Strategic Decision Modeling in Brownfield Redevelopment

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Preface

This thesis grew out of the PhD research project that lasted for a bit more than four years. I have started this project as a PhD candidate in February 2008, within the group that is now named the Real Estate Management and Urban Development Group. In this period, I had to overcome many difficulties, a common thing that would any PhD candidate say. For sure, what remained over that time are many small successes that became even more valuable.

One of the challenges that became a pleasure was the start-up of this research project. Before starting the project, I was involved in writing the PhD proposal together with my supervisors. Although my role was a minor, still it was quite of a challenge to formulate the problem and find a way to address it in a proper research design. The pleasure was to see how the initial idea starts having more and more shape and finely comes with this thesis under the title Strategic Decision Modeling in Brownfield Redevelopment.

In general, the urban development process is characterized by both physical and social complexities. To be able to understand better their impact and interdependences, this thesis employs the strategic choice modeling. Here the strategic implies using the game theory and the choice modeling as being a part of a big branch of random utility theory. On the other hand, a brownfield constitute an interesting playing ground for understanding the urban development processes. At the same time, they make up the largest challenge in city re-development. I found it important and very challenging to spend my PhD thesis on this topic. Finishing it, would not be possible without the people that helped me.

First, I would like to thank to Wim Schaefer, my first promoter. He made it possible to start and finish this thesis. Moreover, for giving me an opportunity to be a part of the research group. I learned a lot from your guide. Above all is how to manage

the research on all the possible levels. Many thanks goes to Bauke de Vries my second promoter for showing a much of interest in this research and even more for trusting in it.

As I already said, I was involved in writing an initial research proposal that finally brought this thesis to the surface. At that stage, Gordon Brown took a part as well. He inspired my to go for the research path and even more supported me at the very first beginnings. Although, not involved in the realization of the project, I am happy that I can say to you that I finished it.

Qi Han started to be my co-promoter around two years after the start of the PhD project. At that time, I was a bit behind the schedule, but everything changed since then. She was my daily supervisor and we scheduled many meetings to catch up. It was a hard but pleasurable work. Thank you for your guide, and all the insights in the modeling. Above all thank you for your persistent patience, trust and kindness.

Doing a research is not just having a solution for a certain problem that I have learned from Jos Smeets. During all these years, on the weeklies although sometimes informal meetings, I was constantly pulled to think in a broader way about the societies its past and the future. I hope that I succeed to implement some of these ideas and thoughts here in the thesis. One is for sure, it will stay with me, and Jos thank you for that.

I would also like to thank to all the external committee members, namely Ingrid Janssen, Nada Lazarević-Bajec, and Erwin van der Krabben. They all gave very valuable feedback on different topics in my thesis.

Besides, I would like to thank to my colleagues, Peter and Joran for helping me with the on-line survey. To Aloys, Wim H., Leonie and Rianne for all the useful advises and comments even more for your support that was very encouraging to go through the research waters. To Ingrid, Annemiek, Linda, Mandy, Carol for their support on all of the administration that I was bothering you about.

I specially want to thank to my PhDs colleagues Erik, Dave, Oliver, Gustavo, Anna, Anastasia, Efi, Gamze, Aida, Pierre, Rubi and the others for all the barbecues, diners, drinks and the time we shared together. It was a real pleasure. Staying here in Eindhoven would not be the same if I did not met such wonderful people. I think I do not have too much to write you here besides thank you so much Mamoun, Agnese, Ozgan, Paty, Loly, George, Carlos, and many others.

Anina you were always there for me for all of the ups and downs, slides and slopes, for all the restless travelling, for understanding the times not being with you and thank you for all your love. I am really waiting that in recent time when the most of the fuzz is gone we can start truly enjoying. To my aunt and uncle, my second mom and dad, I promise that your worries are over and that I will visit you much more. Special thanks to my brother that bravely had chosen not to follow the family tradition but still

has the full understanding and support for me with all his love. Mom and dad you are the best! I really could not do it without you, love you so much.

Brano Glumac
Eindhoven, May 2012

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1 Introduction

1.1 Societal relevance of research for the brownfield redevelopment

Keeping in mind that the potential benefits of urbanization (e.g. secure land tenure) far outweigh the disadvantages, it is clear that the challenge is in learning how to exploit its possibilities (Habitat, 2003). A follow up of this statement is that each city as a complex system will be a lasting occupation for the researchers. Still, a general theoretical model that includes both physical and social complexities and their influences in an economic system is lacking (Batty, 2008; Bettencourt, et al., 2007). Therefore, this research project focuses only on the strategic decision-making in the multi-actor environment concerning the brownfield redevelopment.

Understanding a city and its growth has been studied for over a century. However, the knowledge to understand this phenomenon fully is far from reach also due to its dynamic and changing character in time (Batty, 2008; Batty & Torrens, 2005; Batty, et al., 2004). An urban environment today might be described as a complex and dynamic system in terms of both physical and socio-economical aspects. Physically, cities are regarded as complex systems that mainly grow bottom-up. Their size and shape follow well-defined scaling laws that result from intense competition for space (Batty, 1995, 2008). Beside the physical impact on the city growth, there is a strong evidence that social organization and urbanization dynamics related to the economic development and

knowledge creation consequently also influence the city growth (Bettencourt, et al., 2007). These two aspects of city's complexity influence each other directly. The possibility of making a compact model and theoretical framework that captures all influences remains elusive. A significant obstacle toward this goal is the immense diversity of human activity and organization and an enormous range of geographic factors (Bettencourt, et al., 2007).

In the late 60's (Arnstein, 1969), it was already mentioned that the concept of citizen participation in urban renewal was essential. In relation to this, the author was arguing for a substantive role for the *vow populi* in the planning and decision-making. In current urban redevelopment projects in the Netherlands, there is a growing need to observe the *vow populi*. At least by two parties, public parties as a municipality and private parties present at the market such as developers. This indicates the more complex decision-making processes as well. This insight on the process complexity asks for a shift in planning approach, because the traditional – rational – planning approaches can only be successful in coherent situations in which consensus on values in society exists (Veneris, 1993). This is a very rare case in current spatial planning in which most tasks involve dealing with conflicts, often resulting from differing interests (Golobic & Marusic, 2007). Therefore, a shift was proposed towards a more collaborative and participative planning approach. Among others, authors (Forester, 1987, 1989; Healey, 1991, 1992, 1998; Healey & Barrett, 1990; Innes & Booher, 1999) emphasized the need for increasing the role of communication, collaboration and interaction in planning practices, aiming for a better consensus in development processes.

This resulted in a search for the scientific methods and tools enabling planners to support actors' decision-making at the level of both content and context. In recent years, the potential use of group dynamic techniques has been explored extensively, resulting in the application of several techniques: visualization techniques (e.g. Al-Kodmany, 1999; Alshuwaikhat & Nkwenti, 2002), GIS-applications (Ceccato & Snickars, 2000; Peng, 2001; Rinner, 2001), Group Decision Support Systems (I. Mayer & de Jong, 2004), Planning Support Systems (Geertman & Stillwell, 2004), Multi-Agent Systems (Arentze & Timmermans, 2003) and Simulation Gaming (Mayer, et al., 2005). The development of alternative solutions (plan proposals) stands central in the majority of these techniques. To be able to construct viable alternatives, an insight is needed in the preference and choice behavior of involved actors.

However, the construction of alternative plan proposals within these models is a relative unstructured process. Little work has been done to develop models that systematically relate the characteristics of the brownfield areas to the behavior of actors thereby the insight in the actors' most important points of interest and possible sources of conflicts is still missing. The outcomes of this research address these missing issues.

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In addition, the outcomes contribute to the further development of methods, models, and negotiation support systems in multi-actor environment.

1.2   Research objectives

Previous remarks toward the urban complexities need to be reduced for the purpose of conducting research.

At first, the manageable representation of urbanity is captured by the concept of attributes. In broad sense, attributes represent valuable urban planning content or factors in an urban area, which are interpolated and have different values in cities complex systems. This research specifically addresses the most relevant attributes in brownfield redevelopment process.

Another important element of urban complexity, societal dynamics, is viewed from the position of various actors with their goals, tasks, visions, and partnerships. Interaction between the actors characterizes all urban development processes and, therefore, the brownfield redevelopment as well. To model the interaction within these processes is challenging and this is crucial research objective.

As noted previously, there is a logic and intuitive relationship between actors and attributes. This relationship defines an important research objective to investigate how actors respond to attributes in the context of brownfield redevelopment processes.

Finally, understanding all together the characteristics of brownfield redevelopment tasks in relation to main actor's preferences and their interaction in decision-making will benefit a wide variety of interest groups in the society. In this regard, research objective is to deliver a decision support tool that can be employed both in public policy making and for a strategy choice of a private party. In addition, such a tool will stimulate understanding the complex (re)development tasks of urban areas.

1.3   How to read this thesis

This thesis consists of eleven chapters that address the previous objectives.

Chapters 2 and 3 address the state of the art of the research. Chapter 2 explains the context of the research topics, namely the brownfield redevelopment and multi-actor decision-making. By means of a literature review, this chapter provides an insight in these two research fields and reports on their intersection. Chapter 3 narrows down the field of research elaborated in previous chapter resulting in the thesis' research problem delineation, targets and questions of stagnation in brownfield redevelopment.

Chapters 4 and 5 elaborate on the research methodology. Chapter 4 provides an overview of the methods and background theories that are used to address the previous research targets. Namely, these are the fuzzy Delphi method, discrete choice modeling and game theory. In chapter 5, a reader can find the research concept in general. In other words, a reader can understand how previously mentioned methods were implemented

and which method was used to address a certain research question. In addition, this chapter pictures the start and the end of whole research procedure, its data input/output, processes, reports and decisions all together regarded as a hybrid model.

Chapters 6, 7, 8, 9 and 10 all report on the conducted experiments and their results. Each of these chapters addresses one research question (except chapters 8 and 9) and uses a different method that is also compatible with others. Chapter 6 reports on the most important attributes in brownfield redevelopment and which are the prominent actor groups. In order to derive the list of attributes, this research employs the fuzzy Delphi method. Chapter 7 addresses the second research question and investigates what are the sub groups and their underling preference toward the redevelopment of a generic brownfield area. For this experiment, a discrete choice model or, more specifically, a latent class model is employed. Chapter 8 and chapter 9 both address the third research question about the interaction effect in decision-making process. First, chapter 8 describes the negotiation environment through a game theoretical prism. For this purpose, a game experiment is set to develop and validate two specific games for brownfield negotiations. Secondly, chapter 9 delivers two strategic choice models for two games: an ultimatum and a bargaining game. Chapter 10 discuses the fourth research question. It provides the possible scenarios for negotiation outcomes or future policies.

Finally, chapter 11 summarizes this research, discusses the proposed modeling approach and its implementation in practice today and in the future.

2 Interactions in brownfield redevelopment

2.1 Introduction

Interactions in brownfield redevelopment (BR) are reflections of actors' actions in brownfield development processes and their reactions to other present actors. This postulate demands identifying brownfield redevelopment characteristics and present actors. Therefore follows the investigation of the relevant decision-making approaches.

A brownfield redevelopment mostly occurs in regions that lack the greenfields. Satisfying the demand for the urban land can be addressed (e.g. redevelopment) without expanding into the greenfield. However, to do this, regional representatives needs to be aware of redevelopment benefits. In any case, the capacity to redevelop is mandatory. That is not an easy task. The complexity of a brownfield redevelopment results from various physical, legal and financial issues underlining the involvement of numerous parties on various levels.

Several important changes have influenced the urban planning and redevelopment processes in the last decade. At first, the scope and scale of urban redevelopment projects increased (Kristen R. Yount & Meyer, 1999). Secondly, a traditional linear planning process from the government to the building industries has been replaced by public-private collaborations. This has changed the characteristics of the developer and

municipality. Their interactive involvement play now the major influence in the urban development processes (Brail, 2008).

The interdependence between the mentioned actor groups emphasizes the necessity to collaborate in order to achieve results. This demands new approaches to conceptualize mutual relations by giving attention to mechanisms that coordinate and integrate actors to extent that promote cooperation. Because of that, many scholars showed an interest in the application of the network steering in urban development projects providing a new stream in literature (e.g. Agranoff & McGuire, 2001; Albrechts & Lievois, 2004; Burger, et al., 2008; Swyngedouw, et al., 2002; van Bortel & Elsinga, 2007).

This resulted in a search for scientific methods and tools enabling planners to support actors' participative decision-making (e.g. Tam & Thomas, 2011; Tam, et al., 2009). However, the influence of the distributional power, hierarchy, and conflict have been relatively neglected in the recent process models, although it is still a key component when studying the relation between actors involved in urban development (Minnery, 2007). There have been a very few attempt to analyze systematically how a relational aspect plays a role in a multi-actor decision-making. Analyses of the structures and processes of urban development projects will be effective only to the extent that they recognize the roles of both cooperation and conflict (e.g. Routledge, 2010).

2.2 Brownfield redevelopment challenges

One of the biggest challenges in European urbanization is the redevelopment of the brownfield. For instance, in the Netherlands approximately 35% (27,500 hectares) of the industrial areas (Schuddeboom, et al., 2007), the most spread type of the brownfield (Alker, et al., 2000), are obsolete (Schuddeboom, et al., 2007). As an additional European example, there are 128,000 identified hectares in Germany, going up to the figures of 800,000 and 900,000 hectares respectively within Poland and Romania (Oliver, et al., 2005).

Numerous authors (e.g. Chen, et al., 2009; Robin Ganser & Williams, 2007; NRTEE, 2003) argue that the restoration and redevelopment of a brownfield can provide a range of economic, social, and environmental benefits. Leaving them unmanaged brings the losses of the economic opportunities to the community in which they are present. Some of the benefits are better environment quality, provision of land for housing or commercial purposes, creation of employment opportunities, and especially the reduction in the pressure on urban centers to expand into greenfields. The necessity to deal with these often complex environmental, economic, legal, social, and land use issues for a given property may explain why brownfield problems are not easily resolved.

The brownfield literature reviews a broad range of various aspects thus elaborating different definitions and classifications. The following paragraph provides an overview on prospective definitions and classifications regarding the research framework of this thesis.

2.2.1 What is a brownfield?

The service oriented economy has lead many companies increasingly decide to establish their business on industrial areas (e.g. Pen, 2002). Consequently, the companies started redeveloping them. Any transformation has a significant risk related to the already mentioned complex actors' involvement and financial challenges due to the long redevelopment time and often high remediation costs, for example. Given only these two risks, brownfield sites within the cities are more likely to be transformed compared to those at the cities' outskirts. The location advantages are very well known since the introduction of the central place theory (Christaller, 1966). Obviously, these advantages apply to the brownfield sites as well. Thus, the central point of this research is a generic brownfield located in the urban area including both the urban land and the buildings. Although redevelopment projects have a higher risk compared to greenfield investments (De Sousa, 2002), redeveloping a brownfield especially with the location advantages can create more value for involved actors (Liang, et al., 2008).

Further, the potential multi-actor interest can lead to the creation of a certain form of public-private partnership. Nonrelated to the form, the success of the redevelopment depends largely on the cooperation between these two parties. Especially important can be defining influences of a future land use that captures the supply and demand of a current property market situation (Forester, 1987; Martínez & Henríquez, 2007; Ritsema van Eck & Koomen, 2008).

As mentioned, the location advantages can be an incentive for private parties but also there are other positive physical aspects of a site such as skyline, relief, soil properties, etc. Further more, besides the physical aspects also legal and financial aspects play a role in success of a brownfield redevelopment project. To make an inventory of the important attributes of a brownfield, a previous step would be defining a brownfield and explaining the existing classifications.

Definition

Several different descriptive definitions are given in relevant literature. In this research, I refer to the following: "A brownfield site is any land or premises which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilized. It may also be vacant, derelict or contaminated. Therefore, a brownfield site is not available for immediate use without intervention" (Alker, et al., 2000). The same author offered a visual interpretation of this definition (Figure 2-1) that clearly dived what is a brownfield and what the brownfield may be. This is an

advantage comparing to other existing definitions where these two elements could be overlapping. The cited definition also summarizes existing definitions in Europe (CABERNET, 2002; POST, 1998) and address US examples (USEPA, 1996; K. R. Yount, 2003). Therefore, this definition is regarded as the most adequate for the purpose of this research.
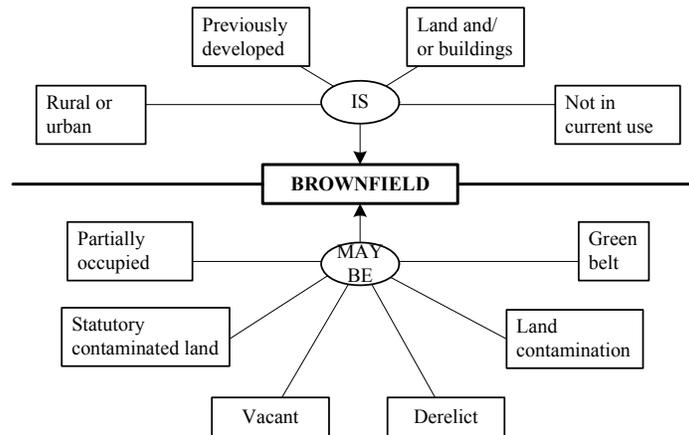
Figure 2-1 Brownfield definition (Alker, et al., 2000)

Alker et al. (2000) also provided further explanation for some ambiguous definition fragments that are listed below.

(1) Previously developed site regards carrying out any building, engineering, mining or other operations, in, over or under the land.

(2) In order that a site is considered a brownfield, it must not be currently in use. A site that is fully used is not a brownfield and when a site is partially used, then only the unused part is called a brownfield.

(3) Contaminated land indicates "… the presence of some biological, chemical or physical hazard on or within a site that would require some remediation before the site could be reused" (Alker, et al., 2000).

(4) Derelict addresses an abandoned or a land so damaged by industrial or other development that it is incapable of beneficial use without treatment.

