A Game Theoretical Approach to Analysis of Value Capturing Implementation

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Abstract

This paper presents the discussion of implementing value capturing as internalization mechanisms for the externalities by relying on concepts and notions drawn from game theory. A game theoretical approach provides a way to formulize the interdependency and cooperation among stakeholders (infrastructure provider, land owners, property developers) in complex decision-making projects, as well as to examine the structure of individual decisions with regard to the implementation of value capturing. This approach is elaborated to provide arguments for efficient ways in implementing value capturing. The Dutch context on location development process is employed to observe the applicability of the arguments.

Keywords

Transportation infrastructure funding, value capturing, externalities, game theory

1 Introduction

The development of major transportation infrastructure and location development (i.e. residential areas, industrial estates, office and retail parks) increasingly takes play in an integrated way (Te Brömmelstoet & Bertolini, 2010). An integrated approach may not only contribute to a better, more sustainable spatial outcome of the development process (from the society's point of view), but it might also be more efficient, although the increased complexity may have an unintended counter effect on efficiency as well (Van der Krabben et al., 2008). Moreover, in financial terms, the integrated approach also provides new opportunities. Traditionally, the public investments in transportation infrastructure are based on tax revenues. Usually, the according budgets available for transportation infrastructure development are limited and – almost by definition - not sufficient to develop all desired infrastructure. In looking for alternative funding for transportation infrastructure development, governments should try to find a way that allows for efficient economic performance, financial justice, and social facility. When transportation infrastructure and location development are combined, value capturing methods may, to a certain extent, offer an opportunity to achieve those goals (Banister & Berechman, 2000; Batt, 2001). In chapter 3, Debrezion et al. (2010) paid attention to the issue of value capturing. Here we define value capturing as a process by which all or a portion of increments in land value that resulted from the installation of special public improvements or any other actions attributed to the 'public effort' are recouped by the public sector and used for public purposes (Smolka, 2000; Smith & Gihring, 2006). Many studies have been carried out with respect to value capturing. A large part of that literature is aimed at the empirical evidence of the incidence of rising land and property value associated with the improvement of transportation infrastructure, especially rail transit, and the associated increased accessibility of the location (see e.g. Diaz, 1999; Ryan, 1999, Du & Mulley, 2006). However, there are limited sources that can be found to explain the decision making process with respect to the implementation of value capturing methods and to answer the question whether value capturing might be a feasible method to financing infrastructure development projects.

The increment land and property values can be considered as positive externalities, generated by public goods provision, that should be internalized (Webster and Lai, 2003; Van der Krabben and Needham, 2009). Referring to the new institutional economics framework, externalities problems are generated by a 'failure' in the definition and assignment of property rights (see e.g. Coase, 1960; Barzel, 1997). Therefore, the implementation of value capturing should take into account the clarification and assignment of property rights, which suggests the importance of interdependency and cooperation among stakeholders involved. From the new institutional economics perspective, there are some difficulties in implementing value capturing. One of the problems is the difficulty of capturing the increasing land value, especially when the land owners refuse to give it up because the property rights over the increment land value had been assigned to them initially. As mentioned by Barzel (1997), property rights of individuals over assets consist of the rights or power to consume, obtain income or benefit from, and alienate their assets. It means that land owners have the right to enjoy the increment value themselves without any obligation to give it back to the community. Therefore, in a situation where the property rights are well assigned – i.e. to the land owner in the Netherlands, who will receive the increment land value (Munoz-Gielen, 2008) – it will be problematic to apply value

capturing unless the institutional arrangements with respect to the assignment of property rights over the increment land value will be changed, or the parties involved will start a bargaining process to reallocate the increment land values among them.
Real-life bargaining processes to reach a consensus and agreement between a transportation infrastructure developer and a location developer are often muddy and obscure. In this chapter, we offer an analysis of bargaining processes in the implementation of value capturing methods as internalization mechanism for the externalities, by relying on concepts and approaches drawn from game theory.
A game theoretical approach provides a way to formulize the interdependency and cooperation among stakeholders (infrastructure provider, land owners, property developers) in complex decision-making projects. Moreover, it can be used to examine the structure of individual decisions (Samsura et al., 2010; Te Brömmelstoet & Bertolini, 2009, 2010). This approach is elaborated in this paper to provide an analysis in implementing value capturing methods. The institutional setting of land development related to infrastructure development and funding in the Netherlands will be used to provide an empirical context to the analysis. The transition that we analyze in this chapter is the integration of infrastructure and location development and the related financial opportunities of value capturing. Thus, we aim to contribute to the development of a new generation of financial tools for integrated infrastructure and area development.

The structure of this paper is as follows. In section 2, we elaborate the discussion about value capturing and externalities problems. Section 3 provides an introduction to game theory and a discussion of the supposed advantages as well as limitations of applying this approach to analyse the bargaining process in implementing value capturing methods. Section 4 presents a brief description of issues related to value capturing within the context of location and infrastructure development processes and its funding mechanisms in the Netherlands. In this section, the stakeholders involved will be introduced along with their strategies and the institutional context in which they operate. In section 5, the bargaining model based on game theoretical approach will be constructed with respect to the implementation of value capturing method in the Netherlands. Finally, section 6 discusses the usefulness of bargaining game theory for modelling the implementation of value capturing processes and suggests the next steps for further analysis.

2 Value Capturing and Externalities Problems

As mentioned above, the increment land and property values to be captured can be considered as positive externalities generated from public goods provision. From an economic perspective, attempts should be made to solve the externalities problem (see e.g. Webster and Lai, 2003; Van der Krabben and Needham, 2009). Therefore, value capturing can be considered as a set of tools to internalize the increment land and property values and thus as the solution for externalities problems.

