any other agent being made worse off. The possibility of such inefficiency has been confirmed in numerous economic applications of game theory. Examples of mutual interdependence considered in this book include those between different firms, between firms and their employees, between the government of a country and the private sector, and between different governments.

1.2. Outline of Subsequent Chapters.

The purpose of this book is to introduce readers to the main concepts of non-cooperative game theory, and to examine how these concepts have been applied within economics. These general aims are reflected in the structure of the book. The first two chapters focus on game theory itself, with little economic analysis except by way of illustration. In contrast chapters 3 to 11 focus much
more on various economic issues that have been analysed using game theory. In the final chapter we review the current state of game theory by discussing a number of criticisms levelled against recent models. From these criticisms we make some recommendations concerning the direction of future research.

In chapter 2 we examine static games. These are one-off games where the players are considered to determine their actions simultaneously. In this context we examine two alternative ways in which games can be represented. These are the normal form and the extensive form. We also discuss various techniques commonly used to solve static games. These solutions correspond to predictions for what each player will do in the game, and are based on the concepts of dominance or equilibrium. It is here that we introduce the commonly used solution technique of Nash equilibrium, and discuss how this may be found for both pure and mixed strategies.

Chapter 3 continues our analysis of game theory by examining dynamic games. These games conform more closely to real world examples where individuals and organisations repeatedly interact with each other. In these games players are often able to condition their actions on past events. This greatly enhances the set of strategies available to players. Once more this chapter discusses how dynamic games can be analysed and predictions made. In this context the key concept of credibility is introduced, and various refinements of Nash equilibrium, such as subgame perfection and sequential equilibrium, are presented.

In chapters 4 and 5 we begin to focus more exclusively on the economic applications of game theory by considering two topics taken from industrial economics. The first is concerned with oligopoly, and examines the consequences of strategic interdependence between currently competing firms. Initially we consider one-off games between oligopolies, and discuss the now classic models of Cournot, Stackelberg and Bertrand competition. The results from these one-off games are then contrasted with the results derived when firms are assumed to repeatedly interact. In particular it is demonstrated that repeated interaction may enable firms to coordinate on the collusive outcome where joint profits are maximised. The second application taken from industrial economics is that of entry deterrence. Here the interdependence is between firms already in the market and potential entrants. To illustrate this type of strategic interdependence we examine the situation where a monopolist has the incentive to try and deter other firms from entering the market and competing against it. Initially this involves a critical discussion of Bain's (1956) Theory of Limit Pricing. Subsequent to this we present more recent models of entry deterrence based on non-cooperative game theory. These models serve to highlight the important roles of predatory pricing, precommitment, and incomplete information in oligopolistic markets.

Whilst the games considered in chapters 4 and 5 are primarily microeconomic, chapters 6 and 7 focus on macroeconomic games. In chapter 6 we analyse New Classical results and give them a game theory interpretation. In the first two sections we illustrate how New Classical Macroeconomics has challenged earlier results related to the effectiveness of government policy. This discussion naturally raises the issue of time inconsistency. This occurs when the government has a short run incentive to deviate from its long run optimal policy. With the private sector perceiving such an incentive the final equilibrium is Pareto inefficient. In the third section of this chapter we evaluate various suggestions for how governments might avoid the problem of time inconsistency.

In chapter 7 our attention turns to New Keynesian Macroeconomics. Specifically we examine a number of game theory models that attempt to explain the occurrence of involuntary unemployment and the effectiveness of government demand policy, whilst assuming that all agents are rational. Three separate, though related, strands of New Keynesian Macroeconomics are presented. The first focuses on efficiency wage models, where unemployment is due to real rigidities. The second examines how unemployment can result when agents do not fully adjust nominal wages and prices to an adverse demand shock. Finally we examine models that exhibit multiple equilibria and coordination failure. This occurs when agents within the economy coordinate on a Pareto dominated equilibrium. Significantly it is argued that this possibility may arise even in the absence of real or nominal rigidities.

Chapters 8, 9 and 10 analyse game theory models set in an international context. In chapter 8 we examine the role of international policy coordination. This chapter argues that given the presence of spillover effects between countries uncoordinated policy is likely to lead to an inefficient outcome. This provides the incentive for countries to try and coordinate their domestic policies.
Despite potential gains there are a number of problems associated with policy coordination. These are also discussed. Finally this chapter seeks to assess the likely magnitude of such gains by reviewing a number of empirical studies.

Chapter 9 considers the possibility that a government may improve domestic welfare with the appropriate use of strategic trade policy. This possibility is discussed in two separate contexts. The first context is where all markets are perfect, but the country itself has some degree of market power. This occurs when the country in question is large, and gives rise to the "optimal tariff argument". With two or more countries pursuing such a policy, however, all countries can be made worse off. Various mechanisms for avoiding this outcome are discussed. The second context that provides some justification for strategic trade policy is when domestic industries engaged in international trade have some degree of market power. Faced with oligopolistic competition we analyse how government trade policy can be welfare enhancing and review some of the problems associated with such a policy.

The final chapter set in an international context is concerned with environmental economics. In chapter 10 we analyse the incentives for countries to enter into international environmental agreements (IEA's). Initially we consider bilateral agreements and then analyse multilateral agreements. In each case we highlight the costs of countries failing to reach agreement over environmental control, and discuss various ways coordination can be achieved. In particular we examine the use of side payments between countries, the prospect of punishing countries that break environmental agreements, and how the number of countries signing IEA's might be expanded.

Chapter 11 is somewhat different from the previous chapters. In this chapter we focus on a recent branch of economics known as Experimental Economics. Instead of analysing the theoretical implications of game theory, we discuss a number of experiments that have been designed to test the predictions of this theory. This is done by testing whether they are confirmed by the behaviour of individuals in a controlled environment. Given how rapidly the literature within experimental economics is expanding we focus on studies concerned with testing three of the more important game theory concepts widely used in economics. These are the concepts of Nash equilibrium, sequential equilibrium, and the possibility of coordination failure in games with Pareto ranked multiple equilibria. From a review of such experiments we conclude that the predictions of game theory often perform remarkably well. Nonetheless it is clear that not all relevant game theory predictions are confirmed by experimental evidence. Despite the inherent problems with interpreting such results we argue that greater research is needed on how individuals seek to solve complex decisions under conditions of uncertainty, and how they seek to learn and coordinate appropriate strategies over time. Similar conclusions are reached in chapter 12. In this final chapter we focus on a number of theoretical criticisms levelled at recent game theory models. These specifically relate to assumptions concerning the rationality of individuals. It is argued that models based purely on instrumental rationality are either self defeating, incomplete or inconsistent. However, rather than being purely destructive these criticisms can be viewed as a stimulus to further research. We predict that this will involve a re-evaluation of what is meant by rationality, and a greater emphasis given to factors such as the role of institutions, culture and the previous experience of agents. Such research is an on-going process, and it is confidently expected that it will lead to further fruitful applications to economics.