(5) Vacant means not occupied or a land on which some previous productive use has been ceased for a significant period.

(6) Partially occupied regards to the land partially taken up or filled.

(7) Intervention can be any form of a physical (e.g. land remediation), legal (e.g. planning policy) or financial (e.g. fiscal intervention) action in order that the land can be utilized again. Either one or more parties joined in a formal or informal partnerships, can undertake these interventions.

The goal of the definition is not only to prevent misunderstanding, but also to lead to common understanding and to provide a framework for all the actors involved within the brownfield redevelopment. Additionally, the definition specifies and classifies

conditions of a certain brownfield site. This condition is of a special importance when the analyst facilitates the decision-making.

Classification

The brownfield classification as any other classification constitutes a fundamental technique for assessing and understanding situations and also it improves decision-making (Y. Chen, et al., 2009). These authors developed a brownfield classification support system that groups cities into nine different categories based on two key characteristics (e.g. BR effectiveness and BR future needs) and responding criteria. The support system is based on the dominance-based rough set approach under the umbrella of multiple criteria decision analysis. This support system helps policy makers on the national level to have better insight and make better decision concerning cities' policies.

Alker (2000) showed an interest in brownfield classification based on the criteria within the brownfield definition (Figure 2-1). Following this approach, the criteria are distributed in the following aspects: (1) first, physical aspects such as site conditions; (2) then those non-physical aspects that are partly socio-economic and partly associated with the perception and image of a site that relate to matters such as a developer confidence and influence of the policy. The idea is to create a generic classification that incorporates all user perspectives.

CABERNET (2002) developed a three-category classification based on two characteristics: market land and property value after the redevelopment and redevelopment costs (Figure 2-2). These categories are named A, B, and C. They reflect the cost-benefit ratio starting with the most favorable option and ending with the last one. The category B is of a special interest in this research. These projects are on the borderline of profitability, therefore these projects tend to be funded through public-private partnerships that assume the collaboration between these two parties. Where the first party should be mostly responsible for non-capital interventions (such as a legal framework, favorable land-use policy, fiscal policies, etc.) and the later one supports the redevelopment project with the capital.
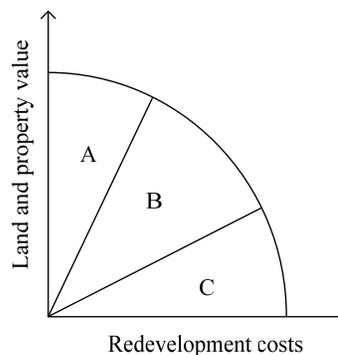
Figure 2-2 Brownfield classification (CABERNET, 2002)

With the previous reference examples, it is clear that the classification can be conducted in many ways. Depending of the criteria, characteristics or aspects, method, goal, and perspective of a classification, the outcome can vary significantly.

2.2.2 Brownfield redevelopment process

Broadly, this research defines a redevelopment as any intervention granting the land be utilized again (Alker, et al., 2000). Still, the brownfield redevelopment is a specific type of area (re)development and the brownfield definition need to be consulted to properly define the brownfield redevelopment. Consequently, a brownfield redevelopment would be an intervention on a site that is not available for immediate use without intervention. In addition, a brownfield redevelopment could be as well seen as a process where the phases separately and jointly define the redevelopment in more details. In general, any area development project consists of several successive phases (e.g. Hieminga, 2006). Further, at each phase exist a final product, defined process and actors that have different interest.

Phases

The following table (Table 2-1) illustrates how a redevelopment process of a brownfield can be interpreted in general terms (Hieminga, 2006). The following phases are of a special interest in this research: initiative and land acquisition phase. Some characteristics are self-explanatory while special attention is given to a multi-actor environment and products.

In the initiative and land acquisition phase the key actors such as market parties, users, and governmental representatives are identified, as well as their properties: internal organization, constraints, demands and power to influence and affect a development process. In the first two phases of the redevelopment, the process forwards certain market knowledge to an idea. The listed products are also shown in the table below (Table 2-1). Together, these products can support the assessment of the risks and opportunities in the redevelopment process mainly related to the program in brief and location analysis.

Finally, it is important to mention that besides indicating various involved actors, processes and their products, a phase dictates the decision that actor needs to make within the given market. More information can be found in the following subchapter (Chapter 2.3.1).

Table 2-1. (Re)Development phases and characteristics (Hieminga, 2006)

Phase	Market	Actors	Process	Products
Initiative	Land market	• developer • owner/user • investor • broker • market research company	*market → idea* initiative feasibility definition	• market analysis • feasibility study • program in brief • project plan
Land acquisition	(Brownfield) market	• landlord • developer • municipality • notary	*idea → location* location assessment	• location analysis • soil research • program in brief
Plan development	Market for design services	• urban design architect • civil engineer • other advisors	*location → design* design test re-adjust design	• sketch design • preliminary design • final design • changes in zoning • specification • construction design • building permission
Financing	Capital market	• bank • stockholder	*design → finance*	• financial plan
Realization	Contractor market	• contractor • real estate developer	*design → building* architec. specific. price estimation planning, realization, monitor, test	• on-site drawing plan • action/activity plan • tender invitation
Renting /Sale	Real estate market	• real estate developer • investor • broker • notary	*building → owner* contract making	• rent/buying contract
Management /Exploitation	Real estate management	• real estate manage. company • owner • user	*owner → user* manage. services contract making	• real estate manage. agreement
Demolition		• real estate developer • contractor	*user → market demand and idea*	

2.3 Multi-actor decision-making

A decision-making in urban 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 & Thomas, 2011; Tam, et al., 2009). The new policy implies pluricentric network steering – in which several public and private actors play a role – instead of traditional hierarchical top-down governmental steering.

This demands a strategy of different present actors to handle conditions that are more dynamic. In general, there are numerous definitions and various kinds of strategies (e.g. Quinn, et al., 1988). The strategy in the context of this research addresses the systematic plan of actions that actor does based on its own perspective of the physical, legal and financial structure of the built environment while incorporating reaction(s) of other present actors.

In current development projects many actors groups are involved. This involvement is different in each project. The most important actors are municipalities, landowners, end-users, and investors. Furthermore, there are additional actors involved. They either can be seen as sub-groups of already mentioned groups such as independent development companies, contractors or completely new groups with different goals such as designers, consultants, environmental groups and citizens. Urban development cannot proceed without commitment of these actors because the decision processes are interdependent. Therefore, one actor cannot determine the outcome of the development process.

This research refers to the collaboration and negotiation in a multi-actor environment. The various interdependent relations between actors are investigated and modeled by van Loon for the purpose of facilitating and stimulating actor's collaboration (Loon, 2008). Different methods and theories (Leengoed, et al., 2008) are used for the same topic while the focal point is the interaction in decision-making. Evidently, that knowledge is beneficial and serves as guidance for modeling in this thesis.

2.3.1 Multi-actor environment in urban development

A decreasing manageability of the development process is present also at the urban area scale, changing the importance of involved actors. Nowadays, the orientation of actors apparently focuses to the opportunities instead of managing the process and controlling the system (Bryson, 2004; Heurkens, 2008; Loon & Wilms, 2006). This refers to the idea of shifting from an urban central planning towards a process management approaches based upon actors decision making.

In this research, the definition of an actor is "… an individual or an aggregated social entity (collective actor) that has the ability to make autonomous decisions and act as a unit" (Pahl-Wostl, 2005). For example, a company or an association is a collective actor with overall accepted rules for collective choice and can thus be regarded as a single social entity (Pahl-Wostl, 2005).

Besides the definitions, there are numerous theoretical settings addressing development processes. This research is based upon the approach that stress the importance of analyzing the social relations of the development process through indentifying actors and their relationships (e.g. Baud & Post, 2002; Healey, 1991).

There is a big difference in goals and means of the private and public actors. While being familiar with both, Dowall estimated five major characteristics that determine actors' land development capacity: (1) goal clarity; (2) performance and risk taking incentives; (3) the scale of operation; (4) operational and strategic flexibility; (5) resources and talent available to the actor (Dowall, 1989).

These differences are underlining that private actors (e.g. developer) are constantly scanning the market to evaluate the competition. The evaluations are made in constantly changing conditions in an urban and land market. In every change, developers seek ways to cover rising land and construction costs. In contrast, public actors (e.g. municipality) are only periodically present at the market, having consequently scarce information about construction and land costs, and housing and plot prices (Dowall, 1989).

Further division of public and private actors is necessary to bring the research on the operational level. Therefore, municipality, investors, developers, users are identified as the four main actors involved in an urban area development processes (Glumac, et al., 2008) (Figure 2-3).
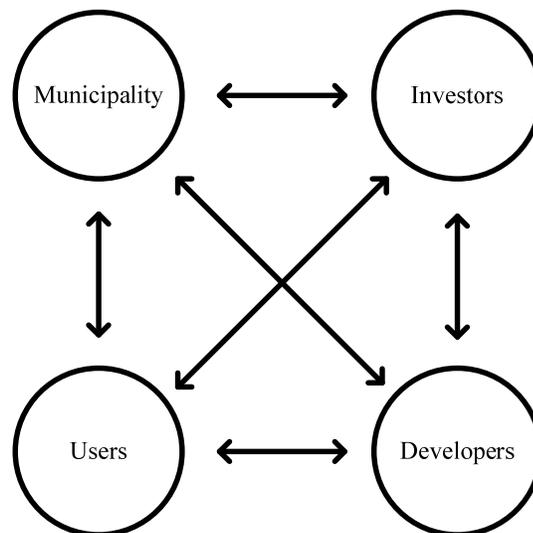
Figure 2-3 Main actors in urban development process

Any of these actors could consist of several subgroups varying in their degree of formality, autonomy and power (Bryson, 2004; Edwards, 2004). In addition, each of the defined actors has its own characteristics (Heurkens, 2008; Loon, 2008) and perceives different information about an area leading to different decision actions. However, a general theoretical model that includes both physical and social complexities and their influences in an economic system is lacking (Batty, 2008; Bettencourt, et al., 2007). To be able to deal with complexity amongst the actors (Batty, et al., 2004; Bryson, 2004), this research focuses on the strategic decision making behavior of two interacting actors: developers and government authorities.

The focus on developers originates from the assumption that the developer is the most influential actor in market-oriented society that deals with the urban land (Andersson, 2005). Furthermore, they frequently interact with government authorities. These two actors are the focus of this research. The presence of the two others actors is also inevitable if analyst wants to understand decision-making within brownfield redevelopment. To model them all, requires a large and sophisticated decision support system (e.g. Saarloos, et al., 2007; Waddell, 2000). In order to make the research manageable in this thesis, these two actors are not neglected but their actions are subordinate of those firstly named. To that account, the assumption is made that the user's actions as are linked to the government actions as having policy roll in the society. Investors actions are considered to be represented in the ones of developers (Figure 2-4).
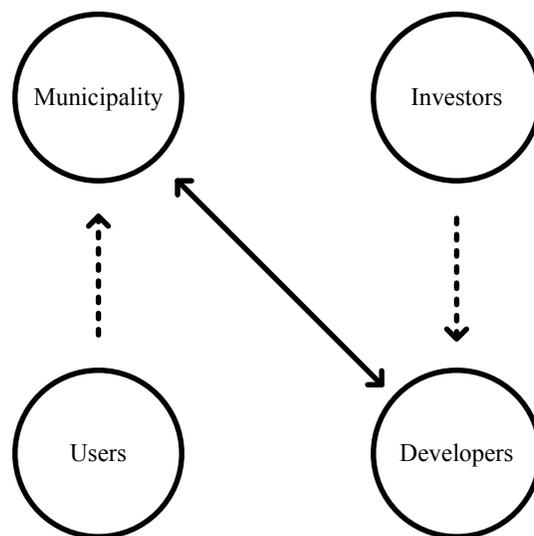
Figure 2-4 Main actors in urban development - simplified interactions

In addition, the developers in fact consist of rather wide variety of real world parties. An inventory is necessary in order to select them and further model their

behavior. On the other hand, only a municipality (together with the regional development agencies) is captured within the previous figure, although there are many more present governmental authorities in urban development process. This is mainly due to that the brownfield redevelopment is consider being a type of urban area development.

Developer typology

"A developer can be defined as the person or firm that is actively involved in the development process and takes the risks and receives the rewards of development" (Peiser & Frej, 2003). Although a valid definition, by understanding the variety of developers and their behavior it would be possible to conclude that no general definition is suitable. Practically, this definition could fit with just some of the developer types. Thus, two more detailed typologies of the developers were investigated (Coiacetto, 2001; Hieminga, 2006). In both of the following examples, the basic goals and means differentiate amongst developers.

Author Coiacetto (2001) made a following typology: (1) passive local property owning developer; (2) "means to mission" developers; (3) specialized client developers; (4) showpiece developers; (5) eye on the street builder-developers; (6) value adding opportunity developers. Although, this author argues that it is more appropriate to make a soft structure of developer's behavioral type, the soundness of these types brings more questions than answers.

Characteristics based on goals and objectives are found in a more structured typology (Hieminga, 2006):

(1) Independent project developer - This group of developers is not associated with other branch-related activities, like the developers that are a part of a construction company. Project development is a goal in itself. Trough the project development activities, the continuity of an operational management and high returns on investments are pursued for shareholders.

(2) Contractor - Goal of this group of developers is to reach a high building production through project development. This group is also called developing constructors. This group is relatively large because almost all middle-sized and big construction companies have a project development unit. This group is largely represented in the development of owner-occupied houses.

(3) Asset investors - This type of project developer keeps the real estate in their own portfolio after development. This group considers real estate development as a mean to come to good real estate investments. Some of the big institutional real estate investors also develop real estate themselves – using the fiscally attractive status of an investment company – but this category mainly exists from wealthy particular investors.

(4) Social housing associations - They are increasingly active and influential on the commercial real estate development market after the liberation in 1995. Project development is a mean for social housing associations to finance uneconomic social investments.

(5) Financial institutions - They are also active in project development.

(6) Architects - For them, development activities are the means to perform design services. Considering the complexity of the total building process and the required (big) size of architectural companies to be able to do this, this group of project developers is relatively small.

Based on this typology, it is clear that developers' characteristics determine the different brownfield site requirements that assure the promising redevelopment. In addition, the very same characteristics can often influence which strategy is applied to redevelop a certain brownfield.

Obviously, individual or personal psychology have a significant role in the behavior of developers. For example, there are established five different interpersonal conflict-handling modes (Kilmann & Thomas, 1977). However, implementing this fact in this research will involve domains of human psychology making the research vast and out of the given scope.

Decision moment

As stated before, the context of this research is modeling the decision-making process, as an interdependent phenomenon of the multiple actors. Decisions concerning the brownfield redevelopment are different for the every single actor. In the context of brownfield redevelopment, there are several questions posed on the involved actors.

First, the development phase influences the decisions of an actor. This research focuses on both the initiative and the land acquisition phase of a brownfield redevelopment process. There are four main decisions that a developer addresses here (e.g. Andersson, 2005; Malpezzi, et al., 2004; McCann & Shefer, 2004): (1) where to build; (2) what to build; (3) when to build; (4) how to develop. These questions address the developer's perception of opportunities in an area. Understanding the questions instead of merely implementing cost-benefit analysis, potentially leads to higher urban value that is in interest of not only a developer but a municipality as well.

Location, location, location is a popularly used term in developer's practice by many authors (De Meirleir, 2006; Salvaneschi & Akin, 1996). Obviously, indicating that the first and the last important thing of the development process is a location. Certainly, that it is one of the most important; still neglecting the other decisions could result in misleading conclusions. Next decision 'what to build' relates to the ratio between supply and demand, also addressed in numerous literature (e.g. Kotler & Keller, 2008). In detail, the decision about potential redevelopment feasibility and the

optimality of any geographic area involves an intuitive matching of the existing supply with an emerging or potential market. The decision about when to build involves knowledge about the real estate market cycles (e.g. Jos, et al., 1994). They differ between physical and financial cycles (Mueller, 1999) that are also different for every single land use. Finally, the decision how to develop relates to the process and products of the first two phases of BR (Table 2-1).

2.3.2 Multi-actor decision-making approaches

As concluded previously, the processes in urban area development have therefore changed brownfield redevelopments as well. In nowadays literature, these changes have been referred as the interaction between actors. This notion brought to attention a relatively new research branch - complex systems in the built environment. Characteristic for this branch is not a mere people's reaction on the given conditions in the built environment but also the interdependent decisions that people perform in relation to the other people. Therefore, decision-making theory has the major role in this field.

There are different studies covering a broad range of decision-making theory. Raiffa (2002) provided the categorization of the most applied approaches (Figure 2-5).

```
                                  ┌─── Behavioral decision making (descriptive approach)
                     Individual ──┤
                                  └─── Decision analysis (prescriptive/normative approach)
Decision making ──┤
                                  ┌─── Game theory (interactive normative approach)
                     Plural ──────┤
                                  └─── Negotiation analysis (collaborative prescriptive approach)
```
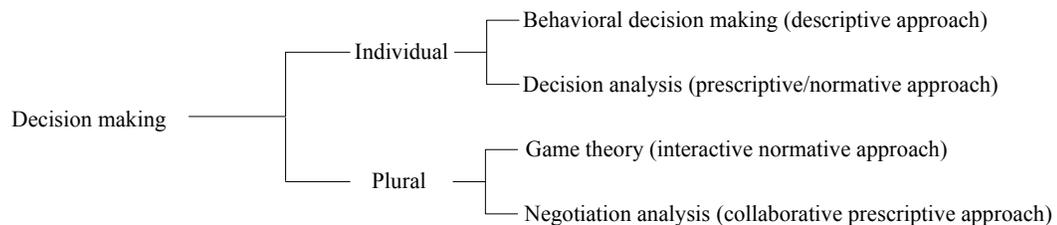
Figure 2-5 Four approaches in decision making (Raiffa, 2002)

The research reported in this thesis combines quantitative methods within decision analysis and game theory. Concerning the decision-making approach, it can be regarded as a combination of the individual prescriptive and interactive normative approach. These and other approaches are summarized in the paragraph below. The idea of merging these two approaches has consequently led to developing a hybrid model (Chapter 5.2.1). Since the model preformed well, the same result can be regarded as a proof for establishing a new approach. Therefore, it is further called the *prescriptive interactive approach*.