In any economics textbook, the discussion about solving externalities problems almost always refers to the works of Pigou (1920) and Coase (1960). Pigou's approach on externalities focuses on the market equilibrium outcome which has to be Pareto efficient. The presence of externalities will break down this equilibrium, because the externalities will make the private marginal costs diverge from the social marginal costs associated with each party's actions. The result is that parties will face the 'wrong' price which will lead to an inefficient allocation of resources. Pigou's solution for this situation is to levy taxes, to force private marginal costs to meet social marginal costs. However, this solution will raise some problems. First, it requires an omniscient and also benevolent tax authority, because it should know the exact tax level to reach marginal social costs. Moreover, this tax authority will be insensitive to rent-seeking behaviour. Second, there is a problem of fairness with the Pigouvian tax concept, because it does not necessarily consider the damage done to parties when they are being taxed and induced to produce at social optimum efficiency.

Coase's approach tries to deal with these problems. He argues that the market itself is able to solve the problem of externalities: when property rights are well-assigned and transaction costs are zero, resource allocation is efficient and independent of the pattern of ownership (Coase, 1960). This principle is well known as the Coase Theorem. Based on this principle, the producers of negative externalities or the receivers of positive externalities should not be taxed, instead they should bargain to decide how and to what extent the externalities could be reduced (see among others Calabresi, 1968; Dahlman, 1979; Varian, 1994).

Considering value capturing, taxes, fees, and regulatory instruments are often used as its main tools (see e.g. Smolka, 2000; Batt, 2001; Wolff, 2007). However, using Coase's terminology, land and property owners have the right to enjoy the increment values of their land and properties, while at the same time the infrastructure developers also have the right to take benefit from it. Therefore, bargaining and negotiation should take place among the parties involved to arrive at the agreement upon the efficient allocation of the increment land value as well as the compensations to reach such agreement. In this paper, the cooperative game theoretic approach is applied to analyse the implementation of value capturing based on the Coase Theorem. The main assumption in cooperative games is that the parties can make binding agreements about the distribution of payoffs without any cost and the solution will be the most desirable coalition structure for all parties involved.

However, Coase's approach goes not without problems, especially because the prerequisite of zero transaction costs is a very strict one which is often not fulfilled in real situations.[1] Moreover, the ability of parties to make a commitment upon the ex-ante agreement to share the outcome in the end is doubtful (Samuelson, 1995). In this kind of situations, the non-cooperative game theoretical approach should be taken into account. The main assumption in this approach is that the parties involved choose strategies separately to get the most desirable outcomes of bargaining for each of them. However, in this paper, we make use of the cooperative game, because we have reasons to believe that in the case of spatial planning in general and infrastructure and location development decisions in particular the parties involved will be able to make a commitment.

[1] Coase was fully aware of this, when he defined the theorem. In fact, what Coase wanted to show is the reverse of the Coase Theorem: "when transaction costs are positive it *does* matter how we have defined an attributed our property rights" (Buitelaar, 2007, 22).

3 Cooperative Bargaining Game: a brief description

In general terms, bargaining can be defined as a process to reach mutual agreement or a contract between two (or more) parties upon a choice of one specific alternative from a given set of alternatives available to them. Bargaining also involves the exchange of consideration among the parties involved. Problems in bargaining arise when the parties involved have conflicting interests over the available set of alternatives. Hence, the main issue that confronts the parties in a bargaining situation is the need to reach an agreement. A main focus of any theory of bargaining are two intertwined properties, namely efficiency and distribution. Efficiency relates to the possibility that the agreement can be reached by the parties involved after some costly delay, while distribution relates to the issue of how the gains from the outcome of the agreement are divided among the players.

Our main tool in analyzing bargaining situations is game theory, or to be specific, cooperative game theory. Game theory has been applied widely to analyze collective decisionmaking situations in which the decisionmakers involved – or, in game theoretical terms, the players – have conflicting preferences or interests (Samsura et al., 2010). It provides a bag of analytical concepts to study the situations in which the conflicting decision-makers interact. Game theory uses mathematics as its main language, although the theory itself is not necessarily mathematical (Myerson, 1991).

Games theory can be distinguished into *cooperative* and *non-cooperative* games. A game is called *cooperative* when players can make binding agreements and *non-cooperative* when there is no possibility of doing so. Cooperative games mainly deal with the situation in which groups or coalitions of players make decision together and involves allocation of benefits from cooperation. In these situations, players can gain more benefits by joining a coalition than by staying alone and playing the game on their own. In the other side, non-cooperative games deals with a situation in which players compete and make decisions independently but their strategies and outcomes of those strategies are interdependent to one another. The cooperative game is utilised in this paper because in the Netherlands, parties involved in spatial planning in general and infrastructure development decisions in particular, are generally focused on reaching commitments based on win-win/mutual agreements (see e.g. Needham, 2007).

In general, a cooperative approach deals with two aims. The first is to find out the coalition structure which gives most benefit to all players. And the second is to observe how the members of a coalition will distribute the outcome or revenues available to the coalition among themselves. In game theoretical terms this is called the *payoffs*. One of the basic questions in the cooperative approach is "*How will the payoff be distributed among the players?*" There are many solution concepts for this problem, among which is *the core* concept. A core payoff vector is a payoff distribution among the players that can not be improved by any coalition. That is, no other coalition can be formed in which the individuals gain more payoffs. Clearly, the core is a strong equilibrium concept and as such a powerful predictor for games in coalition form. Note that the core may consist of many core payoff vectors and hence need not be unique. However, there is also a possibility that a game has an empty core. In fact, any constant-sum game, in which the sum of the payoffs to the players is a constant, always has an empty core. Therefore, other solution concepts have been developed to predict the payoff distributions for this kind of game such as *stable set* and *Shapley value* (see e.g. Kahan and Rapoport, 1984; Owen, 1995; we will discuss it in more detail in the next section). Mainly, cooperative game theory uses the *characteristic function form* as its descriptive frameworks. In *characteristic function form*, a game is given as a pair *(N,v)*, where *N* denotes a set of players and $v: 2^N \rightarrow \mathbf{R}$ is a characteristic function in which a value is assigned to each coalition (called the value of the coalition). The basic idea in coalition making is that each player can gain more payoffs; hence arrive at a better outcome, by forming or joining a coalition.

