Decision-making in real estate development: application of game theory

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pursue their own interests rationally and what outcomes will result if they do so. Because the focus lies on situations in which parties have conflicting and supplementary interests, and interdependence in behavior, game theory is well-suited to describe and analyze decision making in real estate development and real estate decision making situations in which two or more actors or decision makers are involved (Samsura et al. 2010). Basic assumptions that underlie the theory are that decision makers pursue well-defined, exogenous objectives (they are rational and try to maximize their own utility), they have an infinite time horizon (perfect recall), and they take their knowledge or expectations of other decision makers’ behavior into account (they reason strategically). Game theoretical models are representations of real-life situations, which allow us to be led to study a wide range of phenomena. They consist of at least three basic elements in order to predict interaction outcomes: players, strategies, and payoffs.

The players in a game are the decision-makers; a player $i$ is assumed to be a solitary actor who makes decisions one by one as they go along during the game. A complete plan of possible actions is a strategy $s_i$ of player $i$. Therefore, the conjunction of chosen strategies and related payoffs is defined as the outcome of the game. A clear distinction has to be made between the concepts of outcome and payoff; an outcome is the decision, if any, arrived at by the players collectively, while the definite payoff of an outcome for a player is the value of that outcome for the player. Because players will have different valuation systems over the set of possible outcomes, and hence have different preferences over the outcomes, this is where conflicts can arise. In order to predict the outcome of a game, focus of game theoretic modelers is on possible strategies they consider a Brownfield that is -- any land on selecting one or more strategy combinations as reflecting the most rational behavior by the players. A strategy combination that consists of the best strategy for each of the $n$ players in the game is defined as a strategy combination $s = (s_1, s_2, \ldots, s_n)$ of the players in the game. Player $i$'s payoff is denoted as $\pi_i (s_1, \ldots, s_n)$, and this can be defined as a number associated with each possible outcome resulting from a complete set of strategic selections by all the players in a game. Generally, higher payoffs numbers attach to outcomes that are better in the player's rating system. The conjunction of chosen strategies and related payoffs is defined as the outcome of the game. A clear distinction has to be made between the concepts of outcome and payoff; an outcome is the decision, if any, arrived at by the players collectively, while the definite payoff of an outcome for a player is the value of that outcome for the player. Because players will have different valuation systems over the set of possible outcomes, and hence have different preferences over the outcomes, this is where conflicts can arise. In order to predict the outcome of a game, focus of game theoretic modelers is on possible strategies they consider a Brownfield that is -- any land on selecting one or more strategy combinations as reflecting the most rational behavior by the players. A strategy combination that consists of the best strategy for each of the $n$ players in the game is defined as a strategy combination $s = (s_1, s_2, \ldots, s_n)$ of the players in the game. Player $i$'s payoff is denoted as $\pi_i (s_1, \ldots, s_n)$, and this can be defined as a number associated with each possible outcome resulting from a complete set of strategic selections by all the players in a game. Generally, higher payoffs numbers attach to outcomes that are better in the player's rating system.

The principal objective of game theory is to determine what strategies the players ought to choose in order to maximize their individual payoffs. In order to find equilibriums, the players’ most preferred strategies should be defined. Solution concepts are suitable for defining such preferred strategies; a solution concept $F \subseteq \{s_1, s_2, \ldots, s_n\}$ is a rule that defines an equilibrium based on the possible strategy combinations and the payoff functions. Application Game theory can be classified into cooperative and non-cooperative game theory, both matching narrowly with real estate development decision making processes. Cooperative game theory deals with situations in which groups of players already agreed to cooperate. These players aim for coordinating their actions, so that they can act jointly in order to benefit in joint profits. Because these joint profits often exceed the sum of the individual profits, cooperative game theory deals with the question how to divide these joint profits. This might be applicable to situations in which public and private parties negotiate over the division of risks, expenses, and profits in a public-private partnership contract. Non-cooperative game theory primarily deals with the analysis of conflict situations. A conflict can occur when the interests of several decision makers are opposed or only partly coincide. Each decision maker will usually choose an option in his own interest, which need not be in the interest of the others. These individual decisions can result in worse outcomes for all players compared to a coordinated decision. In this section, we will present an example of a non-cooperative game theoretic model, applied on Brownfield Redevelopment.

Decision-making in real estate development: application of game theory

Decision making in real estate development projects has generally undergone a number of important changes over the last decades. This transition represented a shift from governmentally dominated top-down spatial planning to bottom-up, public-private engagement schemes in real estate development (Tam et al. 2009). The new policy implies pluricentric network steering – in which several public and private parties play a role – instead of traditional hierarchical top-down governmental steering.
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Brownfield Redevelopment on the urban district scale. Thirdly, the size of a Brownfield is in the range of one to ten hectares. Finally, we assumed that different decisions would be more or less present depending on the region of the research (this research focuses on the Netherlands).