Descriptive, normative and prescriptive decision-making

In the following text, the distinction amongst descriptive, prescriptive and normative approach is made (e.g. Raiffa, 2002).

Descriptive decision-making indicates how decisions are made, or in detail, how and why individuals think and act the way they do. This approach is dominant in behavioral decision-making mostly studied by psychologists. Their work is empirical and depends largely on clinical studies. The outcome of such studies in general does not suggest any modification, influence or moralization of human behavior, but is providing descriptions without interpretation.

Normative decision-making investigates how decisions should be made. The benchmark of normative approach is complete rationality of an intelligent decision maker. This is at the same time the biggest critic since this approach abstracts the environment and possibilities of the real people. Scholars dominating this field are applied mathematicians and mathematical economists. Their work is mainly theoretical and underline how humans should behave although they might do not. Most of the game theory work has this normative component although there is also a relatively new field of experimental game theory that tries to overcome the problematic abstraction of a real human.

Finally, the prescriptive approach focuses on how decisions could be made better. The idea of this approach is to provide usable outcome such as novel perspectives, decision aids, conceptual schemes, analytical device, etc. Therefore, this approach is not concerned with conceptual ideas but rather with the pragmatic value provided to the end user. Perspective analysis should be based on descriptive and normative theories (Raiffa, 2002). As an additional illustration, one may say that scholars in this field play a role of problem solving engineers while scholars in the normative scene are the analytical scientists.

2.3.3   Individual choice models

As mentioned, this research is based on two approaches in decision-making theory. The first is individual prescriptive/normative approach (Figure 2-5). This section describes this branch very briefly.

Frequently used within this approach are the individual choice models. Although many alternatives originates in econometrics, marketing, and other fields, this method is believed to be the most accurate and general purpose tool currently available for making probabilistic predictions about human decision making behavior (Bennett & Blamey, 2001). Choice models are regarded as the most suitable method for estimating the willingness of end users to pay for the quality improvements. These improvements are described by the attributes but may also be used to estimate the non-market built-environmental costs and benefits. Additionally, unlike standard statistical analysis, these models are able to predict given large numbers of scenarios.

Individual choice models are mostly quantitative and classified as a predictive/normative approach (Raiffa, 2002). Often these models assume that an individual selects the discrete alternative having the maximum utility. While an

alternative is described by multiple dimension features in a specific context called attributes. These models are specified as discrete choice models and they gained much in popularity in different fields, leading to the Nobel Prize awarded to Daniel McFadden in 2000.

There is a major distinction depending on the used data sets. *Revealed preferences* (RP) are based on real choice behavior while the *stated preferences* (SP) requires respondents to choose between hypothetical products (alternatives) that are systematically constructed by the analyst using an experimental design. The advantage of SP data is a possibility to explore the new alternatives while the RP has only a limited access to the real world alternatives. With a carefully designed experiment, we could work around from the problems of collinearity and discover the true utilities for the attributes. Additionally, it gives a researcher great freedom in the creative construction of many improbable but plausible hypothetical products.

2.3.4 Choice behavior in response to other actor's behavior

The above brief overview suggests the increasing popularity and applicability of quantitative normative or prescriptive individual choice models. Although these models can provide the insight in aggregated opinion of separate groups, their interaction between groups might lead to the changed individual preferences thus reducing the precision of individual choice model outcome.

Therefore, this section illustrates the non-cooperative game theory application in studying the mentioned interactions in the context of a brownfield redevelopment. This theory emerged from the attempts to study the games such as poker or chess in beginning of the last century. Assuming that players have to think ahead and devise strategy based on expected countermoves of the other player(s). This strategic interaction has many applications in various economic environments. In addition, it can be useful in analyzing interaction in brownfield redevelopment. The advantage is in its abstraction about players' payoffs and strategies resulting in the outcome based on the concept of equilibrium (e.g. Rasmusen, 2007).

Classified as an interactive normative approach (Raiffa, 2002), game theory has the same assumptions as any normative approach. As mentioned, game theoretic models are abstract representations of real life situations and depend on formal mathematical expressions of these situations. Additionally, "…decision makers pursue well defined exogenous objectives (they are rational) and take into account their knowledge or expectation of other decision makers' behavior (they reason strategically)" (Han, 2006).

Contrary to classical game theory, its experimental extension tends to diminish the problem of depersonalized, rational players thus leading to approach that is more prescriptive. The advantage of straightforward modeling of game outcomes remains. This is an advantage compared to its alternative plural approach negotiation analysis that provides vaguer answers.

2.4 Summary

This chapter provided a brief literature review of the brownfield redevelopment process and multi-actor interactions. This insight helped establishing the most appropriate decision-making approach addressing multi-actor interactions in brownfield redevelopment. Further, following such an approach also distinguishes this thesis from the related research.

First, through the existing brownfield definitions, classifications, redevelopment processes and its economical and special benefits this chapter established a research ground where the multi-actors' interactions occur. Secondly, literature covering multi-actor environment together with former findings led to the elaboration of a decision moment that is actor and context specific. Additionally, a brief review of decision-making approaches was provided. The two most promising approaches are further elaborated. These are individual normative/prescriptive approach (individual choice models) and interactive normative approach (game theory).

In this reaction to this, it has been argued that individual choice models, although very successful in numerous related fields, lack the interaction feature. Further exploration of the strategic choice models that evidently includes this feature is essential. Therefore, this research is aiming at the construction of a model that can be understood as quantitative, *prescriptive-interactive* decision-making approach, a barely established branch.

3 Stagnation in brownfield redevelopment

3.1 Introduction

The previous chapter summarizes the context of this research. It introduces a brownfield redevelopment through the definitions, classifications, phases, and finally the involved actors. Furthermore, the interactions between the actors in the built environment were explained. In addition, the previous chapter explained the existing decision-making approaches and suggested the further possibilities to tackle the interactions depending on the market and political changes.

Within the given context, this chapter elaborates the most significant problems that cause stagnation in brownfield redevelopment that were identified in the existing literature. There are many problems, but this research focuses on the potential conflict of interest (Figure 3-1) as very evident in contemporary changing circumstances (Howland, 2003; Louw & Bontekoning, 2007; Olden, 2007; Yousefi, et al., 2007). In addition, this problem is the least investigated by the research community. This fact underlines the necessity to cope with it. Finally, this chapter defines the research targets and formulates them into the research questions.

3.2 Problem description

As discussed, there is a serious need for redevelopment of a large number of brownfield areas. This is also the case in the Netherlands. Restoration and redevelopment of a brownfield can provide a range of economic, social, and environmental benefits, including restoration of the environment quality and provision of land for many purposes. Still there are numerous problems in the brownfield redevelopment process mainly caused by a large stock of brownfield with high vacancy rate, alternative opportunities for development, information gap for example due to the stigma of a contaminated soil and finally the complexity of development process due to the multi-actor environment. This chapter underlines each of the mentioned causes in the following subsections and reveals why the brownfield redevelopment process is slow.

3.2.1 Large stock with high vacancy

The scale of the brownfield areas in Europe is significant. For instance, in the Netherlands approximately 35% (27,500 hectares) of the industrial areas, the most spread type of the brownfield, are obsolete (Schuddeboom, et al., 2007). In Germany, there are 128,000 indentified hectares, reaching up to the figures of 800,000 and 900,000 hectares respectively within Poland and Romania (Oliver, et al., 2005).

In the Netherlands, two main factors that cause enlargement of the industrial brownfield stock are fast development and rapid obsolescence (Blokhuis, 2010) eventually leading to high vacancy rate.

Local governments like municipalities eagerly develop new industrial areas as an economical stimulus but also because of creating a competitive regional environment. The resulting amount of new industrial areas leads to a lack of occupancy on existing ones, finally creating a high vacancy rate. Olden (2007) has described the process more detailed and named it "a vicious circle of Dutch industrial area market".

Another Dutch author (Schuur, et al., 2001) proposed four different processes of obsolescence: technical, economical, social, and spatial. Technical obsolescence occurs when an area does not satisfy original user needs due to the lack of building and road maintenance. In economical obsolescence, initial need of a user changed over time. Social obsolescence starts with the stricter environmental legislation. Finally, a spatial obsolescence appears when surrounding area changes over the time. These changes represent a new land use. The conflict is caused by the differences of the old inner land and new surrounding land use. Any of described obsolescence leads to abandoning the site and again influences the high vacancy rate.

3.2.2 Alternative opportunities

Brownfield vs. greenfield

There is no specific definition of the term greenfield. Frequently, local authorities have their own interpretation often according to the present-day circumstances. Although there are numerous interpretations, a general understanding is "… any land which has not been previously developed, nor is despoiled by mineral extraction or contaminated by waste disposal. (POST, 1998)"

Relating to the brownfield definition it is easy to conclude that most criteria for a brownfield do not apply for a greenfield. The only thing they do have in common is the vacant land. Therefore, both are suitable for development thus making them competitive at the same time. For developer, a greenfield is beneficial to develop since this is the land without contamination or complicated landownership and all related risks. This lowers the needed expertise and consequently leads to the lower number of actors thus making a greenfield development more straightforward. Therefore, wherever possible from investors' point of view, a greenfield development is in the most cases preferable.

Although brownfield redevelopment may be financially more challenging and complex, it serves a much broader scope than just satisfying the market demand for the space. Therefore, some mechanism(s) that supports the brownfield development assuming the equal spread of risks and benefits among public and private parties seems reasonable.

Other investment opportunities

Concerning the type of a brownfield the source of investment can vary as explained previously (Chapter 2.2.1). Given these conditions, it is important to understand the other investment opportunities that private investor seeks in their real estate portfolio, here I will consider just "green" alternatives.

Doing good and doing well has been a phrase used to describe that an investor can make the profits even though they contribute to a better physical environment. There are numerous actions and movements promoting this idea. Among them, a responsible property investments (RPI) represent application to the real estate industry of a widely used investment strategy known as a socially responsible investing, which numerous individuals and institutional investors have been applied to their investment choices (Floca & Pivo, 2007). Emerging concerns of volatile energy prices, and global warming have pushed green and energy efficient buildings toward daily practice. Besides brownfields, today there are investment funds focused on green buildings, affordable housing, urban revitalization, historic preservation, and other strategies that have social and environmental merit while also generating competitive returns. Although the RPI concept promotes sustainability, it seeks beyond the smart growth or green building by integrating them into the investment practices.

Still there are many challenges in attracting these investments. The mentioned authors (Floca & Pivo, 2007) indentified three capital challenges of starting the capital flow toward RPI: (1) lack of comprehensive definition; (2) instituting a system that can benchmark the level of commitment of a property or a portfolio to social and environmental standards; (3) creating investment alternatives that will facilitate the matching of RPI capital with appropriate investments. Since brownfields are one of the core investments addressing RPI, the previous challenges should be addressed as well. Logically, overcoming these challenges in any brownfield redevelopment project augments the chances that the RPI capital flows in this direction.

3.2.3 Brownfield information gap

Over the time, local communities have had a difficult time understanding the scope and scale of their brownfield situation. Partly, this is due to the lack of information that has resulted in part from the property owner reluctance to reveal contamination potential because of liability fears (Thomas, 2003). As a consequence, "… failure to inform creates a debilitating stigma effect, where properties and entire neighborhoods are avoided because of suspected but unknown contamination potential" (Coffin, 2003).

In order to suppress the asymmetric information issue, the same author suggested a combination of formal and informal tracking records. Where formal information could be environmental or non-environmental related provided by national or European agencies and informal information is one not found in a government agency. Such a database of combined sources should be followed by developing a brownfield information system to track and asses the impact of all brownfield in one community.

3.2.4 Conflict of interest

Shifting rolls of actors

The change in the urban planning practice in general and in the brownfield redevelopment in particular relates to the collaboration between public and private development organizations thus resulting in various forms of cooperative effort. This cooperative effort requires a shift from sequential to strategic, front-end decision-making approaches that allow interaction. The role of the private developer is critical in this process. This role became the *conditio sine qua non* of urban redevelopment. Simultaneously, the role of government moved from a traditional urban government role by local administration to an urban governance, in which governmental bodies and private parties collaborate more closely. Therefore, the policymaking and development as well include the roles of numerous actors present in the both public and private sector.

Nowadays, due to these changes reflected on the shared, overlapping concerns, conflicting interests and the lack of consensus amongst key actors cause the stagnation in redevelopment of a brownfield. The table below (Table 3-1) illustrates broadly the

interests of the two main parties. Original table has been modified in order to underline the most important difference in the context of this thesis and to support the distinction between public and private parties.

Table 3-1 Public and private parties' interests (Blokhuis, 2010b, modified)

Party	Immaterial interests	Material interests
Public	• employment • vital urban economy • spatial and environmental quality • intensive and efficient use of space • sustainable maintenance and management • image of the city • contacts with companies	• financial feasibility of the plan / land development • investments from companies • higher yields from property taxes • rising of land prices or ground rents
Private	• improvement of the urban quality (better functioning of the company) • sustainable maintenance and management (to guarantee the quality on long term) • improvement of image through a better appearance • continuity of operational management • image, quality and sustainability of developments represent a social responsibility further used as sales argument	• higher value of real estate and parcel • saving in costs through a better functioning of the company • saving in costs through effective maintenance and management • returns / yields • building volume / profit • value of real estate, long-term profitable investments

Public private partnership

Public private partnership (PPP) is a concept frequently used in a development practice although uniform definition is still lacking (Weihe, 2005). In most cases, a brownfield redevelopment seeks a form of partnership. This is particularly the case when circumstances are not favorable for an independent development initiative by the private parties (e.g. Grimsey & Lewis, 2002). Another important factor for forming partnerships is a limitation of the public funds that have led governments to invite private sector into various long-term arrangements for the capital-intensive projects.

Historically, the first concession was granted in 1782 to Perrier in France for water distribution (Monod, 1982). From then, there are numerous examples of different public-private arrangements under different perspectives (e.g. Grimsey & Lewis, 2002; Sagalyn, 2007; Weihe, 2005).

In any partnership, forming principles are the same: (1) a clearly defined goal; (2) without a partnership, the project could not be accomplished; (3) partnership must be accepted by the local community; (4) there must be satisfying interest for both parties; (5) each partner contribute within their field of expertise while forming a team; (6) risks are spread equally.

If not assembled properly or according to the key principles, a partnership could be jeopardized. Risk evaluation in these cases is complex and can be looked from various perspectives (e.g. Grimsey & Lewis, 2002; Klijn & Teisman, 2003; Nutt, 2004). Much of the risk of a PPP projects comes from the complexity of the arrangement itself concerning various documentation, financing, taxation, technical details, and sub agreements. In addition, as duration of the project changes the risks are changing as well. A successful project design requires attention on each of the mentioned principles. That eventually leads to the design of contractual arrangements that allocate the risk burdens appropriately.

Negotiation

To resolve a conflict based on different parties' interests, negotiation is one of the most successful choices where parties try to reach a mutual agreement (Yousefi, et al., 2007). Negotiation over brownfield redevelopment is aiming at all parties to share the risks. As in any negotiations, the parties present offers and counter-offers while their objectives and interests are often hidden (Yousefi, et al., 2007).

Within the previous broad distinction on public and private parties, there are mainly three parties involved in the funding of a brownfield redevelopment project: (1) current owner of the site; (2) prospective buyer (or developer or investor); and (3) government (Sounderpandian, et al., 2005). They all can be involved in negotiations depending on a development model (Samsura, et al., 2010). As mentioned previously (Chapter 2.3.1) and elaborated further (Chapter 8.3), this research focuses on the negotiation between developer and the local government representatives.

No matter who are the present actors, it is methodologically demanding to analyze formally the negotiation process. On the other hand, in order to provide an adequate advice, for example in the form of a decision support tool, that formality is required. Concerning the formal frame within the decision-making theory, negotiations are classified as interactive normative or collaborative prescriptive approach (Raiffa, 2002). The interactive normative approach is dominated by the concepts of game theory and the other by negotiation analysis (Chapter 2.3.2). An application of negotiation analysis studies show how to reconcile differences and reach consensus in to brownfield redevelopment (e.g. Pfrang & Witting, 2008). The concept of merging these two approaches is also investigated (Yousefi, et al., 2007) and supported by qualitative and quantitative methods. Still, there is a need for further development towards more functionally beneficial tools. This research provides a model that has a base in quantitative methods and it is formulated formally as a prescriptive - interactive approach.

3.3   Problem delineation

Evidently, the issues in brownfield redevelopment have been separately addressed in many studies. This chapter summarizes them as a large stock with the high vacancy rate, alternatives, information gap, and as a conflict of interest of the present parties. The Figure 3-1 is a cause-effect diagram in which the mentioned issues cause the effect of stagnation in the brownfield redevelopment process.

