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A Comparative Study about Different Modeling Techniques of Game Theory

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Abstract* – Land and property development processes obviously can be seen as a social situation in which the interaction of individuals or groups of individuals is one of the essential elements. To study and understand social situations, it is important to analyse how the decisions of actors are interrelated and how those decisions result in outcomes. In this paper, we propose a game theoretical modelling approach to analyse it. Hence, the objective of the paper is to investigate the usefulness as well as the limitations of game theoretical modelling for analysing and predicting the behaviour of actors in decision-making processes with respect to the development of land and property. For that purpose, we have developed game models for the case study of the development of a green field residential location in the Netherlands with respect to the implementation of new Dutch legislation on cost recovery.

Our study demonstrates that game theory could help us to identify the key strategic decisions of land and property development projects by showing the different payoffs for stakeholders of their chosen strategies and selecting the equilibrium in which all stakeholders involved are best of. We also found many limitations of using game theory in our case study especially regarding the assumptions underlying the model. However, we conclude that game theoretical modelling can be a useful decision support tool in spatial planning, because it provides a way to think about the complexity of strategic interaction and, in particular, about the conflicting structure of collective decision-making processes.

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INTRODUCTION

In this paper we shall study the problem of determining "correct" premium rates for sub-groups of an insurance collective. This problem obviously occurs in all branches of insurance. However, it seems at present to be a really burning issue in automobile insurance. We shall show that the problem can be formulated as a conflict between groups which can gain by co-operating, although their interests are opposed. When formulated in this way, the problem evidently can be analysed and solved by the help of the "Game Theory" of Von Neumann and Morgenstern.

Competition is a 'Key factor' of modern life. We say that a competitive situation exists if two or more individuals are taking decisions in situation that involves conflicting interests and in which the outcome is controlled by the decisions of all parties concerned. We assume that in a competitive situation each participant acts in a rational manner and tries to resolve the conflicts of interests in his favour. It is in this context that game theory has developed. Professor John von Newmann and Oscar Morgensten published their book entitled "The Theory of Games and Economic Behaviour" where in they provided a new approach to many problems involving conflict situations. This approach is now widely used in Economics, Business Administration, Sociology, Psychology and Political Science as well as in Military Training. In games like chess, draught, pocker etc. which are played as per certain rules victory of one side and the defeat of the other is dependent upon the decisions based in skillful evaluation of the alternatives of the opponent and also upon the selection of the right alternative.

HOW DOES GAME THEORY WORK?

This section provides a brief introduction to how game theory actually works. Since the main objective of the paper is to investigate the usefulness of game theoretical modelling for the analysis of land and property development processes, only the basic concepts of game theory are explained here, including games, players, strategies, outcomes and payoffs and solution concepts. Any game consists of two parts, namely a descriptive part which describes the game under scrutiny, and a solution part which describes or predicts the outcomes given the description of the game. This two-component approach can be compared with a mathematical problem, e.g., in linear algebra. We then have a set of equations describing the problem and, subsequently, we try to find a solution of the system of equations. In game theory we describe a collective decision-making situation as a game and try to find its solutions. This analogy of game theory with linear algebra elucidates another important point in game theory. In linear algebra, a system of equations may have one solution, many solutions or no solution at all. The same is true for games. Basically, three descriptive frameworks for the games are distinguished: games in strategy form, games in coalition form or characteristic form and games in extensive form. These three formats have already been constructed by Von Neumann and Morgenstern (1944). In the case study in this paper we model the decision-making processes as a game in extensive form. In this way, we will arrive at a detailed picture of the structure of land and property development processes and the possible outcomes of this structure. It is assumed that players decide sequentially, as in playing chess. The first player makes amove, the second one responds and so on. The whole game can be structured by means of a so-called game tree. This can be seen as a graphical representation of the strategic interactions of the players in Figure.

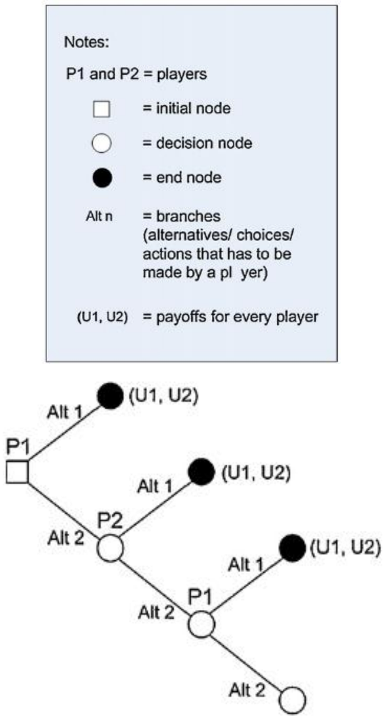

Figure: Game tree.