In the case of value capturing implementation, cooperative game theory is applied to analyse the situation in which infrastructure developers and location developers agree to cooperate in pursuing their development goals by forming a joint venture, but it is still not clear for them how they are going to cooperate. Value capturing implementation in the form of distribution of increment value is one of the considerations that all the parties involved will take into account in deciding the form of cooperation. Therefore, this formulation will reflect the bargaining situation among the parties involved in the infrastructure and location development process, especially in relation to how they are going to divide the increment land and property value when they want to make a partnership or a joint venture.

Nevertheless, like any modelling exercise, inescapably, game theoretical modelling indeed implies a simplification and abstraction from the real world. Moreover, the game theory approach is usually claimed to be too abstract and its underlying assumptions are too unrealistic, including complete information, rational behaviour of players, and the unitary character of players. One might claim that these assumptions are violated in real-life situation. With regard to complete knowledge, stakeholders might not know exactly in which game they are playing and moreover, they might lack information on the preferences of their opponents. The assumption of rationality has also met criticisms. First, are stakeholders able to make a consistent ranking of their preference? And secondly, if stakeholders are capable of defining their preferences, do they indeed act in an optimal way? Another question is whether stakeholders are indeed unitary actors, or whether they them selves are a collection of decision making actors who cannot speak with one voice. Several authors have discussed problems with these assumptions (see e.g. Aumann, 1990; Hargreaves-Heap & Varoufakis, 2004). Also, experimental evidence shows how people might make different choices than theory would predict (e.g. Goeree & Holt, 2001; Plous 1993).

Despite of above argument, as discussed by Aumann (1985), the assumptions in game theory should not be attacked, but instead the theorems and conclusion resulting from the modelling. A complete rejection of the assumptions in game theory is indeed not useful, but repairing several assumptions in particular setting of the game can make the theory better applicable and more relevant. In addition, game theory has been capable of developing more realistic solutions in the last decades for several of the assumptions that are discussed above (Camerer, 1991; Goeree & Holt, 2001). Incomplete information has been modelled in Bayesian games (Harsanyi, 1967). Myerson (1998) developed a general theory of cooperation under uncertainty and Aumann and Mascheler (1995) also worked on the issue of incomplete information. A reply to the rationality assumption has been the idea of bounded rationality (Simon, 1978). Although no formal version of Simon's idea has been developed, Aumann

(1997) reviews some of the approaches game theory has used to deal with rationality, such as evolutionary dynamics and the use of computer simulations.

Here in this study however, we stick to the more traditional game-theoretical methods with the underlying expected utility maximising model and rational behaviour. The advantage of this approach is that it structures the situations to be studied in a simple and clear way. As a first step, it therefore raises insight into the decision problems at stake which in a later stage may be refined and extended into a more sophisticated or realistic model. As we shall see, even the classical methodology of game theory creates useful insights into the case of value capturing implementation.

4 Spatial Development Process and Value Capturing in the Netherlands

From a policy perspective, the main concern of this paper is with the possibilities for value capturing in cases that the development of infrastructure is integrated with property development. In those cases, it is assumed that the property developers benefit financially from the increased accessibility of the location as a result of the public investments in infrastructure: end users (companies or households that will buy or rent the property) will accept higher prices or rents, because they prefer locations with high accessibility. On the other hand, the public authorities that are responsible for the infrastructure development are often confronted with substantial gaps in the available public budgets for infrastructure development. In such situations there seems to be room for negotiations or bargaining: when property developers benefit in financial terms from the public investments in infrastructure, it makes sense that the public sector asks the private sector for a financial contribution to the necessary investments.

The next section presents a game theoretical model focusing exactly on these negotiations for value capturing. In the present section we pay attention to the context in which those negotiations take place. What is the rationale for value capturing? How much value can be captured? And how is the development process for those integrated developments organised?

4.1 Rationale for value capturing

The Dutch national government aims to reduce mobility problems by, among other things, large public investments in new road infrastructure and public transport, but struggles to find the resources to finance these plans. To resolve the financial problems, innovative financial arrangements with respect to both road infrastructure and public transport development are being investigated. The *Raad voor Verkeer en Waterstaat* (RVW), the advisory board to the Minister of Transport, has suggested to implement improved instruments for value capturing in projects that combine large infrastructure development with location development (RVW, 2004). This proposal is supported by another influential advisory board, the VROM Raad, which advises the Minister of Spatial Planning (VROM Raad, 2004). The assumption underlying those proposals is that the public investments in infrastructure and / or public transport will improve the accessibility of (development) locations connected to the new infrastructure or public transport link which will result in higher property prices and rents (Van der Krabben et al., 2008). The RVW defines value capturing as:

'*a group of instruments that enable capturing, directly or indirectly, the increased value of land and property as a result of public investments in transport infrastructure, and to use it for financing the activities that are responsible for the increased values*'. (RVW, 2004, p. 47; translation by the authors).