Having a broader view of the causes-effect relation is beneficial to approximate the impact of each of them separately. In addition, such an overview enables the selection of the most important or urgent cause to be addressed. Obviously, addressing all of them would be vast and out of this research scope. *Brownfield stock* enlargement and *information gap* are problems on the national scale. Although still present, these problems are either successfully resolved at the national level policies or extensively elaborated in existing literature. Various *alternatives* to a brownfield redevelopment exist and certainly cause partly the stagnation of redevelopment process in general. Still, the least researched cause of the stagnation is the *conflict* of involved actors. Given the context of necessity for the partnership due to the economic and political contemporary circumstances, the impact of this cause is assumed the highest, thus it is the central focus of this research.
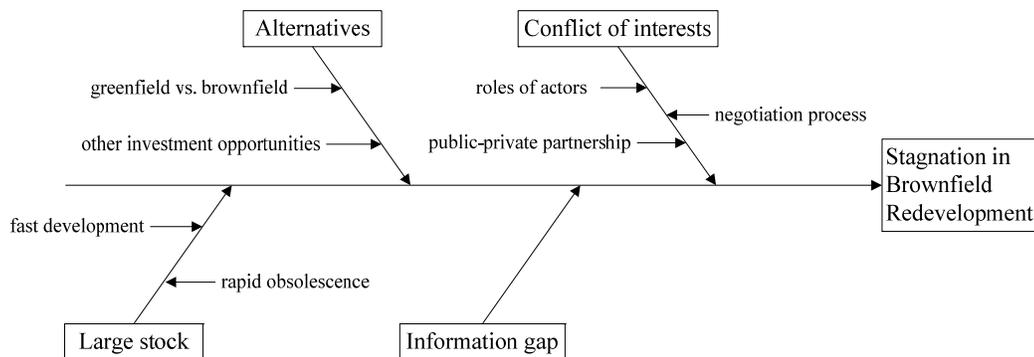
Figure 3-1 Cause-effect diagram of brownfield stagnation

Key actors, municipalities and private developers have shared and overlapping concerns or individual conflicting interests usually leading to lack of consensus on a brownfield redevelopment project. The characteristics of a specific brownfield as well as preferences of involved actors may lead to successful redevelopment or can be a source or potential threat for stagnation. In particular, this research focuses at possible stagnation in relation to: (a) attributes of a brownfield, (b) preferences of actor groups (c) characteristics in the negotiation process between the groups of actors. Little work has been done to develop models that systematically relate the characteristics of brownfield areas and redevelopment plans to the behavior of actors (Carlon, et al., 2007;

Chen, et al., 2009; Sounderpandian, et al., 2005; Thomas, 2002; Wey & Wu, 2008; Yousefi, et al., 2007).

3.4 Research target and questions

This research contributes to a better understanding of the stagnation causes of a brownfield redevelopment and investigates the possible solutions of the problem. The focus is on the multiple (public and private) actors. Their interests assert the changes of the nowadays-established pluricentric urban development. The goal of this research is to analyze these interactive processes. Based on the results, a model that supports directing of the course of the multi-actor decision-making will be presented.

3.4.1 Research target

As was already stated, a comprehensive model that captures the complexity of both the brownfield area itself and the interaction between involved actors is lacking. Therefore, a prescriptive interactive approach based on quantitative methods is suggested as a promising option.

That approach would help establishing the foundations for a better-planned and managed decision-making process for a brownfield redevelopment. Within this approach, a hybrid model is developed. That model assists decision makers to overcome common challenges of negotiations such as not reaching a mutual agreement. This can be achieved through a range of analytical tools that clarify interests, identify tradeoffs, and recognize the party satisfaction. Therefore, an optimal agreement might be generated or become more feasible. In this research, such an agreement supports the maximized benefits of the two involved parties within the redevelopment of a brownfield.

3.4.2 Research questions

Regarding the research target, the following research question will be addressed:

• How to model the interaction between the key actors while accounting their individual preferences towards a brownfield redevelopment, and provide a decision support additionally?

Therefore, the following sub-questions will be elaborated:

• What are the most significant brownfield attributes for a promising area-scale redevelopment?

• How will each group of actors appreciate the chances for a redevelopment based on their preference toward the brownfield attributes?

• How could the interaction between these actors be represented and modeled in the decision process?

• How could a possible problematic negotiation outcome be improved by interventions in terms of developing scenarios?

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4 Methodological background

4.1 Introduction

The previous chapter delineates the research and addresses it through the form of a research target and questions in this thesis. As discussed previously, the focus is on the multiple (public and private) actors and their separate interests to assert the changes in the future redevelopment of a brownfield. Therefore, a research target is set to develop a comprehensive model that captures the complexity of both the brownfield area and the interaction between involved actors. Further, mentioned research questions help to isolate the research target into the separate and manageable parts of this thesis.

This chapter introduces all research methods that are employed and gives an indication to which research question the method is used for. The method application in the context of a brownfield redevelopment is elaborated in detail in the following chapters reporting on the experiments (Chapter 6; Chapter 7; Chapter 8; Chapter 9). In addition, the compatibility of the chosen methods and their applications is addressed in Chapter 5.

The most of the brownfield redevelopment studies have been predominantly based on the qualitative methodologies. Although in-depth interviews, surveys, case studies represent valuable contribution to this research niche, there is a need for quantitative tools that are able to assess the gathered information, model them, and use this

knowledge to support decision-making. Until now, there is a relatively small contribution in this regard (Carlon, et al., 2007; Chen, et al., 2009; Sounderpandian, et al., 2005; Thomas, 2002; Wey & Wu, 2008; Yousefi, et al., 2007).

As mentioned previously, different research questions demand for a method that corresponds optimally with the addressed problem. Specifically, every research question (Chapter 3.4.2) is linked to an appropriate method. One of the challenges frequently present in many researches is to make an appropriate choice for research method for specific questions and even more to make these methods compatible with each other. The methods used in this research are the: fuzzy Delphi, discrete choice modeling, game theory and strategic choice. At first, to structure and identify the most important attributes a fuzzy Delphi method is used (question 1). Discrete choice modeling provides an insight in the preferences of actor groups (question 2). The outcomes of the interactive decision-making process not only depend on an individual choice but also on the influence of the choices of an actor's opponent. Therefore, this research focuses on negotiation games (game theory) in order to find possible strategies in negotiations concerning brownfield redevelopment (question 3). Based upon these findings, interaction between the selected actors is modeled as a strategic choice (question 4). As mentioned, the following paragraphs provide only a methodological overview, while the applications of the selected methods in the context of the brownfield redevelopment are addressed separately in the following chapters (Chapter 6; Chapter 7; Chapter 8; Chapter 9).

4.2 The fuzzy Delphi

4.2.1 Background

There are three basic types of information uncertainty, namely ambiguity, discord and fuzziness (Klir & Yuan, 1995) that are covered by numerous uncertainty theories. Due to the human factor in evaluation, in this case the importance of a certain attribute, a type of the uncertainty is present. That is the fuzziness or vagueness resulting from the lack of definite or sharp distinction. Therefore, using a proper method is crucial to have a clear overview of the attributes relevant for the brownfield redevelopment.

The fuzzy Delphi method (FDM) derived from the traditional Delphi method and fuzzy set theory. Various researchers contribute to the origin of this approach (Hsu & Chen, 1996; Ishikawa, et al., 1993; Murray, et al., 1985; Noorderhaven, 1995). The traditional Delphi method questionnaires have tendency that both the questions and the answers are indistinct. Additionally, there is a notable problem to solve the fuzziness in expert consensus in group decision making. Murray, et al., (1985) first proposed the application of fuzzy theory to the Delphi method. Further on (Ishikawa, et al., 1993) used the maximum-minimum method together with cumulative frequency distribution and fuzzy scoring to compile the expert opinions into fuzzy numbers. The expert

prediction interval value was then used to derive the fuzzy numbers, resulting in the FDM. Noorderhaven (1995) indicated that applying the FDM to group decision can solve the fuzziness of common understanding of expert opinions. Additionally, Hsu & Chen (1996) suggested similarity aggregate method (SAM) that use trapezoidal fuzzy number and is able to estimate the group consensus.

This method is based upon group thinking of the qualified experts that assures the validity of the collected information. The benefits of using FDM with SAM underline practical matter such as saving the survey time and reduce the number of questionnaires. More important is that it takes into account the fuzziness that confronts every survey process assuring that there is no misinterpretation of an expert's prime opinion thus genuinely reports their responses. In this way, the efficiency and quality of the questionnaires are improved.

The triangular membership function is the most frequently used function. Although other functions like trapezoid, quadratic, Gaussian may contain more information. This research implements both trapezoidal and triangular fuzzy number in different experiments.

Recently, fuzzy logic applications in urban development studies emerged as well (Damigos & Anyfantis, 2011; Hui, et al., 2009; Juan, et al., 2010; Khanzadi, et al., 2010; Sivam, et al., 2007; Taleai & Mansourian, 2008; Q. Wang, et al., 2009).

4.2.2   Expert groups in Delphi

In general, Delphi method does not provide conclusions from a huge database where statistical sample represents random population. It is a support tool for a group decision making, where the experts have thorough knowledge about the specific topic. That is urban development in this research. Consequently, one of the crucial points for this method is the choice of and grouping of the experts. The initial guidelines applicable for the Delphi method appeared in mid 70's when Delbecq, et al. (1975) described a step-by-step procedure to ensure the identification of relevant experts by addressing different disciplines, organizations and literature. The appropriate distinction among expert groups is essential for having any significant conclusions. For example in the case of the heterogeneous group, either no mutual agreement or consensus could be accomplished or their aggregated results would be meaningless. Additionally, separating groups allows comparison of their opinion. Therefore, this study will introduce the panels that represent different expert groups.

4.2.3   Classical Delphi procedure

There are three characteristic phases of a Delphi survey: 1) brainstorming for important factors; 2) narrowing down the original list of the factors to the most important ones; 3) ranking the list of important factors (Schmidt, 1997).

4.2.4   Modified FDM using SAM

Modifications made (Table 4-1) on classical Delphi procedure consists of the add ups for experts' solicitation (Delbecq, et al., 1975) and implementation of SAM (Hsu & Chen, 1996) in ranking phase within FDM. In this way, we assured the identification of the relevant expert groups and shorten the number of questionnaires comparing to classical Delphi method. Additionally, the validity of the survey results is advanced by implementing the SAM that provides more reliable calculations and insight in different group assessment than other FDMs.

Table 4-1 Modified Delphi procedure

Phase	Tasks
Identify experts	• Identify relevant disciplines, organizations, literature
	• Write in names of individuals in previously defined topics
	• Invite experts for panels
	• Target size is 10-15 experts per panel
	• Stop inviting experts when each panel size is reached
Brainstorming	• For this phase only, treat experts as individuals not panelists
	• Starting point is the collection of the attributes from literature
	• Remove exact duplicates, and unify terminology
	• *Questionnaire 1*:
	• Send consolidated list to experts for the validation
	• Collect the information about their qualifications
	• Ask contacts to nominate other experts
	• Refine final version of consolidated lists (target 20-23 attributes)
Ranking	• *Questionnaire 2*:
	• Experts rate attributes by giving four weights (fuzzy number) per attribute
	• Compute ratings by using SAM (Hsu and Chen 1996)
	• Final result is a rank list for each panel

These are the methodological steps:

(1) Validate predefined list of the attributes - In the questionnaire 1 the participants were ask to approve and add missing attributes from the initial list derived from the literature survey. This step refers to brainstorming phase in classical Delphi method (Delbecq, et al., 1975; Schmidt, et al., 2001). The experts judged the attributes derived from the literature.

(2) Collect opinions of expert groups - Find the evaluation score of every attribute given by each expert by using four weights in a row from 1 to 10 associated with linguistic description in questionnaire 2.

(3) Set up unique trapezoidal fuzzy number - here we used SAM (Hsu & Chen, 1996) that method has the following steps:

(3.1) Calculate an agreement degree $S(\tilde{R}_i, \tilde{R}_j)$ between expert E_i and expert $E_{j.}$. That can be determined as a proportion of consistent area and the total area. The intersection area of two trapezoidal numbers (Appendix A), describes all possible

combinations of the intersection area and the significant points used for its calculation) has a following calculation:

$$S(\tilde{R}_i, \tilde{R}_j) = \frac{\int x \ (min\{\mu_{\breve{R}_i}(x), \mu_{\breve{R}_j}(x)\})d_x}{\int x \ (max\{\mu_{\breve{R}_i}(x), \mu_{\breve{R}_j}(x)\})d_x} \qquad (4.1)$$

where i = 1, 2, …n and j = 1,2,…m

If $\tilde{R}_i = \tilde{R}_j$ then $S(\tilde{R}_i, \tilde{R}_j) = 1$ or we can say that two experts have the same estimation value. Contrary if there is no overlap in two opinions then $S(\tilde{R}_i, \tilde{R}_j) = 0$. To conclude, the higher the percentage of overlap the higher the agreement degree. When there is no overlap a new classical Delphi survey needs to be deployed (Hsu & Chen, 1996). After calculating agreement degree for all pairs, we can construct an agreement matrix and compare responses amongst all participants in the panel.

(3.2) Agreement matrix *AM* gives us an overall insight into the agreement between the experts:

$$\begin{bmatrix} 1 & S_{12} & \cdots & S_{1j} & \cdots & S_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ S_{i1} & S_{i2} & \cdots & S_{ij} & \cdots & S_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ S_{n1} & S_{n2} & \cdots & S_{nj} & \cdots & 1 \end{bmatrix} \qquad (4.2)$$

where $S_{ij} = S(\tilde{R}_i, \tilde{R}_j)$ if i ≠j; and S_{ij} = 1 if i=j.

(3.3) Average agreement degree of an expert $A(E_i)$ follows:

$$A(E_i) = \frac{1}{n-1} \sum_{j \neq i}^{n} S_{ij} \qquad (4.3)$$

(3.4) Relative agreement degree RAD_i of an expert E_i follows:

$$RAD_i = \frac{A(E_i)}{\sum_{i=1}^{n} A(E_i)} \qquad (4.4)$$

(3.5) Define the degree of importance W_i of every expert E_i where i=1,2,…,n. this feature is important because it give us a possibility to make distinction between various experts. Namely, the most important experts are the ones that were involved in BR and have the development experience five or more years. We assigned them the weight one, i.e. $r_i = 1$ where i=1,2,…n. Then we assign the weight $r_i = 0.8$ for experts that were either involved in BR or have five or more years of experience. Finally, we

assigned $r_i = 0.6$ for experts that neither were involved in BR nor have five years of experience. It could be then formulated:

$$\forall E_i \subset BR \text{ and } \gamma \geq 5 \rightarrow r_i = 1$$
$$\forall E_i \in BR \text{ or } \gamma \geq 5 \rightarrow r_i = 0.8$$
$$\forall E_i \in BR = \emptyset \text{ and } \gamma < 5 \rightarrow r_i = 0.6$$

(4.5)

where i=1,2,…n; BR - E_i involved in brownfield redevelopment; γ - years of experience.

Afterwards, we calculated the degree of importance as follows:

$$w_i = \frac{r_i}{\sum_{i=1}^{n} r_i}$$

(4.6)

where i=1,2,…n

(3.6) Calculate the consensus degree coefficient CDC_i of expert E_i where i=1,2,…n.

$$CDC_i = \beta \cdot w_i + (1-\beta) \cdot RAD_i$$

(4.7)

where $0 \leq \beta < 1$

(3.7) Overall fuzzy number of combining expert opinion or an aggregation result $\tilde{R}$ follows:

$$\tilde{R} = \sum_{i=1}^{n} (CDC_i(\cdot) \tilde{R}_i)$$

(4.8)

where (·) is the fuzzy multiplication operator

(4) Defuzzification - the purpose is to turn unique trapezoidal numbers into a single real number. We use simple center of gravity method (Klir & Yuan, 1995) for overall fuzzy number $\tilde{R}$ of each attribute to derive a definite value $\tilde{S}$.

(5) Screen evaluation indexes – at the end a delineation of numerous attributes can be achieved by setting the threshold value α. The principle of screening is as follows:

If Sj ≥ α, then No. j attribute is very important
If Sj < α, then No. j attribute is less important

Finally, after the screening we could distinguish most important attributes for each expert panel thus compare their choices and agreement degrees among all panels.

4.3   Discrete choice modeling

4.3.1   Background

Discrete choice modeling (DCM) is a relatively new statistical technique that looks at the choices that individuals make between alternatives of products or services. This modeling technique allows analyst to examine the impact of product configuration, service bundling, pricing and promotion on different classes of individuals. Where each product or service (a redevelopment project as well), based on Lancaster's theoretic assumption (Lancaster, 1966) can be described as a bundle of product characteristics or attributes.

This research investigates the decisions of the most relevant actors concerning brownfield redevelopment in its initial stage (Chapter 2.2.2). To elaborate these decisions based on actors' choices on given generic brownfield alternatives shown the fruitful results.

Economists and cognitive psychologists developed DCM in parallel. DCM bases on the theory of choice behavior that can consider inter-linked behavior. Thurstone (1927) proposed previously mentioned theory calling it random utility theory. In the 1970's, McFadden extended Thrustone's original pair wise to multiple comparison (McFadden, 1976). In addition, he developed the statistical estimation technique that enabled widespread application of DCM (e.g. McFadden, 1986; McFadden & Train, 2000). McFadden won the 2000 Nobel Prize in Economics for this achievement. Besides contributions of McFadden, Ben-Akiva (1973) published his dissertation on this subject approximately at the same time. While Louviere, Anderson and Bunch helped develop original designs for DCM experiments (e.g. S. P. Anderson, et al., 1988; Bunch, 1991; Louviere & Timmermans, 1990).

Data collection (revealed and stated preferences)
There is various types of data and data collection methods available to estimate preferences and choices of certain group of respondents (e.g. A. Kemperman, 2000). In general, there is a major distinction on *reveled preference* and *stated preference* models. The main difference between them is type of used data. Revealed preference models are based on data retrieved from the real market conditions while stated preference models are based on respondent's observations from the experimental environment. As expected, both have their pros and cons.

Since they are based on real market situation that already has happened, revealed choice models indicate the past behavior. Data is mostly derived form statistical sources but also questionnaires reporting on respondents past events, choices and preferences. This leads to why the revealed preference models have expected high external validity often indicating a high predictive power. There are some limitations (Blokhuis, 2010; Han, 2006; Janssen, 2011; Kemperman, 2000). With the data describing past choices

for example, the analyst cannot investigate the alternative if it did not exist at the tested time. Therefore, new product or services cannot be tested directly. Even if an analyst want to test only the existing alternatives, deriving the conclusion could be biased since the respondent could considered some unknown or unrecorded alternative in their choice. Additionally, when assembling the revealed data, analyst have no or limited control over the correlations between the attributes and their levels. Usual real market example would be the correlation between price and quality. At the end practically, in reveled data collections respondents can respond just one observation. This requires larger samples thus making the survey more demanding.