MODELING APPROACHES

In general, three conceptual devices have been deployed in the conflict literature to capture the strategic structure of a game: a game tree is used to represent a game in the extensive form; a payoff matrix is the basis of the normal or strategic form of representation; and a mathematical function that assigns a payoff to every player and to every combination of players is known as the characteristic function form of representation. The extensive and the strategic forms are typically used in the analysis of two- and, some-times, three-person games. The characteristic function form is most frequently encountered when an n-person game is under consideration.

The First Wave: Zero-Sum Game Theory - Almost all of the early applications of game theory in international relations drew upon the theory of zero-sum games (see, inter alia, Kaplan, 1957; McDonald 1950; McDonald and Tukey 1949; Morgenstern 1959, 1961a; and Williams 1954). Since zero-sum games were the object of von Neumann and Morgenstern's attention, this should not be surprising. But the first generation of applications were also developed during the most intense period of the cold war. Hence, they also reflected, perhaps unwittingly, the heated political climate in the United States.

The Second Wave: Nonzero-Sum Game Theory - The theoretical foundations for the second wave of the game theory literature in international relations were, once again, laid by a mathematician. This time it was John Nash, a co-recipient of the 1994 Nobel Prize in economics. (Nash shared the prize with John Harsanyi and Reinhard Selten whose work will be discussed below.) It was no accident that this prize was awarded on the fiftieth anniversary of the publication of von Neumann and Morgenstern's opus.

The Third Wave: Dynamics and Equilibrium Refinements - During the third wave, formal modelers began to think outside the (2 x 2) box. From roughly the early to mid-1980s to the mid-1990s, there was a distinct move away from static strategic form games toward dynamic games depicted in extensive form. The assumption of complete information also fell by the wayside; games of incomplete information became the norm. Technical refinements of Nash's equilibrium concept both encouraged and facilitated these important developments.

APPLICATION OF GAME THEORY

We shall first illustrate the problem by a simple example. We consider a group of $n_1 = 100$ persons, each of whom may suffer a loss of r, with probability $P_1 = o.1$. We assume that these persons consider forming an insurance company to cover themselves against this risk. We further assume that for some reason, government regulations or prejudices of managers, an insurance company must be organized so that the probability of ruin is less than o.oo1 If such a company is formed, expected claim payment will be $m = n_1p_1 = 10$ and the standard deviation of the claim payments will be

$$\sigma = \sqrt{n_1 p_1 (1 - p_1)} = 3$$

The Theory of Games has as its purpose just to analyse such situations of conflicting interests. In some cases the theory will enable us to find a solution without resorting to arbitrary rules. In other cases the theory will make it clear that the problem in its very nature is indeterminate, and that some "additional assumption" or "arbitrary rule" is indeed required.

A More General Case **-** In this Section we shall try to build a more general theory on the basis of our discussion of the example above. We shall now consider m groups. Group *i (I - I,...,m)* consists of persons who are exposed to risk of a unit loss with probability p_i. We shall refer to this set of groups as *M*. Let S be an arbitrary subset of *M*.

We assume that the groups in any subset can form an insurance company to protect the members of the groups against the losses, and we assume further that the safety requirements are the same as in the example of the preceding Section (i.e. probability of ruin < o.oo1).

If the groups in the subset S form an insurance company, the amount of premium they have to pay will be

$$v(S) = \sum_{S} n_i p_i + 3\left(\sum_{S} n_i p_i (1 - p_i)\right)^{\frac{1}{2}}$$

where summation is over all members of *S*.

LIMITATION OF GAME THEORY

Infinite number of strategy - In a game theory we assume that there is finite number of possible courses of action available to each player. But in practice a player may have infinite number of strategies or courses of action.

Knowledge about strategy - Game theory assumes that each player as the knowledge of strategies available to his opponent. But sometimes knowledge about strategy about the opponent is not available to players. This leads to the wrong conclusions.

Zero outcomes - We have assumed that gain of one person is the loss of another person. But in practice gain of one person may not be equal to the loss of another person i.e. opponent.

Risk and uncertainty - Game theory does not takes into consideration the concept of probability. So game theory usually ignores the presence of risk and uncertainty.

Finite number of competitors - There are finite number of competitors as has been assumed in the game theory. But in real practice there can be more than the expected number of players.

Certainity of Pay off - Game theory assume that payoff is always known in advance. But sometimes it is impossible to know the payoff in advance. The decision situation in fact becomes multidimensional with large number of variables.

Rules of Game - Every game is played according to the set of rules i.e specific rules which governs the behaviour of the players. As there we have set of rules of playing Chess, Badminton, Hockey etc.

Strategy - It is the pre-determined rule by which each player decides his course of action from his list available to him. How one course of action is selected out of various courses available to him is known as strategy of the game.

CONCLUSION

The particular results which we have arrived at in the preceding sections obviously depend on our very arbitrary assumptions about the safety requirements of insurance companies. It is, however, clear that the whole argument could be carried through with safety requirements or equivalent restrictions in a different form. It might have been more realistic if we had considered administrative costs instead of safety loading. We can for instance assume that these costs in an insurance company depend on the number of policies n, and on the number of claim payments *m*.