It is clear that financing infrastructure projects or public transport plans would be made easier if the government body involved could capture value increases. One of the issues here is, however, what the rationale is for value capturing. For a better understanding of this issue, we refer to the distinction, made by Van der Krabben & Needham (2008), between the concepts of cost recovery, creaming off development games, and value capturing. 'Cost recovery' refers to a situation where the costs of public works in a plan area are recovered from the property owners in that area. In the Netherlands, the municipalities' legal powers for the enforcement of cost recovery have improved considerably since July 2008 through the introduction of a new Spatial Planning Act that involves new legislation on planning processes as well as on cost recovery (TK, 2008). The second concept concerns 'creaming off' the development gain (or: betterment) caused by changes in the land-use plan (in the sense of the 1942 Uthwatt Report on compensation and betterment for the UK). The supposed development gain is based on increased property values in the area. Internationally, there is much discussion on the legitimacy and the feasibility of this. The other reason why property values might increase is public works – in particular, transport infrastructure, but new open space also might have a similar effect – which enhance the value of properties near to them. In those situations, 'value capturing' may be considered. Van der Krabben & Needham (2008) state that: 'when a project includes both changing the land-use plan and improving infrastructure, it can be difficult to distinguish between the value increase caused by betterment and that caused by improved services'. In the Netherlands, both instruments for creaming off development gains and value capturing are missing. However, the contribution of property owners to the financing of plan-related costs of public works - based on cost recovery by the government body responsible for the plan - usually involves part of their development gains. And moreover, the government body involved and the property developers may still come to a voluntary agreement regarding capturing the increased value of land and property as a result of public investments in transport infrastructure.

4.2 How much value can be captured?

A substantial body of literature exists discussing value capturing. Many studies, mainly based on US-based experiences, have demonstrated the positive impact of public sector infrastructure investments on property prices (e.g. Church, 1990; Batt, 2001; Riley, 2001; Nash et al., 2001; Enoch, 2002; Rybeck, 2004). To illustrate how much value can be captured we refer to a recent study by Van der Krabben et al. (2008) in which the potential for value capturing has been calculated in Dutch station areas. For the calculations we made use of the hedonic price analysis by Debrezion et al. (2010). The value to be captured in those cases concerned the (expected) value increase of new properties in the station areas, as a result of public investments in the railway stations and the rail connections (upgrading to high speed train rail services). For each of the areas, it was estimated how high the office rents would be in the vicinity of the station both without the (new) transport infrastructure and with the new infrastructure. The difference can be attributed to the investment in transport infrastructure. These estimates were made using a property value model that was discussed extensively in Van der Krabben et al. (2008). The case study analysis for three Dutch station area redevelopment projects shows that between 15 and 20% of the rents for office space in the vicinity of a railway station can be ascribed to the accessibility by public transport (table 1). It means that in the case of a new railway or light rail station, the infrastructure developer could in principle claim 15 to 20% of the values of the properties that will be developed in the station area.

Table 1: Increase in office rents, based on estimations from the property value model (in million)

	Office rents in station areas		
	Breda	*Arnhem*	*Schiedam*
Present situation (without positive impact station area)* Annual office rents per m^2	€ 181.52	€ 178.91	€ 205.14
Present situation (before station area redevelopment) * Annual office rents per m^2	€ 208.39 (+14.8%)	€ 208.79 (+16.7%)	€ 240.22 (+17.1%)
Improved situation (after station area redevelopment) Annual office rents per m^2	€ 210.56 (+16.0%)	€ 210.04 (+17.4%)	€ 240.83 (+17.4%)

Source: Van der Krabben et al. (2008)

* *The rents predicted by the model under 'present situation' are not necessarily equal to the actual rents in the 'present situation', due to the fact that the variables related to the characteristics of the building / tenant are left aside. This means that the model predicts rents for 'average' office space, specified for the locations involved.*

4.3 Development model

Finally, the (outcome) of negotiation processes about value capturing will depend on both the project type and the development model that has been applied to the integrated development of both new infrastructure and property. We distinguish two project types: line infrastructure development (for instance, a new motorway combined with the development of industrial estates near the motorway) and node development (for instance, station area development combined with public transport development). Usually a national (or provincial) government body is responsible for the infrastructure development, while municipalities together with property developers take care of the location development. Until recently, separated financial schemes were used for both the infrastructure and the location development project. Consequently, the national government body responsible for the infrastructure development did not negotiate with the location developers for a financial contribution.

So, until recently the national infrastructure developer used to have almost no bargaining powers to negotiate about value capturing. However, the above mentioned introduction of a new Spatial Planning Act in 2008 also changed this status quo. Under the former Spatial Planning Act, provincial and national government bodies were not allowed to develop land use plans, which led to the situation that has been explained above (municipalities were responsible for location development). Under the new Spatial Planning Act, however, national and provincial government bodies may develop land use plans and can decide to take charge of the location development as well. It is assumed that national and provincial government bodies will make use of this right in case of supra-local projects (like line infrastructure projects). This will bring them in a much better position to negotiate directly with the location developers for value capturing.

5 Bargaining Game for Value Capturing

The bargaining game presented in this paper models part of the decision-making process with regard to the integrated development of both new infrastructure and property, in the Dutch planning context (under the new Spatial Planning Act).[2] The part of the decision-making process that will be simulated in our game concerns the negotiations about value capturing between the infrastructure developer (usually a government institution) and the property developer(s). The model excludes other parts of the decision-making process, including decisions regarding for instance location choice, the desired accessibility profile of the location, the real estate programme and the partnership construction.

5.1 Cooperative Game Model

As mentioned earlier, in this study, we have restricted ourselves to the analysis of a game in cooperative approach, more specifically, in characteristic function form, in analyzing the bargaining process regarding the implementation of value capturing as well as its solution concept. By applying this approach we aim to analyse the bargaining process between the infrastructure developer and the location developer, assuming that there is an increment value of land and properties caused by the development of infrastructure to be captured. The solution concept for the game is utilised to find the equilibrium for the payoffs disbursement, i.e. the distribution of the increment value among players involved. This will allow us to analyse the amount of increment value that can be captured by the infrastructure development from the bargaining process. In this experimental game, we consider a situation with three players: one Infrastructure Developer (ID) and two Location Developers (LD1 and LD2). This provides us with a basic situation for analyzing the games with multiple players which are often called as n-person games (Luce & Raiffa, 1957). These three players bargain to form a deal about the contribution of the location developers to financing the costs of the infrastructure development. The deal is, in game theoretical terms, to agree on how to divide the outcome of a coalition.