Much of these issues brought the idea of making the models based on stated preference data. In this approach, the experimental designs are used to construct hypothetical products or services. Additionally, there is also a full control over the existing alternatives in the choice task and the correlations between the attributes. In addition, the choice tasks are distributed randomly to respondents. In regards to all these adjustments he internal validity of stated preference is higher than the one of revealed preferences (Louviere & Timmermans, 1990). Contrary to previous models, here the responds can react on several tasks thus making the survey more feasible. The problem with stated preference model might be its external validity due to the potential inconsistency with the real world data.

When deciding to use either revealed or stated preference models, analyst should be aware of previously mentioned characteristics. However, the stated preference models are most useful when there is scarce or no data available for newly introduced explanatory variables. This is a very important issue in the field of brownfield redevelopment where even the basic statistical records are absent or misleading (Chapter 3.2.3). Therefore, this research employs the stated preference models.

4.3.2   Discrete choice experiment procedure

Some authors provided detailed process of choice experiment design in stages (Hensher, et al., 2005). This research also follows those stages elaborated in chapters explaining the specific experiments (Chapters 7, 8). Informatively, any discrete choice experiment has the following general stages:

(1) Problem refinement relates to questioning about specific problem and the need for conducting an experiment. Although the questions are already defined in broader sense (Chapter 3.4.2), here they need to be readdressed in more specific manner: to whom the analyses should be beneficial, what is the specific context of the choice task, etc.

(2) Identifying alternatives, attributes and their levels. At first, analyst should be aware of all possible alternatives that are available for decision makers in the context being studied. Not including all possible alternatives, produces a constraint that is a threshold on the utility maximizing outcome (Hensher, et al., 2005). Besides approaches

that solicit all alternatives then reducing their number, it is also possible to use experiments that do not name the alternatives named *generic* or *unlabeled* alternatives. The later is employed in this research due to the choice task.

There are numerous possible techniques to identify attributes ranging from the qualitative in-depth interviews to almost theoretical approaches (Timmermans, et al., 1982). For this procedural step, this research employs fuzzy Delphi method and uses the findings within the brownfield redevelopment (Glumac, et al., 2011). In this stage, also important is the number of attributes that will be used further, more attributes requires more complicated and demanding experimental design.

Attributes levels and attribute level combinations. The levels represent the range of actual or potential variation of the context being studied (Louviere, et al., 2010). In the survey, the levels should provide meaning to the decision maker. Similar as for the previous stage, there is no unique approach to decide the appropriate levels of attributes. Although, higher the number of levels the more demanding experimental design gets. On the other hand, the greater the number of levels the more information analyst can gather and hopefully that will result in better accuracy. Authors suggesting that using two level and four levels attributes results in more manageable experimental design (e.g. Kemperman, 2000) although even the different number of levels in the same choice experiment could be produced.

(3) Experimental design actually consists in many stages and to fully understand them further reading is necessary (Hensher, et al., 2005). Here, the most important ideas are mentioned.

At first, there are some considerations in regards to type of experimental design to be used and how to reduce the experiment size. The most general class of experimental designs is *full factorial design*, where all possible treatment combinations are enumerated. In plain words, all combinations of attributes and their levels are used. Therefore, full enumeration of possible choice sets equals to L^{MA} for labeled or L^M for unlabeled experiments, where L is the number of levels of one attribute, M is the number of alternatives and A is the number of attributes (Hensher, et al., 2005). For example, if we have a choice task of two alternatives where each alternative have 7 attributes with 3 levels, full enumeration equals to $3^{(7 \times 2)}$ when using labeled or 3^7 in unlabeled alternatives. Instead of using 4782969 or 2187, the analyst might make an experiment only with a fraction of those treatment combinations and reduce the experiment size. As noticeable, utilizing labeled or unlabeled alternatives and choice of number of attributes' levels has a major influence on the size of the experiment. More information about the experiment conducted in this research is described in chapter 7 and 8. Designs in witch only the fraction of total treatment combination is used are called *fractional factorial designs*.

For generating such designs, there is also a rigid procedure in order to be statistically efficient (e.g. Hensher, et al., 2005). Following concepts are necessary to be familiar with when want to generate and reduce the size of an experimental design: *orthogonality, main and interaction effects, linear and non-liner effects, labeled and unlabeled* alternatives.

"Orthogonality is mathematical constraint requiring that all attributes be statistically independent of one another" (Hensher, et al., 2005). It implies zero correlation between attributes. Consequence of having non-orthogonal designs is incorrectly estimated parameters of a model.

A second concept, effect is the impact that particular treatment has upon dependant variable, which is a choice variable in choice experiments. Therefore, main effect is the direct independent effect of a single attribute while interaction effect is obtained by combining two or more attributes that would not have been observed separately (Hensher, et al., 2005). It is important to make a distinction between the concept of interaction effect and correlation. In plain words, a correlation is said to be relationship between two variables while an interaction may be thought as the impact two (or more) variables have on third (dependent) variable.

If there is an attributes with three levels (e.g. low, medium, high), attribute linearity assumes that the utility for the difference between low level and medium level is the same as the difference between the medium and high level. This is rarely the case and the solution lies in different coding (*dummy* and *effect*) that allows non-linear effects. Instead of having just one variable per attribute, this coding supports having multiple variables addressing very same attribute. The number of newly created variables equals the number of levels of addressing attribute minus one. In this way, there is a different value of utility link to each level of attribute.

Secondly, crucial in this stage is a decision if only the main effect or also the interaction effects will be tested and if the linear or non-liner levels of attributes are appropriate. The experimental design can be generate in many statistical packages (e.g. SPSS) or retrieved by already generated designs (Hahn & Shapiro, 1966).

Finally, allocating attributes to design columns is necessary in the case that analysts besides the main effects want to investigate interaction effects as well. For this task, analyst must code the attributes using orthogonal codes due to the more preferable statistical properties (Hensher, et al., 2005). To generate interaction columns the analyst just simple multiplies the appropriate main effects columns (Hensher, et al., 2005). The procedure is the same for two-way, three-way or higher dimension interaction effects. The next step is to check the complete correlation matrix with all main and interaction effect variables. If the effects are uncorrelated, we can conclude that effects are *uncounfounded* with each other. The most appropriate correlation coefficient would be J-index, however the most software packages do not provide this option therefore an

analyst can use the Spearman rho or Kendall's tau correlation coefficient (Hensher, et al., 2005).

(4) Questionnaire design stage also consists of several sub-stages: generating choice sets, randomizing choice sets and constructing survey instrument. "A *choice set* represents the basic mechanism of conveying information to decision makers about the alternatives, attributes and attributes levels that exist within the hypothetical scenarios of study" (Hensher, et al., 2005). There is an example from this research (Figure 7-1). At this point, analyst attaches cognitively meaningful attribute labels to attribute levels that are previously established within usable experimental design expressed in coding structure.

Randomization of choice sets across the survey is important and this is the next sub-stage. Ignoring this leads to possible bias from the order in which the choice sets appear to the respondents. It could be that there is a sort of learning process during the survey. If this is the case then the choices made later are likely not to have the same utility or preferences than those starting choice sets. At this point, the problem of how to handle the randomization of choice set is not formally established. Theoretically, the complete randomization would be ideal (every decision maker have complete random combination of treatment combinations in every choice set) while in practice that means that every decision maker should have a unique questionnaire. Unfortunately, there is no clear guidance as how many randomized questionnaire are optimal and per how many respondents should be distributed. In addition, randomization technique can vary depending on the survey instrument as well.

Similar as any questionnaire construction, choice data collection has the threat of data integrity linked to the respondents' ability to process the information. This is manly due to the tasks that are too long, too difficult or lacking the reality in given context. Therefore some suggestions were suggested (e.g. Kemperman, 2000) that every questionnaire should have: (1) simple instructions; (2) uniform interpretations of the terms and tasks; (3) sufficient and illustrative examples; (4) descriptive story and decision context of the experiment; (5) explanation of experiment objectives. In the quest for better questioners, besides traditional textual questionnaires there have been developments in using pictures, photographs, and multimedia (e.g. Janssen, 2011).

(5) After the choice and preference data has been collected, the finale stage is to model and analyze the data with some specialized software (e.g. Bierlaire, 2009; Greene, 2008). Depending on the model, analyzes or deliverables differ. Although in general, the first analysis reports on current condition of a situation in given time while second is a simulation model that allows analyst to construct hypothetical scenarios. Deliverables include indentifying critical success factor as for example a development of a certain location, compare different location potential, segmenting the finial users or competitors, estimating the demand on regional level, etc.

4.3.3 Random utility models

Random utility theory proposes that there is unobservable utility of every individual by researchers. Therefore, in derivation of discrete choice models, the utility value is composed of systematic (explainable) and a random (unexplainable) component. Systematic components comprise attributes explaining differences in choice alternatives and covariates explain differences in individuals' choices. Random utility components comprise all unidentified factors that affect choices due to the taste variation, stochastic preferences of individuals and measurement errors (Han, 2006).

Formally, any discrete choice model can be expressed within the following:

$$U_{in} = V_{in} + \varepsilon_{in} \tag{4.9}$$

Where U_{in} is unobservable utility that individual n associate with choice alternative i, V_{in} is systematic, explainable component of utility that individual n associates with alternative i and ε_{in} is random component associated with individual n and option i.

Because there is a random component, utilities or preferences are inherently stochastic as viewed by researchers. So, researchers can predict the probability that individual n will choose alternative i, but not the exact alternative that individual n will choose (e.g. Louviere, et al., 2000).

The systematic component V_{in} depends on the way that respondents combine their part-worth utilities where usually a linear compensatory model is assumed:

$$V_{in} = \sum_{k} \beta_k X_{ink} \tag{4.10}$$

Where $\beta_k X_{ink}$ is known as mentioned part-worth utility of alternative i; β_k is a parameter indicating the contribution k to the utility of alternative i; X_{ink} represents the value of each attribute level k of alternative i estimated by respondent n.

Further, it is assumed that the decision-maker chooses the alternative with highest utility, formally presented as (Train, 2003):

$$U_{in} > U_{jn}, \forall j \neq i \tag{4.11}$$

In this case, the probability that an individual n chooses alternative i can be formally expressed as:

$$
\begin{aligned}
p_{in} &= Pr(U_{in} > U_{jn}), \forall j \neq i \\
&= Pr(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}), \forall j \neq i \\
&= Pr(V_{in} - V_{jn} > \varepsilon_{jn} - \varepsilon_{in}), \forall j \neq i \\
&= Pr(V_{in} - V_{jn} > \varepsilon_{jin}), \forall j \neq i
\end{aligned} \tag{4.12}
$$

From this equation (4.12), the probability that individual *n* chooses alternative *i* equals the probability systematic component (V_{in}) and its associated random component (ε_{in}) is higher than the components for all other *j* alternatives in the choice set. Since the random components ($\varepsilon_{jn} - \varepsilon_{in}$) are not explainable, analyst can only make statements on explainable ones ($V_{in} - V_{jn}$). For the calculation purpose, if the random components over the alternatives are assumed to be normally distributed (ε_{in}; ε_{jn}) than the difference ($\varepsilon_{jn} - \varepsilon_{in}$) is as well ($\varepsilon_{jin}$). Different DCM can derive by assuming different random component distribution. The most common models are the logit model (McFadden, 1974) assuming Gumble distribution and the probit model (Bliss, 1934; Thurstone, 1927) assuming normal distribution.

4.3.4 Binominal probit model

A binominal probit model is a type of regression where the dependent variable can only take two values, for example join the venture or not. This model has a random utility function where the error terms are independently and identically distributes (IID) according to the normal distribution. Continuing the example in previous subchapter and substituting the equation (4.10) into the equation (4.12) we have the following probability:

$$p_{in} = Pr\big(\beta_k X_{ink} - \beta_k X_{jnk} > \varepsilon_{jin}\big) \tag{4.13}$$

Let the β'_{xi} represent the difference between part-worth utilities of alternative *i*, where *x* is the union of the two sets of covariates, and β is constructed from the two parameters vectors, then binary choice model applies to the probability that:

$$p_{in} = F(\beta'_{xi}) \tag{4.14}$$

Where F is the cumulative distribution function (CDF) of random variable ε_{jin}.

$$p_{in} = \int_{-\infty}^{\beta'_{xi}} \phi(\varepsilon_{jin})\, d\varepsilon_{jin} \tag{4.15}$$

Where $\phi(\varepsilon_{jin})$ is normal density function ($\mu=0$, $\sigma^2=1$):

$$p_{in} = \int_{-\infty}^{\beta'_{xi}} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\varepsilon_{jin}^2}\, d\varepsilon_{jin} \tag{4.16}$$

A model of sample selection can be extended to the probit binary choice model, where:

$$p_{in} = (y_1 = 1^| \, x_i) = F(\beta'_{xi}) \tag{4.17}$$

With the underling structure in any event:

$$y_i^* = \beta'_{xi} + \varepsilon_i \ , \ \varepsilon_i \sim N[0,1], \ y_i = 1(y_i^* > 0) \tag{4.18}$$

This model is most often estimated using standard maximum likelihood procedure. With the use of software packages for example NLOGIT (Greene, 2008), analyst estimates the values of the parameters that will maximize the likelihood function.

4.3.5 Latent class model

In general, it is difficult to examine the heterogeneity in random utility models such as binominal probit. This is due the fact that an individual's characteristics are invariant among a set of choices (Boxall & Adamowicz, 2002). This limitation has been relaxed in several studies (e.g. Boxall & Adamowicz, 2002). Amongst them, latent class model is used tracing its development since late eighties (McCutcheon, 1987). Latent class model predicts an unobserved behavior from a series of multivariate discrete variables. It is called a latent class model because the behavior being predicted is unobserved (latent) and discrete (class). A class is based on conditional probabilities that determine the likelihood of an individual being classified into it.

This model introduces heterogeneity in the systematic part of utility. The utility function for individual *n* choice among *i* alternative at choice situation *t*, given that the individual belongs to class *c*, is expressed as:

$$U_{int} = \beta'_c X_{int} + \varepsilon_{int} \tag{4.19}$$

Where X_{int} is a union of all attributes that appear in all utility functions, and β'_c is a class specific parameter vector; the ε_{int} represents the unobserved heterogeneity for individual *n* and alternative *i* in choice situation *t*. The probability that alternative *i* will be chosen for the class *c* follows:

$$p_{i_{n|c}} = \frac{exp(\beta'_c X_{int})}{\sum_{i'=1}^{i_n} exp(\beta'_c X_{i'nt})} \tag{4.20}$$

As noted, the class is not observed. For this purpose, the multi nominal logit in which individual specific characteristics rather than attributes of choices produce choice probabilities is applied. This model is initially used by two authors (P. Schmidt & Strauss, 1975). With incorporating these assumptions allows the probability of membership in class *c* to be formally expressed as:

$$p_{nc} = \frac{exp(\lambda_c Z_{nt})}{\sum_{c=1}^{c} exp(\lambda_c Z_{nt})} \tag{4.21}$$

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Where Z_n is a vector of both the psychometric construct and socioeconomic characteristics, and λ_c is a vector of parameters.

Now define $p_{nc(i)}$ as the joint probability that individual n belongs to class c and chooses alternative i. This can be expressed as the product of the probabilities defined in equations (4.20) and (4.21):

$$p_{nc(i)} = \sum_{c=1}^{c} \left[\frac{exp(\beta_c' X_{int})}{\sum_{i'=1}^{i_n} exp(\beta_c' X_{i'nt})} \right] \left[\frac{exp(\lambda_c Z_{nt})}{\sum_{c=1}^{c} exp(\lambda_c Z_{nt})} \right] \tag{4.22}$$

Such a model is able to explain simultaneously the choice behavior based on both the attribute data and the individual consumer characteristics. The latent class parameters are estimated using maximum likelihood estimation, several authors reported that extensively (McCutcheon, 1987). In addition to its mentioned favorable features, there is an evidence that this model is also useful in strategy elicitation (Joffre & Adamowicz, 2001) making it even more appealing to be the part of this research.

4.4 The game theory

4.4.1 Background

The outcomes of the decision-making process are depending on not only an individual choice made, but also including the influence of the choices of an actor's opponent. Game theory (e.g. Neumann & Morgenstern, 1944) is a suitable theory to test behavior of involved actors in interactive decision-making situations. Even more, game theory assumes that the decision making of players is always interdependent. Therefore, game theory mainly aims to give an insights on situations in which decision-makers interact (e.g. Colman, 1995; Osborne, 2004; Rasmusen, 2007; Shoham & Leyton-Brown, 2009; Stengel, 2008).

Both cooperative and non-cooperative types of games are used to study actors' interaction (Shoham & Leyton-Brown, 2009). The cooperative branch studies the formation of coalitions among actors while the non-cooperation branch can be used to study how actors strategically behave toward each other when the cost of bargaining and coordination is too high. Consequently, players have to think ahead and devise a strategy based on expected countermoves of the other player(s).

Therefore, the principal objective of game theory is to determine what strategies the players ought to choose in order to 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 interdependency in behavior, game theory is well-suited to describe and analyze urban development and related decision making situations in which two or more actors or decision makers are involved (e.g.

Glumac, et al., 2011; Liang, et al., 2008; Mayer & de Jong, 2004; Mayer, et al., 2005; Mu & Ma, 2007; Samsura, et al., 2010; Wang, et al., 2007).

More specific for this research, game theory seems a suitable method to investigate interaction within brownfield redevelopment process as well. The basic arguments follow. (1) Game theory is based on the premise of relational interdependency between actors that response to the multi-actor environment in brownfield redevelopment (Chapter 2.3.1). (2) In game theory, players make decisions based on their utility function, which is directly related to their needs and interests. (3) The application of game theory gives insight in the strategies in negotiation depending on the various interests essential in brownfield redevelopment (Chapter 3.2.4), and in possible actions to predict the others actors' estimations.