**Game type**
We restricted ourselves to analysis in the extensive form or a game tree analysis where the players act sequentially. The extensive form of the game compared to the strategic form brings more realistic representation of the reality. As mentioned before the game is non-cooperative.

**Players of the game**
We focus on two groups of actors in whole Brownfield Redevelopment process. These are the Municipality (M) and Developer (D) that would potentially form a JVC.

**Strategy**
At first, we will determine the negotiation issues that are treated as strategies in the game. In this game we address two issues: the availability of a building claim and developer's influence on the future land use and parcellation. The building claim is one of the crucial characteristics for any land development model (Samura et al., 2010). Potential to influence future land use emerged as the most important attribute in our survey (Glimau et al., 2010a).

Parcellation together with servicing (land clean-up and infrastructure developing) is a stage characteristic for every land development model (Samura et al., 2010). Additionally, the selection upon the negotiation issues is reduced to land use mix and density of development (parcellation) at a local neighborhood scale to describe the development typology. Similarly, both the land use and parcellation are used to compose development types.

By assigning the levels to these negotiation issues we defined the possible actions of the players and D. Their actions differ and each action is represented by a branch (Figure 1). A reader can notice that player M has 20 possible actions: BC, H, M, L, A and player D either a deal in which building claim is available (BC) or not available (NBC). For every possible action of player M, player D can accept (a1, a2) or reject (r1, r2) the deal on the next decision node in the game. The game stops when the end nodes are reached.

This procedure practically explains the complete plan of possible actions of the players and D. Their actions differ and each action is represented by a branch (Figure 1). A reader can notice that player M has 20 possible actions: BC, H, M, L, A, R1, R2, R3, A1, A2, A3, R1, R2 when starting with the branch (action) BC, and similar ten starting with the branch (action) NBC that define the set of possible actions of the player M. Similarly, player D has 22 possible actions that defines the set of possible actions of the player D.

**Payoff**
Each outcome (end node) has its payoff. Upper number indicates the payoff of a certain outcome for the first player (M) and lower number indicated the payoff of the second player (D). In this example (figure 1) the payoffs are assumed by the following logic. For every branch ending with action H Player M will have the smallest payoff (1) while the player D will have the highest payoff (3).

Contrary, for every branch ending with action L Player M will have the highest payoff (3) while the player D will have the smallest payoff (1). Underlining logic of this statement is: higher developer’s influence means higher developer’s (player D) payoff and contrary the municipality’s (player M) payoff is smaller. Additionally, for the NBC branches the player D will have 20 percent less payoffs since it won’t participate in building the plots and player M will have 10 percent higher payoffs since they can sell the plots to other parties on the market. When the deal is not made (actions r1, r2) payoffs will be the smallest for both players, with 0 and -1 respectively for players D and M. Built upon the previous notion, the player M’s payoff is defined as πM (s1, …, s26) and the player D’s payoff as πD (s1, …, s26).
Perspectives of Game Theory
As decision processes in real estate development projects become more complex, we have to find theories that can support the governance of such processes through interventions. Game theory can be applied to real estate development project environments, resulting in a very basic understanding of players’ choice behavior and expected decision outcomes, together with recommendations concerning the application of intervention strategies in conflict situations. However, one should realize that game theory presents an abstraction from reality: not all intricacies of real-life interaction processes in real estate development projects are covered; and deliberately so. The aim is to use the abstract representation of the interaction structure as a tool to understand the behavior of the involved parties a bit better, not to mimic real-life to every detail. Furthermore, a major critic of the classical game theory is the assumption of completely rational players with complete information. To partly overcome the problems related to the assumptions of game theory, the concept of bounded rationality can be introduced. This can be achieved by combining game theory with methods that enable the possibility of having a ‘vector’ or ‘multi-valued’ utility function. This is a main subject in the research of the authors, of which the first results can be found in Glumac (2010b) and Blokhuis (2010).

References

Emerging urban futures and opportune repertoires of individual adaptation
This paper summarizes the goals and scope of a new large scale research project, funded by the EEC. The ultimate goal of this research project is to develop the first comprehensive model of dynamic activity-travel patterns in the world, expanding and integrating concepts and partial approaches that have been suggested over the last few years. Dynamics pertain to different time horizons. Long-term decisions such as demographic change, changing job or house may also prompt or force people to adapt their activity-travel patterns.