[2] The national planning context probably influences for a great deal the outcome of the bargaining processes. When we would model a similar bargaining game for instance within the context of the British planning system, the outcome would be influenced by the concept of planning obligation in the Town and Country Planning Act. The concept of planning obligation means that the local authority grants permission only if the developer pays for related works, like infrastructure and open spaces (Cullingworth & Nadin, 2002).

The game is based on a number of assumptions regarding the strategies of the players, their bargaining powers and the planning context. Those assumptions are mainly derived from development practice in the Netherlands, as explained in the previous section.

1) First, we assume that there is no institutional restriction for the infrastructure developer to capture the increment land value throughout the formation of a joint venture or coalition with the location developer(s). This is related to the new legal powers for national and provincial government bodies to develop land use plans under the new Spatial Planning Act. On the other hand, the infrastructure developer does have legal powers for the enforcement of cost recovery, but does not possess any legal powers to enforce value capturing. It is assumed that full cost recovery takes place, but that the development gains for the location developers exceed the costs that are recovered.
2) The second assumption is that the existing land use plan allows both the planned infrastructure and planned location development project.
3) The infrastructure developer holds the land for infrastructure development; the location developers own all the land that is available for location development. It implies that land owners are not involved in the game.[3] And, since the infrastructure developer will be responsible for the land use plan, the municipality is also not involved in the game.
4) In the game we distinguish between situations in which the bargaining process takes place before the infrastructure development process has actually started and situations in which bargaining starts after the infrastructure has been developed (see below).
5) The game concerns new infrastructure development, because the increment land and property values will be more substantial in this kind of projects compared with projects intended to improve the existing infrastructure.
6) In line with the empirical evidence of the amount of value that can be captured in station area development projects we found in Van der Krabben *et al.* (2008), we assume in our game that the development of new infrastructure will increase land and property values by 20%. In our hypothetical situation with one ID and two LDs, the LDs aim to develop 100 units of properties. For the sake of illustration, one unit is worth of € 1000. *Ceteris paribus*, the value of each LD's properties will be € 100,000 without the infrastructure, while the development of the infrastructure will give an increment value and add as much as € 20,000 to the value of its properties. The bargaining process focuses on how to divide these outcomes among the three players involved.
7) It is also assumed, in addition to the previous point, that location development will still be profitable, in case the maximum of € 120,000 will be captured (in that case: profit will be low, but still acceptable for the location developer).
8) The costs of the infrastructure and commercial development are left outside the game, because they are not part of the bargaining process. We assume, however, that for ID, capturing (part of) the increment value would add substantially to financing the project, while for LDs, providing (part of) the increment value would still leave their commercial developments profitable, but would seriously affect the profitability of those developments.

[3] A different game can be played when the game starts at an earlier point in time, before the location developers had acquired the land. In that case, the (original) landowners should be involved in the game as well. However, in Dutch planning practice, the bargaining about value capturing will usually take place between ID en LD's

9) It is assumed that free rider behaviour will give no benefit to any player.
10) Finally, like in any kind of game in game theory, the solution for this game will be focused on the determination of the outcome which can be expected to occur if the game is played by rational players.

In cooperative games, the concept of rationality diverges into *individual rationality* and *collective rationality*. The concept of individual rationality implies that a player in a coalition will not accept any payoffs less than what he could obtain if he acts alone or without forming any coalition with anyone and without making any bargaining at all. Formally, this concept is given by the inequality:

$$x_i \geq v(i) \quad (i = players\ involved = 1, 2, \ldots, n) \tag{5.1}$$

The concept of group rationality, on the other hand, implies that no subset of players should get less than they can get by joining a coalition or in a formal way:

$$v(S) \leq \sum_{i \in S} x_i \quad for\ all\ S \quad (S = coalition) \tag{5.2}$$

We also might say:

$$\sum_{i=1}^{n} x_i = v(N) \quad (N = grand\ coalition) \tag{5.3}$$

When these two rationalities apply, or in another words, those three equations are fulfilled in a set of payoff structure, then that particular payoff structure is called the core of the game: the equilibrium of the coalition. The core is a very appealing solution concept because it is relatively easy to apply.

As mentioned earlier, the core of the game might be empty. Basically, the non-emptiness of the core can be investigated from the characteristic function of the game. As discussed by Kahan & Rapoport (1984), for N = 1, 2, 3, the core is not empty only if $v(123) \geq {}^1/_2[v(12) + v(13) + v(23)]$. Furthermore, this condition also implies that the game must be superadditive and the core will always be found in the coalition structure {123} or the grand coalition. The core solutions for the grand coalition can also be visualized in a geometrical representation (see below).

For this game, we consider three situations in which the players can form a coalition:
1) ID will build the infrastructure only if it can form a coalition with LD. Along with that, LD will not be able to build the land and properties if there is no infrastructure to be built by ID. The bargaining process is assumed to take place before the infrastructure development process has started.
2) Similar to situation 1, ID will only build the infrastructure if it is able to form a coalition with LD. However, unlike in situation 1, LDs are able to develop the land and properties even if the infrastructure is not provided by ID. However, the new infrastructure will increase the value of LD's land and properties. In this situation, the bargaining process is also assumed to take place before the development process has started.

3) ID is able to build the infrastructure without making any coalition with LD. However, a coalition would provide more benefit to ID. In this situation, the bargaining process will take place after the infrastructure has been developed.

Based on the assumptions and concepts above, we are able to analyze now the bargaining process in the implementation of value capturing, for each situation where ID, LD1 and LD2 can form a coalition. Each location development can create a value of € 100,000 (without infrastructure development) or € 120,000 (with infrastructure development). Infrastructure development can also create a value of € 20,000, without location development. The costs of the infrastructure and location development are left outside the game, because they are not part of the bargaining process.