4.4.2 Game elements: players, strategies, payoffs

Basic assumptions that underlie the theory are that decision makers pursue well-defined, exogenous objectives (they are rational), they have an infinite good memory (perfect recall), and they take into account their knowledge or expectations of other decision makers' behavior (they reason strategically). Game theoretical models are highly abstract representations of real-life situations, which allow them to be used to study a wide range of phenomena. In order to predict interaction outcomes a game consists of at least three basic elements: *players, strategies, and payoffs*.

The players in a game are the decision-makers; a player n is assumed to be a solitary actor who makes decisions as a single decision body.

The strategy s_n is a plan of all possible actions $A_n = \{a_n\}$, defining what player n might do in any given situation during the game, aiming for utility maximization. All players make their own choices by selecting a strategy, but the result for each player is dependent on the choice of the other player. The resulting set of strategies for each of the N players in the game is denoted as a *strategy profile $S_N = \{s_n, ..., s_N\}$*. If the game has only two players, a strategy profile is therefore a pair of strategies with one strategy per each player.

Finally, player n payoff is denoted as $U_n (s_1, ..., s_n)$, 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 payoff 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.

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In order to predict the outcome of a game, focus of game theoretic analysts is on possible strategy profiles and on selecting one or more strategy profile as reflecting the most rational behavior by the players.

4.4.3   Games in extensive form

In general, there are two types of games: the *strategic* and *extensive form* games. The main difference between them is how the players act. Consecutively, the players act either *simultaneously* or *sequentially* being aware of previous moves of the players. It is important to underline that the games in extensive form are represented with the *game tree,* although some literature considers them as the same notion. Every game in extensive form can be transformed in the game in strategic form, although that is often much larger than the game tree in extensive form. Converting in reverse is only possible under the condition when the players are not aware of another players' actions. Such games in extensive form are called games with *imperfect information*. Contrary, this research assumes the perfect information, more to be argued in further text (Chapter 8). The perfect information means that a player knows the game state and therefore the complete history of the game up to then.

There is no convention how to design a game tree. The following example (Figure 4-1) draws the tree downwards starting with the *root* on top. The *nodes* represent the state of the game while two successor nodes represent the move of the player. Lines called *edges* connect them. The line that connects two successors nodes are a possible player's move or an *action (X, Y, a, b, c, d)*. If decision maker *(1, 2)* performs an action, this node is called *decision node*. Alternatively, an action can be determined by the nature, in that case the node is called *chance node*. Then the move or action is random, predefined with the probability. The nodes without the successor are named *terminal nodes*. At such a node, every player gets a *payoff* that is a real number.
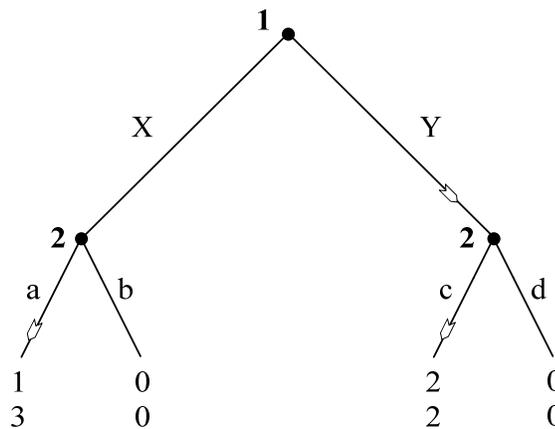
Figure 4-1 An example of ultimatum game tree

4.4.4 Solution concepts

A solution concept is a formal rule for predicting how the game will be played. The central concept of non-cooperative game theory is that of *equilibrium* called *Nash equilibrium*. That is named after John Nash who introduced this solution concept in 1950's for games in strategic form. A strategy profile that consists of the best strategy for each of the *n* players in the game is defined as an equilibrium $s^* = (s^*_1, ...,s^*_n)$. Players choose equilibrium strategies in trying 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 $F : \{S_1, ...,S_n, U_1, ...,U_n\} \rightarrow s^*$ is a rule that defines an equilibrium based on the possible strategy profiles and the payoff functions.

Sub Perfect Nash Equilibrium (SPNE)

In the extensive games, backward induction always produces Nash equilibrium, also called Sub Perfect Nash Equilibrium (SPNE).

Optimal play of any player should maximize their payoff. This payoff can be decided irrespectively of the others players actions when observing the player's last action. That is the reason why process called backward induction starts with the decision node closest to the leaves. A player chooses the action at this node giving him the maximum payoff naturally. An action is chosen in this way for every decision node when all subsequent actions have been decided. In previous example (Figure 4-1), player 2 chooses between the payoffs 3 and 0 on the left side node and between payoffs 2 and 0 on the right side node. Therefore, player 2 chooses actions *a* and *c* (indicated by the two arrows). Going backward in time, player 1 chooses action *Y* (also indicated by an arrow) assuming previously described behavior of the player 2. The action selected by the backward induction is not always unique since it can be the case when more than one action provides the maximal payoff. This procedure defines every action in all decision nodes in complete game tree and describes a strategy for each player. The result of backward induction is therefore a strategy profile. In extensive form games, it is then also possible to state that SPNE and strategy profile obtained by backward inductions are synonyms.

4.4.5 Experimental game theory

The emergence of the game experiments is two-folded. There is a need for empirical information about the principles of strategic behavior and the ability of experiments to provide such information (Crawford, 2002). Especially in non-cooperative games such as ultimate and altering bargaining games employed in this research, the predictions of classical game theory are very sensitive to the structure of the game. Relying only on the existing (data) input of research context usually leads to unobserved or uncontrolled structure of the game. Although experiments often share some of these problems, the

control and observation given the modern experimental techniques provides a notable advantage in indentifying the relationships between strategic behavior and the environment (Crawford, 2002). Still, the theory and experiment play strongly complementary roles. Where theory provides a framework to gather empirical data and interpret the respondent's behavior and experiments indicating which parts of the theory are most useful in predicting and identifying behavioral parameters that theory does not reliably determine (Crawford, 2002).

Particularly in this research, the construction of a game experiment consists of three parts. At first, a validation part that examines the assumed game structure, secondly description part giving the context of a decision moment, and an interpreting part in which respondents make (strategic decisions) actions in negotiation based upon the described game. Every of these experiment segments is described in detail in following chapter (Chapter 8). At this point, it is important to notice that the descriptive part designs situations in which the structure of potential interests can be precisely described and where people's attention can be directed to the specific, controlled features. For applying an experiment design, this study used factorial fraction design similar as for the discrete choice experiments. This approach seems appropriate for describing the game; by designing generic brownfield redevelopment projects composed from a limited set of important project and process characteristics, insight can be gained in dependencies between the specific interactive actor decision-making and these specific characteristics. Considering the interpreting part, the principles from game theory analysis are used to estimate the outcomes of the interactive actions in negotiation process.

4.5   Strategic choice model

4.5.1   Background

Besides the notion in game theoretical framework, strategy can be defined as the position that an actor occupies and the design of the course of (inter)action that he makes in consideration of his goals (Ajzen, 2005). Discrete choice models reflect on the choices of the single entity actors. Therefore, these models do not capture the existence of the other actors. Bridging together the game theory analysis and discrete choice into one hybrid model tend to improve group behavior models. Such a hybrid model is the major contribution of this research. As already underlined in previous chapter (Chapter 2.3.2), this is barely established field of research and in this thesis such a model is regarded as the prescriptive interactive approach in decision theory.

In order to study interactive behavior, the combination of discrete choice models and game theory is a relative new approach in built environment literature. In general, examples are adopted form other fields of the research (Anderson, et al., 2001; Bas, et al., 2008; Blevins, 2010; Chen, et al., 1997; Choi & Desarbo, 1993; Clarke & Signorino,

2010; Hensher, et al.; Le Cadre, et al., 2009; Luo, et al., 2007; Signorino, 1999a, 1999b, 2003; Signorino & Yilmaz, 2003; Soetevent & Kooreman, 2007; Toivanen & Waterson, 2000). The elaboration of a strategic (as defined) behavior in the field of an urban development even in more general notion of the built environment has been quite limited (Blokhuis, 2010; Han, 2006).

4.5.2   Discrete choice and strategic choice: the difference

In general, the choice model distinction can be made as follows (Signorino, 1999a): (1) nonstrategic nonsequential choice, (2) nonstrategic sequential choice, and (3) strategic choice. The first also know as discrete choice, has been already addressed in detail and (Chapter 4.3). The second has received much less attention (Signorino, 1999a). And the third is explained here and have more and more applications (e.g. Anderson, et al., 2001; Bas, et al., 2008; Blevins, 2010; Choi & Desarbo, 1993; Clarke & Signorino, 2010; Han, 2006; Le Cadre, et al., 2009; Luo, et al., 2007; Signorino, 1999b; Soetevent & Kooreman, 2007). The full demonstration of the general model to specific applications, but also how the choice and outcome probabilities relate to the characteristics is presented in one of the flowing chapters (Chapter 9).

Further development led to theoretically defining the combination of previous interaction models and individual choice models. Han (2006) suggested that integration within the discrete choice framework where individual *n* payoff for strategy *j* consists of three components. (1) A choice alternative-specific component named *exogenous U* that expresses the exogenous attractiveness for a given alternative. (2) The second is an interaction component or *endogenous U* that captures the expected impact of other individuals' choice behavior. (3) Finally, an idiosyncratic error term, ε, treated as an individual and alternative specific random variable whose distribution is common knowledge among all individuals, but whose exact value is private information to the individual *n*. The previous can be formally expressed as (Han, 2006):

$$U_{nj} = U_j^{exogenous} + U_j^{endogenous} + \varepsilon_{nj} \qquad \text{(4.23)}$$

Exogenous component

The first term in equation (4.23) represents the traditional attributes of the choice alternatives that affect payoffs. In experimental terms, this component is defined as a condition. This term can be formulated as in the equation (4.10), where the preference accounts for the variation in utility over a generic brownfield redevelopment project defined by several attributes, and reflect the preference to redevelop a brownfield. There are four attributes included in this component: location, embeddedness, administrative support, synergy with surrounding users. For complete description and implementation consult the following chapters (Chapter 7; Chapter 9). It might be possible to characterize the decision maker by another vector of attributes, if the preferences or

tastes of different members of the population vary systematically with some known socioeconomic attributes, experience, involvement in brownfield projects, different company profile. Similar to conventional discrete choice models, linearity in parameters is not as restrictive and many functions of the attributes is possible: polynomial, piecewise linear, logarithmic, exponential, and other transformations of the attributes are possible for inclusion such as frequencies.

Endogenous component

The next component in equation (4.23) captures the attractiveness of a choice alternative as a function of the behavior of other individuals (Han, 2006). The new element introduced in this section is that there are now multiple decision makers, each of whom must condition their behavior on the expected behavior of the others. Endogenous component consists of different games. Therefore, choice probabilities are based on the choices players are expected to make in equilibrium. Formally, the exogenous component can be regarded as utility related to the equilibrium of Γ games. Let Γ be the class of all games and, for each game $G \in \Gamma$, let S_G be the set of strategy profiles of G. A solution concept is then an element of the direct product $\Pi_{G \in \Gamma} 2^{S_G}$:

$$U_j^{endogenous} = \sum U_{G \in \Gamma} 2^{S_G} \tag{4.24}$$

These three games are in fact, three negotiable attributes over the future brownfield redevelopment between two players (municipality and developer). These attributes are building claim, future land use and future parcellation. The structure of the game is essential. In this regard, the games are designed to be compatible with discrete choice models such that attributes' levels (Chapter 7) are present as actions in the game structure. This is done for the practical purposes, necessary to construct a hybrid model (Chapter 5; Chapter 9; Chapter 10). For example, previous example (Figure 4-1) defines the game structure for the building claim game where actions (X, Y) refers to two attribute levels (having a building claim, not having the building claim). Following chapter (Chapter 9) displays a strategic finite choice model in extensive form for all three attributes.

4.6 Summary

This chapter summarizes the characteristics of the chosen methods, the benefits of using them and their validity to the particular research question. Similar for all of the methods is their ability to highlight and quantitatively capture the interdependent nature of people's behavior applied in the context of the brownfield redevelopment. The methodological output in the given context, defines the research approach presented in this thesis.

More specifically, four methods are discussed in detail the: fuzzy Delphi method, discrete choice modeling, game theory, and strategic choice. All of them have been addressed to a specific research question in the field of brownfield redevelopment. First, the fuzzy Delphi method has been used to identify the most important attributes of the brownfield redevelopment potential. In addition, this method enables the proper solicitation and initial indication of the various groups of actors. Afterwards discrete choice modeling is introduced. Its theoretical background provided a sound relevance to estimate the individual preferences of the respondents. Since this method requires specific data, a procedure of a discrete choice experiment is described in detail. As an aside, this chapter argues in favor of stated preference data mainly due to the lack of sufficient information related to the brownfield redevelopment issues. In addition, two models (binominal probit and latent class model) that are used in this research are discussed in detail. The follow-up discussion concerns game theory and its suitability to describe and design the interactions in the formal way related to the presence of different actors in brownfield redevelopment. Therefore, the standard feature of any game has been described briefly: player's information, actions, strategies and payoffs. The solution concept sub perfect Nash equilibrium has been also introduced as a valid solution concept for the games in the extensive form. Rather than relying only on the classical game theoretic approach, this research is based on the game experiments that provide empirical input and it is used as a supplement for the classical game theory. Finally, a strategic choice model has been introduced as a mean to support the bounded rationality of the players. Specifically, this model estimates the impact of the negotiable attributes in brownfield redevelopment. Where a negotiable attribute is represented as a separate theme.

As explained each of the methods separately, tackles a different research question. Still combining these methodologies could provide an additional insight into the interactive choice behavior of the decision makers in real life situations. This is supported by the attempts to develop a hybrid model (Figure 5-2) in the context of the brownfield redevelopment. Such a model should capture the prescriptive ability of the discrete choice models and interaction of multiple players' characteristics for the game theory. The hybrid model could be classified as the barley-established branch, the interactive prescriptive approach in decision theory. Therefore, the next chapter elaborates on the links between different methods and discus the further benefits of doing so.

5 Method implementation

5.1 Introduction

The goal of the research is to accelerate the brownfield redevelopment process. Considering the statement that the major contributor to the stagnation is interaction between various actors, the objective is to analyze and predict the occurrence of conflicting interests in redevelopment processes, and offer recommendations concerning the best deal in public private partnerships.

This research focuses at possible redevelopment stagnation in relation to: (a) the attributes of a brownfield; (b) the preferences of actors groups; (c) the characteristics in the negotiation process between the two groups of actors.

In order to structure and prioritize the attributes the fuzzy Delphi method is used. Discrete choice models derived from stated preference and choice experiments provide an insight in the behavior of actor groups. Derived utilities of municipalities and developers are used both as input for the negotiation in game theory environment and as a part of the finial prescriptive model. The outcomes of the decision-making process are depending on not only an individual choice made, but also including the influence of the choices of an actor's opponent. Therefore, research focuses specifically on ultimatum and bargaining games (game theory) aiming on finding possible strategies in negotiations concerning brownfield redevelopment. Conclusions that are derived from

the game theory analysis are used together with discrete choice models as a calibration to improve a final prescriptive model.

Research data is gathered through on-line surveys with experts.

Based upon this methodology and gathered data, interaction between the selected actors is modeled. The outcomes of the research project will assist decision makers to predict possibility of stagnation and to overcome the challenges of conventional negotiation. Little work has been done to develop models that systematically relate the characteristics of the brownfield areas to the behavior of actors thereby giving an insight in the most important points of interest and in possible sources of conflicts.

5.2 Conceptual research framework

As introduced, this research project provides analysis of the preferences and common and conflicting interests of different actors in brownfield redevelopment process. Further, by developing a group behavior model this research offers recommendations concerning the choice of the best cooperating partner in public-private partnership (PPP), thus accelerating brownfield redevelment.

To deliver the proposed output the research project is divided in three main phases (Figure 5-1).
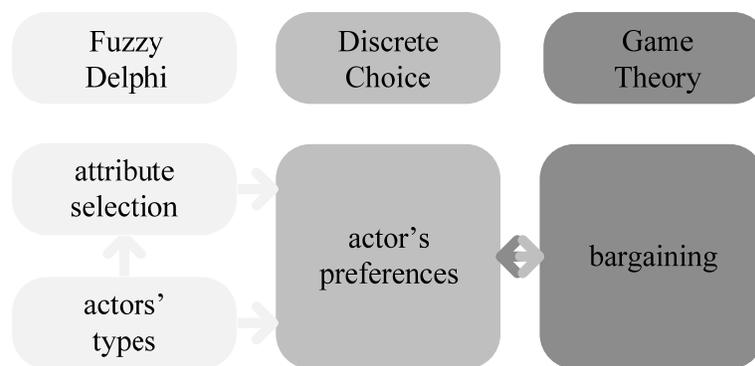
Figure 5-1 Conceptual research framework

The first phase explores the attributes that are relevant for the decision to redevelop a brownfield or not. In addition, the first phase indicates the most important actors and makes a distinction between the public and private actors. It employs fuzzy Delphi method (Chapter 4.2; Chapter 6).

The second research phase focuses on revealing the different actors' utilities concerning a brownfield redevelopment choice described with previously mentioned attributes. The second research phase examines the utilities of the main actors. Similar as in first phase, the utilities are the basis of the decision to start a brownfield

redevelopment. Discrete choice model is used to estimate the actors' utility and the probability of their choices (Chapter 4.3.5; Chapter 7).

Finally, the third research phase investigates interactive behavior between two actors (public and private). More precisely, this research phase at first formalizes the negotiation procedure in game theoretical framework. Secondly, by using backward induction as implementation of a solution concept, this research phase provides insights of the probabilities of certain negotiation outcome and related utilities of both actors (Chapter 4.4; Chapter 4.5; Chapter 8; Chapter 9).

The result of these three research phases is a newly developed group behavior model that incorporates actors' individual utilities but captures as well the actors' interaction effect in negotiations. Such a hybrid model have an advantage on the choice forecast in brownfield redevelopment projects of a certain actor's group and could be used as a part of a future decision support tool to find an optimal PPP agreement.