If we assume that the cost function is of the form

$$a\sqrt{n} + b\sqrt{m}$$

the expected cost of an insurance company formed by Group *i* will be

$$C_1 = n_1 p_1 + a\sqrt{n_1} + b\sqrt{n_1 p_1}$$

Hence this model is substantially the same as the one we have studied in the preceding sections. The gain will in this case be a saving in administrative cost.

By making use of game theory, we have analysed stakeholders' strategic behaviour in land and property development processes. To investigate the usefulness of game theory for modeling decision-making processes in land and property development processes, we have built a game theoretical model of a typical greenfield residential development in the Netherlands concerning the implementation of new Dutch legislation on cost recovery. Our study has demonstrated that game theory helps to identify the key strategic decisions to be made in this type of development projects, shows the different payoffs, in relative terms, for stakeholders of their chosen strategies and enables to select the equilibrium situations in which all stakeholders are best of. However, we are also aware that the case study, in its present form, still contains many limitations. In this final section we discuss the problems that must still be solved to increase the attractiveness of game theory for decision support with respect to land and property development.

Finally, the application of game theoretical modelling to complex decision-making processes like in land and property development processes, involves, by definition, the simplification of reality in the model. There are much more coincidental events involved and much more linkages between types of actors (e.g., informal relations between stakeholders) and mixed types of actors in reality. One example of this simplification problem is the path dependency of the tree. In our model, we have assumed that the municipality will start the tree, but it is also possible in a real-life situation that other stakeholders will start the tree which will probably lead to different outcomes. Although we believe that more complexity can be built in, game theoretical models – like any other model – are always an abstraction of reality.

REFERENCES

- Bojrch, Karl, "The Utility Concept applied to the Theory of Insurance", The ASTIN Bulletin Vol. I (1961), pp. 245-255.
- Bulmer, S., Dolowitz, D.P., Humphries, P., Padgett, S., 2007. Policy Transfer in European Union Governance. Routledge, London.
- Byrne, D., 2003. Complexity theory and planning theory: a necessary encounter. Planning Theory 2 (3), 171–178.
- Camerer, C.F., 2003. Behavioral Game Theory: Experiments in Strategic Interaction. Princeton University Press, Princeton.
- Camerer, C.F., Loewenstein, G., Rabin, M. (Eds.), 2004. Advances in Behavioral Economics. Princeton University Press, Princeton.
- Harsanyi, John C., "A bargaining model for the cooperative n-person game", Annals of Mathematical Studies, No. 40, pp. 325-355, Princeton 1959.
- Kreps, D., 1990. Game Theory and Economic Modeling. Oxford University Press, Oxford.
- Luce, R. Duncan and Howard Raiffa, "Games and Decisions", John Wiley & Sons 1957.
- Luce, R.D., Raiffa, H., 1957. Games and Decisions: Introduction and Critical Survey. Dover Publications, Inc., New York.
- Mu, L., Ma, J., 2007. Game theory of price decision in real estate industry. International Journal of Nonlinear Science 3 (2), 155–160.
- Myerson, R.B., 1991. Game Theory: Analysis of Conflict. Harvard University Press, Cambridge, MA.
- Nash, John F., "The bargaining problem", Econometrica 1950, pp.155-162.
- Needham, B., 2006. Planning, law and economics: the rules we make for using land. Routledge, London.
- Needham, B., 2007. Dutch Land Use Planning: Planning and Managing Land use in the Netherlands, the Principles and the Practice. Sdu Uitgevers b.v, The Hague.
- O'Neill, B. (1994a) "Sources in Game Theory for International Relations Specialists." In M. Intriligator and U. Luterbacher (eds.) Cooperative Models in International Relations Research. Boston: Kluwer.
- Oye, K. (ed.) (1986) Cooperation Under Anarchy. Princeton: Princeton University Press.
- Pearce, D. (1984) "Rationalizable Strategic Behavior and the Problem of Perfection." Econometrica, 52: 1029 – 50.
- Radboud University Nijmegen, Inaugurale Rede, Nijmegen.
- Salskov-Iversen, D., 2006. Learning across borders: the case of Danish local government'. International Journal of Public Sector Management 19, 673–686.
- Taylor, N., 1998. Urban Planning Theory since 1945. Sage Publications Ltd., London. van Deemen, A., 2006. Speltheorie en strategische besluitvorming in organisatie.
- Van der Krabben, E., Lambooy, J.G., 1993.Atheoretical framework for the functioning of the Dutch property market. Urban Studies 30, 1381–1397.
- Zagare, F.C. (1984) Game Theory: Concepts and Applications. Beverly Hills, CA: Sage.
- Zagare, F.C. (1987) The Dynamics of Deterrence. Chicago: University of Chicago Press.