5.1.1 The game for situation 1

Under the first situation, no player alone can realize a profit, so $v(\text{ID}) = v(\text{LD1}) = v(\text{LD2}) = 0$. ID and LD1 together will create a value of € 120,000 if they form a coalition, because LD1 can create € 100,000 and the extra € 20,000 will be added to it as the increment value caused by the infrastructure development. It will be also the case for a coalition between ID and LD2. However, the coalition between LD1 and LD2 alone will be worth nothing, because both developers cannot build their land and properties if the infrastructure is not provided. The grand coalition, consisting of ID, LD1 and LD2, will create a value of € 240,000, because LD1 and LD2 will each create € 100,000, while for both of them € 20,000 will be added because of the infrastructure development. For ID = 1; LD1= 2, and LD2 = 3, we summarized this information by the characteristic function:

$$\left\{ \begin{array}{l} v(1) = v(2) = v(3) = 0; \\ v(12) = v(13) = 120{,}000; \\ v(23) = 0; \\ v(123) = 240{,}000 \end{array} \right\}$$

In this game, there are several payoff divisions which satisfy both individual and group rationality, i.e. the core. One such division is (80,000; 80,000; 80,000). We can see in this structure that ID, LD1 and LD2 get more than they would have received if they would have acted alone. Therefore, it satisfies the individual rationality. It is also obvious that in this payoff structure, each pair gets more than they would have received in a coalition and all three get as much as they can in this game, which means that the requirement for group rationality has been fulfilled. However, this payoff structure is not the only one that satisfies the two concepts of rationality. Figure 5.1 shows all the cores of the game for the first situation.

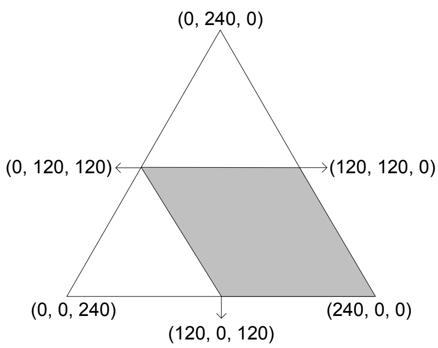

Figure 5.1: The core of the game for situation 1

Figure 5.1 shows that the core payoffs (all points in the shaded area) are within a convex polygon bounded by 4 points: (120, 120, 0); (120, 0, 120); (0, 120, 120); and (240, 0, 0)[4].

Although these boundary points satisfy the two concepts of rationality and hence can be considered as the core, these particular payoff structures may still seem to be unfair. The fact that the core in this situation might not be unique and fair makes it difficult to apply as a predictive tool. The best outcome of the game would be to find a solution concept that predicts a unique expected payoff allocation for the players. Shapley (1953) approached this problem axiomatically. He was looking for properties we might expect to satisfy such a solution concept. For that purpose, he characterized the mappings φ that satisfy these properties.

In the game, assuming the players to be rational, the players can foresee that the grand coalition will eventually form, since all three players can get more by working together than in any partition into a separate coalition. The question that each player is then considering, is how to bargain as the grand coalition will be formed.

In this game, suppose ID approaches LD1 with the proposition to form a coalition. At the most, ID could ask 120,000 from LD1, because the joint venture between ID and LD1 will exceed LD1's prospects when acting alone (LD1 gets nothing if it acts alone). It will be the same if ID approaches LD2. Of course, ID cannot expect that LD1 or LD2 will immediately agree to this proposition. In fact, the same proposition can also be brought forward by LD1 to ID or LD2 to ID. The other possibility for ID is to approach LD1 and LD2 together at the same time. ID could ask, at the most, 240,000, because the coalition of LD1 and LD2 only would get nothing at all. Therefore, ID is worth 240,000 to them as the third member of the coalition. Here we can see that the players' bargaining power depends on which coalition he or she is about to join.

To generalize the situation, let us suppose that the grand coalition will eventually be formed by increasing from one to two to three members. Without any specific information on the order in which the members will join, let us suppose that all orders are equal. Therefore, the following orders of joining may arise with the probabilities as noted:

(ID, LD1, LD2) with probability 1/6
(ID, LD2, LD1) with probability 1/6
(LD1, ID, LD2) with probability 1/6
(LD1, LD2, ID) with probability 1/6
(LD2, ID, LD1) with probability 1/6
(LD2, LD1, ID) with probability 1/6

It is clear that each player – when he took the initiative - was not approached by anyone in two of the six circumstances. In that case, the value will be zero. Therefore, with a probability of 1/6 + 1/6 = 1/3, each player can expect to get 0. Let us continue to analyze ID. With a probability of 1/6, ID can expect to get 120,000 from LD1 or from LD2. Then there are two circumstances that ID is approached by the coalition of

[4] To calculate the boundary points, consult Kahan & Rapoport (1984)

LD1 and LD2. In this case, with the probability of 1/3, ID can expect to receive 240,000. In sum, ID's expected prospect is:

$$\varphi_{ID} = 1/3*0 + 1/6*120{,}000 + 1/6*120{,}000 + 1/3*240{,}000 = 120{,}000$$