As explained, each research phase employs different method (Figure 5-1) in order to achieve the expected, their outcomes need to be compatible. That compatibility reflects on the research design itself. The following subchapter further elaborates this issue in procedural manner.

5.2.1 Research procedure - hybrid model

The whole research procedure is captured in the following flowchart (Figure 5-2) and can be regarded as a hybrid model. Research starts with gathering literature to identify important attributes and main actors (left upper corner) and ends with giving proposal for scenarios in regard to the optimal deal or negotiation strategy (left lower corner) in brownfield redevelopment projects.

Previously mentioned phases are traceable on this figure as well. Here they are in more details, explained by the classical flowchart symbols (Appendix B). Phase one and two are carried through *experiment 1* and *experiment 2* while phase tree is split-up in two parts, namely *experiment 3* and *experiment 4*. In brief, the following figure summarizes the inputs and outputs of every experiment. In addition, their essential parts are self-explanatory given the flowchart symbols within separated, squared grey lines. In detail, each experiment is explained in following chapters: Experiment 1 (Chapter 6); Experiment 2 (Chapter 7); Experiment 3 (Chapter 8); Experiment 4 (Chapter 9).
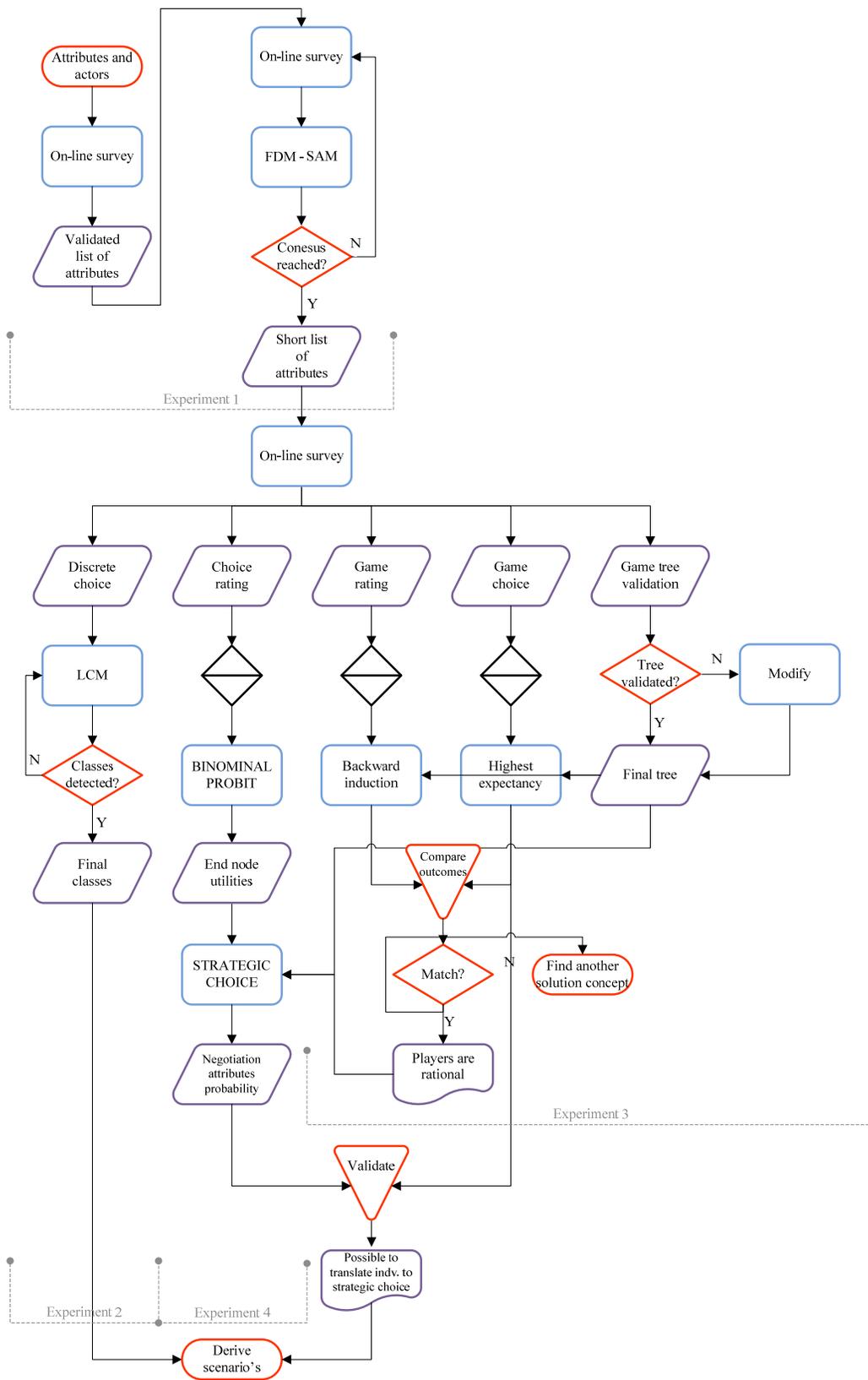
Figure 5-2 Research procedure - hybrid model

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5.3   Conclusions - toward a decision support system

The shifting planning process also has major implications for the design of decision support systems. Virtually all these systems (Brail, 2008) are based on a planning model that assumes a leading role of government where government institutions are deemed for developing alternative plans or scenarios. In addition, these systems articulate a set of goals or objectives, typically relevant for society. The model underlying the system then simulates or predicts the impact of the alternatives designs, plans or scenarios on human behavior and this information in turn is then used to derive a set of performance indicators.

A decision support system (DSS) is a system that improves and supports decision-making capabilities of an individual (e.g.Arnott & Pervan, 2005). Additionally, the term *system* refers to the information-processing devices (software programs) that actively engage in the decision-making process (Arentze & Achten, 2007). Historically, first systems started emerging in the early 1960's and thorough their evolution there were numerous developments (Arnott & Pervan, 2005). This research in future lies in the branch of negotiation support systems (NSS). Technically specific, the future NSS for brownfield redevelopment would be model-oriented with optimization system type. This specific taxonomy (Alter, 1980) addresses the guidelines for actions by generating the optimal solutions.

The state of the art in decision support technology does not incorporate mechanisms of interactions between actors nor about performance indicators that are relevant to the multitude of different actors. Although there are some valid starting proposals considering the interaction, there are limited to framing the possibilities of gaming and decision support system (Mayer & de Jong, 2004; Mayer, et al., 2005), where the comprehensive statistical model is still lacking. Logically, the lack of interaction is the same for the existing DSS examples in the brownfield redevelopment (Chen, et al., 2009; Shan & Xu, 1996; Sounderpandian, et al., 2005; Thomas, 2002; Wey & Wu, 2008; Yousefi, et al., 2007; Zeng & Zhou, 2001).

If one wishes to develop a DSS tool for interactive multi-actor planning one needs an appropriate model of the decision making process. Unfortunately, a formal model of the interactive decision process has not been developed for this domain. The current research project therefore aims at contributing to this gap in the literature. In particular, the goal is to understand better how the interactive decision-making of main actors in brownfield redevelopment processes can be modeled. A better understanding of these processes is a key requirement for the development of multi-actor planning support systems.

As any DSS future NSS should consist of following main features (e.g. Arentze & Achten, 2007): (1) the database (or a knowledge base); (2) the model (the decision context and users' criteria); (3) user interface (input and output). This research

contributes to developing model base that stores and manages the models to support the analysis, design and choice tasks in the decision processes. As mentioned earlier in text, the developed models or hybrid model (Figure 5-2) is optimization driven. It searches for good solutions given the problem of the choosing the partner or optimal agreement in the future PPP for brownfield redevelopment project.

An important part of a successful NSS is the modeling of the actors' interaction and their preferences towards the brownfield redevelopment. Concerning the modeling, a strategic decision model has been developed. Prior to this development all the relevant models has been introduced (Chapter 4) and an integrated approach has been proposed (Chapter 5). In the following chapters, the experiments has been designed, data collected to conduct the analysis and validation of the proposed approach (Chapter 6, 7, 8, 9).

6 Attributes and actors of a brownfield redevelopment: Experiment 1

6.1 Introduction

A brownfield is well described by various definitions and the idea to redevelop it is supported by indentifying numerous benefits for the society. Further, the existing literature covers a broad range of different aspects of the brownfield redevelopment thus elaborating different attributes. At present, there is no overview of the brownfield attributes from the area development perspective focusing on the physical, legal and financial aspects of a site and property.

Therefore, this chapter aims to contribute to the complex decision making process in brownfield redevelopment by identifying, structuring and rating the most relevant attributes of development potential. It introduces the method that highlights the importance of rigorous procedure for the panel data collection and advances the weighting of the attributes. This is of particular importance for the field of the area and real estate development appraisal since the present attributes influence the future marketability and cost of a development. Missing these attributes seriously endangers

the appraisal. A similar threat can influence any econometric model recently extensively used in policy-making.

The first step in this experiment is to conduct the literature survey that indicates relevant attributes for the brownfield redevelopment. Firmly, the existing literature misses the proper structure from the perspective of the real estate development leading to the false conclusions about the importance of a certain attribute. Additionally, the existing studies lack the attention on the diverse expert's group priorities. Such aggregated results reduce the validity of the specific attribute relevance in the specified setting. For example, the different developer types assess the same brownfield redevelopment attributes differently.

Besides being able to capture the diversity amongst the experts, the employed method has an additional advantage. Due to the human factor in evaluation, specifically the importance of certain attribute, a type of uncertainty is present. There are three basic types of information uncertainty: ambiguity, discord and fuzziness (Klir & Yuan, 1995). They are covered by numerous uncertainty theories. Concerning the stated problem, we specified the fuzziness or vagueness as crucial to get a clear overview of the real estate attributes. This uncertainty results from the lack of definite or sharp distinctions. For this problem, research employed the fuzzy set theory implementation on the classical Delphi method (Murray, et al., 1985), called fuzzy Delphi method.

The survey was conducted among experts grouped by the specific goals and tasks. This chapter presents the findings what are the attributes and how different expert groups value them in regards to development potential.

6.2 Attributes in brownfield redevelopment

Alongside the general definition, many researchers describe in detail different attributes of a brownfield. The identification and selection of the relevant attribute(s) may depend on the perspective of the research problem, or derived on the basis of the applied methods such as conjoint analysis (Alberini, et al., 2005) meta-analysis (Nijkamp, et al., 2002), assigning the importance using nominal scale (Syms, 1999), assigning weights using ordinal scale (Thomas, 2002).

Attributes are an extension and detailed overview of a brownfield definition. An attribute is the characteristic of a product that consists of various levels (e.g. Louviere, et al., 2000). Within this definition, this research addresses attributes relevant for the future expectations of a generic brownfield redevelopment project.

In addition, different actor groups can influence some of the attributes while others cannot (Atherton, et al., 2008). Investigating both broadens the possibilities for the risk analysis, implementation in various econometric models, etc.

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Relatively extensive literature review provided numerous attributes that influence brownfield redevelopment. In addition, this review enables some procedural advantages (Chapter 4.2.4).

The perspective of site and property valuation grounds the newly proposed list of attributes since this niche of real estate development precedes others and it is still very relevant. Here are some of them for site (Burton, et al., 2005; Lewis, 1990; Peiser & Frej, 2003) and property (French, 2004; Lucius, 2001; Roulac, et al., 2006; Stevens, et al., 1992). Real estate development risk, as any other risk, is an impact estimation of the critical variables and therefore important literature source (Chen & Khumpaisal, 2009; Doorn, et al., 2005; Xu, 2002; Zhu & Hipel, 2007). Finally, there is already existing literature elaborating various relevant brownfield redevelopment attributes in general (Ganser & Williams, 2007; Peiser, 2007; Thomas, 2002; Thornton, et al., 2007). Literature addressing quantified attributes (Alberini, et al., 2005; Bacot & O'Dell, 2006; De Sousa, 2002; Ginevičius & Zubrecovas, 2009; Juan, et al., 2010; NijkampRodenburg, et al., 2002; Syms, 1999; Wedding & Crawford-Brown, 2007). In addition, some literature addresses the brownfield classification (Carlon, et al., 2007; Chen, et al., 2009; Klapperich, 2002). In addition, an extensive part of the literature deals with the specific issues, in this thesis referred as the attributes in the brownfield redevelopment. Some of them are: ownership (Adams, et al., 2001), negotiation in pubic-private partnerships (Belniak, 2008; Chang & Sigman, 2007; Pfrang & Witting, 2008; Yousefi, et al., 2007), crime (Carroll & Eger, 2006), employment (Howland, 2007), housing (Dixon & Adams, 2008; R. Ganser, 2008), and land use (Grissom, et al., 2010; NijkampBurch, et al., 2002; Page & Berger, 2006), decision support systems (Coffin, 2003; Thomas, 2002; Zeng & Zhou, 2001), pricing (Lentz & Tse, 1995; McCarthy, 2009; Sibdari & Pyke, 2010).

Relevant literature from various sources intuitively provides numerous attributes. These attributes are structured in order to reduce their number to a manageable one and to eliminate the exact duplicates and overlapping attributes. For that purpose, this chapter introduced three essential aspects for understanding the land development processes. That are "… the physical, legal and financial aspects of land and property" (French, 2001: 400). This division is also supported by (Miles, et al., 2007) and (Peiser & Frej, 2003) that are assuming the existence of the same aspects: the legal and financial aspect (institutional) enabling investment and rewards for undertaking a project and the physical aspect to which the project is expected to connect the technologies and construction used in the development. These aspects are preconditions that, if not present, determine the risk of a project. Both are strongly dependent on governmental policy and mechanisms. This structure led to differentiation of the 22 real estate attributes (Figure 6-1).

```
                                    ┌─Proximity
                                    ├─Accessibility
                                    ├─Usage
                                    ├─Embedded into the urban fabric
                                    ├─Contamination level
                      ┌─ Physical ──┼─Skyline
                                    ├─Land relief
                                    ├─Soil properties
                                    ├─Flora & Fauna
                                    ├─Heritage
                                    ├─Archeological site
                                    └─Existing neighborhood image

Redevelop
    a         ───────┤
Brownfield                          ┌─Ownership
                                    ├─Administrative support
                      ├─ Legal ─────┼─Approval process
                                    ├─Support of local residents/users
                                    └─Support of surrounding residents/users

                                    ┌─Governmental incentives
                                    ├─Potential for different land-use
                      └─Financial───┼─Value capturing
                                    ├─Liquidation option
                                    └─Current real estate value
```

Figure 6-1. Brownfield real estate attributes

The noted attributes in brownfield literature evidently miss the previously shown structure. Therefore, the important attributes are missed which finally leads to difficulties when weighting the attributes. Additionally, the same literature lacks the attention on the thorough separation of expert's groups such as underlining independent developers and contractor-developers as two different entities.

6.3 Questionnaire design and data collection

6.3.1 Phase 1 - Identifying the experts

Identifying experts thus related actors consists of several steps. At first, we prepared a Knowledge Resource Nomination Worksheet - KRNW (Delbecq, et al., 1975) or identify the most influential disciplines, organizations and literature that help categorizing the experts and assure that all important classes of experts are introduced. The research team of the authors and one practitioner, all familiar with issues concerning the urban development in the Netherlands, compiled the KRNW. Secondly, we populate KRNW with names. Addressing disciplines, organizations and related literature represent multiple sources that are necessary to identify as many experts as possible. Experts were randomly recruited by addressing separately each of the referred sources. Afterward, we further populate the list by personal contacts. By following the procedure and having the random respondents, we avoid the trap of potential bias information traced from using the unvaried sources. Each discipline required a different approach to identify experts:

a) Developers - To achieve homogeneous character of the group all chosen private developers are big companies established in the Netherlands reported by The Association of Dutch Property Developers (NEPROM, 1974). This research used the previously mentioned (Chapter 2.3.1) developer's typology (Hieminga, 2006).

b) Government development agencies - making a homogeneous group of governmental representatives is harder than for private parties. They work on different scale: local, regional, state and cover different aspects of development. For that purpose, on the side of public sector we indentify one important panel group in the Netherlands. It consists of the expert appointed in the regional development agencies. They have more active role in stimulating development than local, regional and state land authorities responsible for setting the rules and minimum quality requirements. We identified 9 organizations: BOM, GOML, Netwerk Friesland, Stichting Groninger bedrijfslocaties, Drentse bedrijfslocaties, Oost NV Enschede, Oost NV Arnhem, POM West Vlaanderen, and OMFL.

c) Academics - we populated the list of major authors via a literature review of the relevant academic journals papers.

All panels should have 10-15 people each as recommendation in Delphi literature for homogeneous groups (Delbecq, et al., 1975). Within each panel group the goal is that at least a half of participants have been involved in brownfield redevelopment in the Netherlands. This design will ensure the identification and invitation of the most qualified experts available.

6.3.2 Phase 2 - Brainstorming

Originally, brainstorming phase consists of two questionnaires (Delbecq, et al., 1975; Schmidt, 1997). The first one consists of an open-end question where all participants can suggest any attribute. This questionnaire is replaced in this study by having a unified and structured list of attributes derived from the extensive literature review of the brownfield attributes (e.g. Alberini, et al., 2005; NijkampRodenburg, et al., 2002; Syms, 1999; Thomas, 2002). The second questionnaire remains unchanged in which the experts validate the list of the previously categorized and described attributes. They were asked to add missing ones and not to select unimportant attributes.