This expectation is called the *Shapley value* of the games to ID. This value does not only represent the expectation, but also the bargaining power of ID in the coalition. In general, by designating the Shapley values by φ_i (in which i is the players involved) and for ID = 1; LD1= 2, and LD2 = 3, we have:

$$\varphi_1 = \tfrac{1}{3}[v(123)] - [v(23)] + \tfrac{1}{6}[v(12)] - [v(2)] + \tfrac{1}{6}[v(13)] - [v(3)] + \tfrac{1}{3}[v(1)] - [v(\emptyset)] \quad (5.4)$$

$$\varphi_2 = \tfrac{1}{3}[v(123)] - [v(13)] + \tfrac{1}{6}[v(12)] - [v(1)] + \tfrac{1}{6}[v(23)] - [v(3)] + \tfrac{1}{3}[v(2)] - [v(\emptyset)] \quad (5.5)$$

$$\varphi_3 = \tfrac{1}{3}[v(123)] - [v(12)] + \tfrac{1}{6}[v(13)] - [v(1)] + \tfrac{1}{6}[v(23)] - [v(2)] + \tfrac{1}{3}[v(3)] - [v(\emptyset)] \quad (5.6)$$

We can calculate then the expected prospects of LD1 and LD2:

$\varphi_{LD1} = 60{,}000$

$\varphi_{LD2} = 60{,}000$

It is obvious that the summation of the expected prospects of all players is equal to the value of the grand coalition.

5.1.2 The game for situation 2

In situation 2, ID alone cannot build the infrastructure and create any profit, while LD1 and LD2 still can develop their land and property and create € 100,000 each if they act alone. Like in the first situation, if either LD1 or LD2 agrees to create a coalition with ID, the pair (LD1,ID or LD2,ID) will create a value of € 120,000, because the infrastructure will then be developed creating an extra value of € 20,000 for LD1's or LD2's initial value. However, unlike in the first situation, here the coalition between LD1 and LD2 will create a value of € 200,000 because it will combine their initial value. The value of the grand coalition will be the same as in the first situation, because it will combine the value of the coalition of ID and LD1 and also ID and LD2. Then, for ID = 1, LD1= 2 and LD2 = 3; this information can be summarized by the characteristic function as follows:

$$\left\{ \begin{array}{l} v(1) = 0; \\ v(2) = v(3) = 100{,}000; \\ v(12) = v(13) = 120{,}000; \\ v(23) = 200{,}000; \\ v(123) = 240{,}000 \end{array} \right\}$$

Using the same method that has been applied for the first situation, we can also conclude that the core for the game in the second situation is non-empty and it can be drawn using the geometrical representation as shown in figure 5.2.

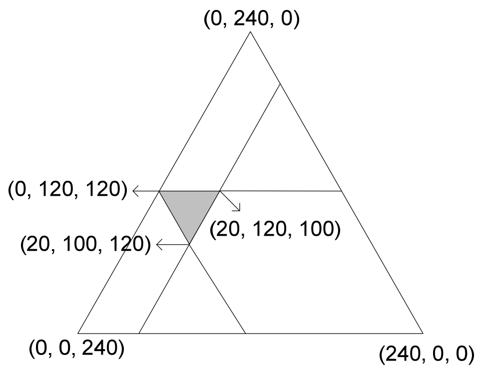

Figure 5.2: The core of the game for situation 2

Here we found that the core is lying within a convex polygon bounded by 3 points: (0, 120, 120); (20, 120, 100); and (20, 100, 120). Similar to situation 1, these core structures also seem to be unfair. Therefore, again we look for the solution concept that predicts a fair and unique expected payoff allocation for the players, i.e. the Shapley value. Using the equation (5.4), (5.5), and (5.6) we can find the Shapely Values for ID, LD1 and LD2 in situation 2. They are:

φ_{ID} = 20,000
φ_{LD1} = 110,000
φ_{LD2} = 110,000

5.1.3 The game for situation 3

In situation 3, ID can build the infrastructure without making any coalition with LD1 or LD2. Then, when ID develops the infrastructure alone, this development will increase the value of LD's land and property 'automatically' by 20%. Using the same figures as in the first and second situation, both LD1 and LD2 will have a value of € 120,000 due to this development. Suppose ID and LD1 agree to form a coalition. The value they create will also be € 120,000 because there is no additional values brought into the coalition by ID due to the fact that they has already been delivered to LD1. The coalition of ID and LD2, consequently, will also give the same outcome. While the coalition of LD1 and LD2, in this situation, will create a value of € 240,000, as the summation of their initial values. And the grand coalition will also create a value of € 240,000, again because ID gives no additional value to the coalition. This information can be summarized by the characteristic function as follows for ID = 1; LD1= 2, and LD2 = 3:

$$\left\{ \begin{array}{l} v(1) = 0; \\ v(2) = v(3) = 120{,}000; \\ v(12) = v(13) = 120{,}000; \\ v(23) = 240{,}0000; \\ v(123) = 240{,}000 \end{array} \right\}$$

Unlike in the first and the second situation, we found here that the core is in a single point (0, 120, 120). The geometrical representation of this core is given in figure 5.3.

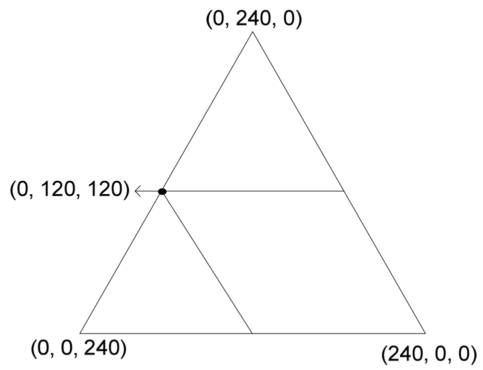

Figure 5.3: The core of the game for situation 3

Interestingly, using the analysis of Shapley value, we also found the same result:

$\varphi_{ID} = 0$
$\varphi_{LD1} = 120{,}000$
$\varphi_{LD2} = 120{,}000$

5.2 Discussion

Based on the analysis of the bargaining process for capturing increment land value as performed above, we found three different outcomes for three different situations in which the players can form a coalition. Based on these outcomes we can investigate how much value can be captured, if the players involved can bargain to divide the increment value of land and property within the process of coalition formation. In situation 1, the Infrastructure Developer could obtain € 120,000 based on its bargaining power. It means that the value that can be captured by Infrastructure Developer is more than the increment value it creates from the development of the infrastructure. Using our experimental figures, the increment value caused by the infrastructure development for one Location Developer is € 20,000. Since in our experimental game there are two Location Developers, the total increment land and properties value will be € 40,000. The Infrastructure Developer might be able to obtain € 120,000, because its bargaining power is very strong in this situation due to the fact that the Location Developer cannot develop its land unless the infrastructure is developed. Therefore, the increment value of a Location Developer's land and property caused by the Infrastructure Development in this situation, actually, is not € 20,000 but € 120,000.

In situation 2, the Infrastructure Development can expect of € 20,000 from the bargaining process in the coalition formation with Location Developers. It means that the value to be captured by the Infrastructure Development is lower than the total increment values it creates. Here the bargaining power of the Infrastructure Development is not as strong as in the previous situation, because the Location Developer still can develop its land even if the Infrastructure Development does not build the infrastructure.

And for situation 3, the bargaining power of the Infrastructure Developer is even lower than in the second situation. The expected payoff in forming a coalition is zero for the Infrastructure Developer. This situation can be explained as follows: The fact that the Infrastructure Developer can build the infrastructure without forming a coalition with the Location Developer makes the option of forming a coalition unattractive for the Location Developer. The reason for this is that the Location Developer can get the increment value without forming a coalition with the Infrastructure Developer because the infrastructure that brings the increment value to Location Developer' land and properties can be built by the Infrastructure Developer alone. Based on the concept of rationality, forming a coalition is only attractive if it brings added values for the coalition member. In this case, the attractiveness of forming a coalition is related to the possibility of acquiring the increment land and property value. Therefore, in this situation, the Infrastructure Developer has no bargaining power, because there is no added value for the Location Developers to form a coalition with the Infrastructure Developer. The coalition that will be formed then will have a payoff distribution that is exactly similar to the initial value of its member.

From the analysis, we learned that the equilibrium amount of increment value caused by infrastructure development that can be captured is varied from one situation to another. Therefore, the policy of value capturing that endorse the Infrastructure Developer to recoup the amount of increment land and property values as it is, without any consideration regarding the situation in which the infrastructure development process interacts with the land development process, will be problematic because it may result in the inefficiency of resource allocation.

6 Conclusions

In this paper we analysed the bargaining process between the infrastructure developer and the location developer(s) regarding the implementation of value capturing, by making use of a cooperative game theory approach. We have argued that bargaining is a 'natural process' to solve problems of externalities. We have also brought forward that, like in everyday life, bargaining quite often plays a decisive role in decision-making processes for spatial development. The outcome depends of course to a large extent on the institutional planning context in which those decisions are made. Negotiations about contributions to plan-related costs, creaming off development gains and value capturing almost always involve a process of bargaining. Modelling those bargaining processes may help to improve our understanding of the outcome of it. In this paper we aimed to demonstrate the usefulness of game theoretical modelling for this purpose.

The games show how game theory can be used to increase our understanding of bargaining processes. We found from the analysis that the amount of increment land and property values caused by the infrastructure development, that can be captured from the bargaining process, varies. This is due to the situation or context in which the players can form a coalition which will affect the bargaining power of the players involved. We also found from the analysis that the Infrastructure Developers' bargaining power is stronger when the Location Developer is dependent on the infrastructure to be built and also when the decision to build the infrastructure can only be taken by the Infrastructure Developer if the Location Developer agrees to cooperate beforehand. Our advice to the Infrastructure Developer in the game would be to wait with infrastructure development until (one of) the Location Developers is willing to make a coalition. To convince the Location Developers to form a coalition, it will help when the success (or: profitability) of the location development heavily depends on the infrastructure development (for example, in case of the development of a new transport node). Contrarily, our advice to the Location Developers would be to start location development (and even acquiring land) only after the infrastructure has been completed (though they probably would have to pay more for the land). The recent changes in Dutch planning law and the possibility for the national government body that is responsible for the infrastructure development to develop its own plans and enter the negotiations about value capturing directly – as we did in our game – is believed to influence the (outcome of the) bargaining process. Because the experiences with the new planning law and the changing roles for national and provincial government bodies are still very limited, we do not know yet how the status quo will change.

We are aware of the analytical problems of this approach. Since every model is a simplification of the real world, its reliability depends on basic assumptions that are used as the basis for its construction. In the games that we have constructed in this article we have assumed that the transaction costs of the bargaining process and the coalition process are zero. We referred to the Coase theorem to explain that a situation of zero transactions costs can not easily be fulfilled in the real world. Therefore, the next step for this research should be an analysis that takes transaction costs in forming a coalition into account. It means that we must bring in the *institutional context* into the model, which is in fact the argument made by Coase. We believe that – as the next steps in the construction of the model – at least part of this complexity can be brought into the model. Second, the figures regarding the value of the coalition still should be validated empirically, although we use the results of earlier studies to draw those experimental figures. This can be done as well, for instance by surveys amongst all stakeholders. Moreover, the outcomes of the games and the equilibriums that we have found must be tested. For this purpose, the games can be 'played' in a laboratory situation by real stakeholders. Another aspect that must be analyzed is, in the case of value capturing, the impact of the 'captured value' on both the financial budgets of the infrastructure developer and the location developers. In our game, the profits of the location developers will drop with 20%, which is quite substantial. However, in case of a major infrastructure development, the value captured most likely only adds a small percentage to the financing scheme of the infrastructure developers. Finally, the model we developed in this study does not take into account the possibility of free-rider problem. Here we consider that free rider behaviour gives no benefit to all players involved. The reality may not be like that. However, in the case where the free rider problem may occur, the model can be extend into what so called as *partition function form* which is the generalization of the *characteristic function form* that we employed in this study.

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