Settings of a decision problem

Besides the attention who is making a decision, the indication of the most important attributes severely depends on the settings of the decision problem. This research controls the settings of the experiment by proper brownfield definition, indicating the development phase, a size of the site, the future land-use and region. First, mentioned experts look at a brownfield definition (Alker, et al., 2000). However, as a special case under the brownfield definition this research focuses on the ones that are located in the urban areas. This delineation captures the ongoing preference of developers for the urban versus rural brownfield due to the location advantages. The second condition to be considered is a development phase. Consequently, the experts are introduced to the target of this research that is the initiative and land acquisition phase of the development process. These two phases address a different part of the development process with accompanying products. For initiative phase, the development process brings forward certain market knowledge to an idea described with products such as: market analysis, feasibility study, program in brief, project plan. For the land acquisition phase, the process bridges an idea and potential location(s) where the products are: location analysis, soil research and program in brief. The third part of the settings is a brownfield size that ranges from 1 to 10 hectares. Finally, considering the usual big size of a brownfield it is assumed that there will be probably more than one future land use (e.g. housing, business, services, green, etc.), where the decision about the best ratio would come later. Additional to all named land-uses, a land development - servicing is considered as a separate option. Finally, this research assumed that different attributes would be more or less important depending on the region of the research. This research elaborates a Dutch example.

Questionnaire design 1

Main goal of the questionnaire 1 is to validate predefined list of the attributes. The participants were asked to approve and add missing attributes from the initial list derived from the literature survey. Some of them were slightly modified and new ones

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were added based on the feedback from participants. For example, the "accessibility" initially consisted of two attributes: one for the car and the other for public transport. Since the same respondents included both attributes and some added accessibility by "slow" traffic, we decided to merge them in one attribute. An example for newly added attribute is "embedded into the urban fabric" that came up latter as one of the most important attributes. We can conclude that this step was very important. The finial product of the first questionnaire is a list of attributes divided in three aspects: spatial characteristic, legal, and finance. The brought–up attributes and their descriptions follow in table 2.

In this questionnaire, we were also collecting the biographical information about the experts' qualification in the field. The data recorded includes the number of years spent in development practice or government agencies and the number of projects dealing with the brownfield redevelopment. By this manner, we gathered the relevant information on each expert in order to include his or her expertise in ranking phase. Additionally, they were asked to nominate new experts within and outside their organization providing us with as much contacts as possible.

The survey started in early 2010 and last for two months. It was conducted by on-line survey program *SyncForce® SurveyWorld®.* At first, we contacted each panelist personally by phone and explain the subject of the study, the procedure including, and his or her commitment that is filling in 2 x 10 min questionnaires over the period of 2 months. The first on-line questionnaire can be accessed the first day they confirm the desire to participate. Also, the incentives that may lead experts to participate are identified: a) the opportunity to learn from the consensus building b) access to report of the survey c) invitation for the seminar. These incentives are especially important for the busy experts. In the questionnaire 1, the participants were asked to approve and add missing attributes from the initial list derived from literature survey. The experts choose their discipline from well-described options regarding distinct goals and objectives. Some developers selected two different disciplines thus resulting in 52 distinct expert opinions.

The distribution is as follows: a) developers 65.39% or separately, independent developers 23.08%; contractors 19.23%; investors 7.69%; housing associations 9.62%; financial institutions 5.77%; architects 0.00%; b) government agencies 23.08%; c) academia 11.64%.

The total number of contacted experts in this questionnaire is 95 amongst them 45 experts replied thus making the 47.37% response rate.

Since this questionnaire was simple, we did not receive any fault data therefore no clearance was necessary.

The following descriptions (Table 6-1) were available when the respondents where evaluating the importance of each attribute.

Table 6-1 Brownfield attributes' description

Aspect	Code - Attribute	Description
Physical	A1 - Proximity	Site proximity to key city sites, measured in km.
Physical	A2 - Accessibility	How good is the access to the site by car (measured by the distance (km) from high-way weighted by the traffic flow), by public transport (measured by walking distance (minutes) from the stop weighted by their frequency), and by slow traffic (existence of walking and biking path).
Physical	A3 - Usage	Usage of the Brownfield site can be described within three levels. Partially used; Vacant (land on which some previous productive use has ceased for a significant period of time); Derelict (land so damaged by industrial or other development that it is incapable of beneficial use without treatment).
Physical	A4 - Embedded into the urban fabric	Extent to which the development area can be integrated into the urban fabric.
Physical	A5 - Contamination level	Two elements are considered. At first, it is the uncertainty level of the site contamination. Secondly, it expresses the land contamination level by approved institutions.
Physical	A6 - Skyline	How do surroundings (buildings, greenery) look like (e.g. poor, fine, extraordinary) at present time.
Physical	A7 - Land Relief	Third or vertical dimension of land surface (flat , slopes, hills)
Physical	A8 - Soil properties	Relate to sand, hydrology and drainage patterns, grading or fill required to build, piles needed.
Physical	A9 - Flora & Fauna	Presence of vegetation and endangered species.
Physical	A10 - Heritage	Existing structures that are not allowed to be demolished, featuring cultural monuments.
Physical	A11 - Archeological site	The extent to which archeological excavations are necessary or if they are already identified on the site.
Physical	A12 - Current neighborhood image	The sum of beliefs, ideas and impressions that people have of that neighborhood at present.
Legal	A13 - Ownership	Describe the fragmentation level of the ownership of the land/buildings.
Legal	A14 - Administrative support	Transparency and perceptions of continuity in governance, politics and the bureaucracy. Potential to make various Public Private Partnership (PPP).
Legal	A15 - Approval process	Time and number of the documents needed to start up the construction phase of development.
Legal	A16 - Support of local residents/users	The extent to which the present inhabitants (and / or users) support the redevelopment. (e.g. local inhabitants do not want to move because of redevelopment and they will not support the redevelopment at all)
Legal	A17 - Support of surrounding residents/users	The extent to which the surrounding area inhabitants (and / or end-users) support the redevelopment.
Finance	A18 - Governmental incentives	Various government incentives for development (tax shelter, subsidies) expressed as the percentage (%) of total investment.
Finance	A19 - Potential for different land-use	The potential amount of m2 that can be allocated to each relevant land-use (influence the future land-use ratio, density, height)
Finance	A20 - Value capturing	Various forms of taxes after the development.
Finance	A21 - Liquidation option	The extent to which the remediation costs of previous owners and / or users can be recovered. Who has the legal obligation to clean or manage land or property.
Finance	A22 - Current Real Estate Market Value	Present market value of the land and property (from an valuation report).

6.3.3   Phase 3 - Rating

The initial structured list of attributes allowed us to skip the narrowing phase of Delphi method and reduce the overall number of questionnaires in the survey. As a validation for our intervention, we reach the suggested narrowing phase target number (Schmidt, et al., 2001) of the attributes (20-23 items) at the end of the brainstorming phase.

At the questionnaire 2, experts that were now treated in separate panels rated the chosen attributes. The experts within each panel individually submitted the weights on the scale from 1 to 10, indicating relevance from none to extreme, for every attribute when addressing the importance of the attributes for the decision "to acquire the brownfield or not". Afterward, FDM calculation applying SAM is used to assemble the opinions for every panel and deliver the ranking list of attributes.

Questionnaire design 2

To rate the attributes experts were asked to estimate the importance of previously agreed attributes by using two range of weights (maximal and optimal) in ordinal scale 1 to 10 (Figure 6-2). At first, they filled in the maximal range from-to certain weight responding to theirs most broad importance over that attribute. Secondly, they filled in the optimal range responding to theirs most specific importance. For example, instead of giving an attribute *Flora & Fauna* only one weight (5 for example) participants will give four different weights instead within two ranges, maximal and optimal. At first, for the maximal range or most broad importance, they could say that its weight is from 3 to 6. Depending on case and different market condition, a same attribute has different importance. Sometimes the importance vary in its extreme (the range between two weights is very big) and sometimes vary slightly (the range between two weights is small). Secondly, for the optimal range or most specific importance, we could say that its weights vary from 4 to 5. And this range weight is based upon whole expert's experience during different cases, market conditions, etc. in regard to described decision problem. To recapitulate, instead of giving just weight (5) experts will provide us with a four weights in range (3, 4, 5, 6). In this way, there is much more information from a respondent thus making the data analysis more reliable.
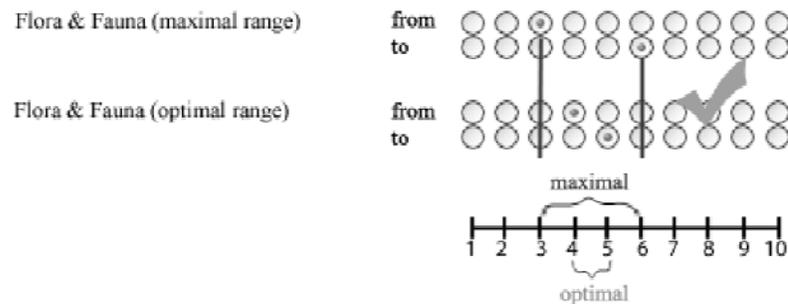
Figure 6-2 Rating the attributes: an example from on-line questionnaire

State of the art literature (Delbecq, et al., 1975; Schmidt, et al., 2001; Schmidt, 1997) suggests the number of 10-15 participants from a homogeneous group could give more reliable results. Therefore, we have sufficient participants for developers and within two expert groups, independent developers and contractors. We regarded experts in these groups as homogeneous since the companies that were involved are the biggest developer companies in the Netherlands (NEPROM, 1974). Additionally, the experts asked to participate were drawn just from the project development departments of the companies. Besides developers, all governmental agencies have the same task and position in urban development therefore they were regarded as homogeneous group as well. Academia is also regarded as homogeneous group since the experts were contact on account of relevant articles for brownfield redevelopment. Amongst all indentified groups following three are regarded as the most significant. Independent-developer group equipped with substantial equity amounts and in the possession of a huge asset portfolio could easier find their way through financially risky segment of redevelopment also the land development is their core business. Developer-contractors assumedly will be less repellent to the idea to enter a brownfield redevelopment project since they are more risks proof for the attribute related to the physical aspects of a brownfield. And finally, we observed governmental agencies as representatives of the authorities' interest. In the second questionnaire, we used lower number of respondents, exactly 35 experts with the overlapping disciplines. Structure of the participants is as follows: a) developers 30 (71.42%) including 11 independent developers (26.19%); 12 contractors (28.57%); 4 investors (9.52%); 2 housing association (4.76%); 1 financial institution (2.38%); 0 architect (0.00%); b) 6 government agencies (14.29%); c) 6 academia (14.29%).

The total number of contacted experts in this questionnaire is 120 amongst them 35 experts replied thus making the 29.17% response rate.

In this questionnaire, we neglected the answer of one respondent that did not fill in the on-line questionnaire correctly. Additionally, for the calculation purpose in SAM we extended the maximal range for some attributes (e.g. instead from 3 to 6, we calculated it from 3 to 6.1) in order to achieve intersection area of two trapezoidal numbers.

6.4 Evaluation and results

As already described, this study consists of three phases. At the first phase, the participants were identified and enrolled from all disciplines named in the previously mentioned knowledge research nomination sheet (KRNW). The participants' variety assures that all relevant attributes were collected in the brainstorming and the second phase. Furthermore, the ranking phase provided a formal and quantitative insight of the expert's opinion on the attribute's importance within and amongst the different groups.

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6.4.1 Aggregated results

Following table (Table 6-2) represents the aggregated opinions of all 35 experts that participated in questionnaire 2 through unique fuzzy number (W), ratings - defuzzified number (S) and the rank for every attribute. All the calculations are base on the equations noted in one previous chapter (Chapter 4.2.4). Calculations are executed in the *Matlab®* program.

Table 6-2 Overall rating of brownfield redevelopment attributes

Code – Attribute	W = (a, b, c, d)				S	Rank
A01 – Proximity	5,80	7,30	8,43	9,23	7,69	4
A02 – Accessibility	6,07	7,26	8,32	9,13	7,70	3
A03 – Usage	4,82	6,18	7,38	8,60	6,74	14
A04 – Embedded into the urban fabric	5,92	7,33	8,09	9,22	7,64	5
A05 – Contamination level	5,19	6,61	7,62	9,00	7,10	11
A06 – Skyline	2,49	3,91	5,47	6,85	4,68	21
A07 – Land Relief	1,98	3,08	4,24	5,98	3,82	22
A08 – Soil properties	3,36	4,75	5,86	7,38	5,34	20
A09 – Flora & Fauna	4,12	5,62	6,65	7,84	6,06	19
A10 – Heritage	5,00	6,54	7,60	8,71	6,96	12
A11 – Archeological site	4,20	5,95	7,19	8,72	6,51	17
A12 – Existing neighborhood image	4,39	6,04	7,17	8,10	6,42	18
A13 – Ownership	5,63	6,81	7,97	9,18	7,40	7
A14 – Administrative support	6,36	7,66	8,77	9,57	8,09	2
A15 – Approval process	5,81	6,99	8,17	9,12	7,52	6
A16 –Support of local residents/users	5,44	6,79	7,98	8,94	7,29	8
A17 – Support of surrounding residents/users	5,49	6,88	7,85	8,88	7,27	9
A18 – Governmental incentives	4,53	6,18	7,49	8,70	6,72	16
A19 – Potential for different land-use	7,00	8,34	9,24	9,85	8,61	1
A20 – Value capturing	4,80	6,23	7,42	8,57	6,75	13
A21 – Liquidation option	4,72	6,33	7,26	8,65	6,74	15
A22 – Current Real Estate Market Value	5,44	6,62	7,67	8,85	7,15	10

In these overall ratings, two attributes are significantly more important than the others: potential for different land-use - A19 and administrative support - A14. We could intuitively also approximate that these attributes are very important. Still they were not present or they were regarded as less important in existing literature. Therefore, popularly used term location, location, location (e.g. De Meirleir, 2006; Salvaneschi & Akin, 1996), indicating obviously that the first and the last thing of a development process is a location can not be supported. Certainly, a location is one of the most important attributes - in our study described with proximity - A01 and accessibility - A02 but neglecting the other attributes could result in misleading conclusions about the development potential. Surprisingly, the contamination level - A05, characteristic for many brownfields, is not ranked in the first ten attributes as well as the liquidation option - A21 a financial instrument connected to the land contamination. We derived two arguments based on this fact. At first, contamination

level is overall regarded as negative in urban environment therefore it is possible that the reaction is to weight this attribute substantially more comparing to other attributes because it is socially preferable. In addition, the choice of the participants is for sure something that influences this ranking. Secondly, as explained earlier in the text, we conducted our survey in the Netherlands. The uncertainty about the contamination of the land is less than in the other countries due to the trust in the institutions obligated to report on that issue. This is linked with the Dutch planning legislation, and it is country specific. Another attribute ranking that was not listed the same as in the existing lists is the land relief - A07. Usually ranked high, this is not the case in our survey. The reason is that the land is mostly flat in the Netherlands. Similar conclusion considering geographical character stands for the soil properties - A08. The ground is mostly sandy and the piles are needed for the larger structures.

To be able to model a decision on 'redevelop a brownfield or not' we need to extract a bundle of attributes to reduce the complexity of their interdependence. Such a model should be robust where designer is aware of its reality abstraction. Different modeling methods require different input thus the number of the necessary attributes could vary. Using a threshold value is one way to select more important attributes. Figure 6-3 shows the number of selected attributes (x-axis) in relation to the set-up threshold value (y-axis). For example, with threshold value 8 we would select 2 attributes while setting the threshold value at 3,5 we would select all 22 attributes. Obviously, as a threshold value lowers more attributes are drawn.
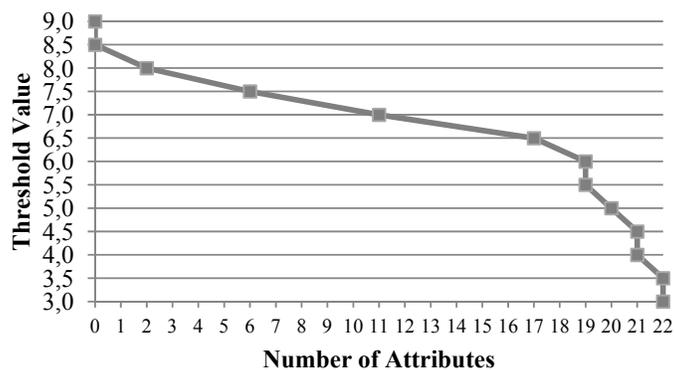
Figure 6-3 Threshold value with corresponding number of brownfield attributes

6.4.2 Different groups' opinion

Besides having an overview based on aggregated ratings, it is interesting to investigate how different groups rated the same attributes (Figure 6-4) differently. While comparing separate groups, experts valued only one attribute: potential for different land-use (A19) as very important for all three groups (threshold above 7.5). Evidently, they have different priorities represented in their ratings.
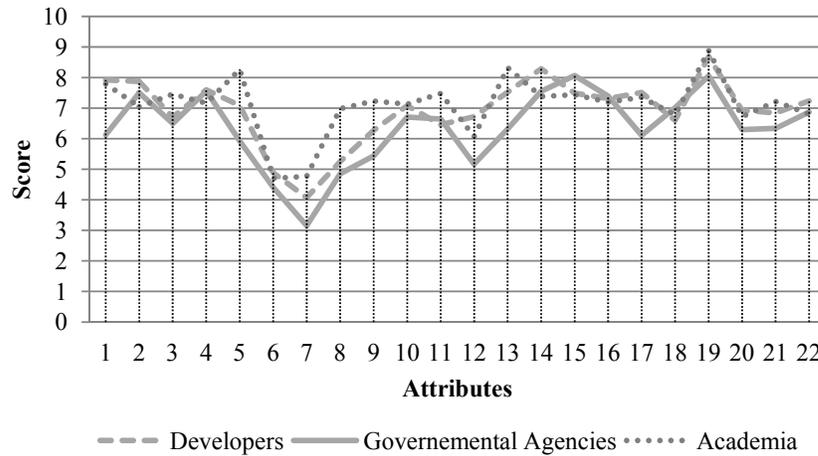
Figure 6-4 Ratings by three expert groups

Two methods were used to explore the level of interdependence between three different groups. Additional to the previous ratings computed with SAM (Hsu & Chen, 1996), SAM is used to analyze the diversity amongst the expert groups toward the specific attribute represented in the agreement matrix. An agreement matrix (Chapter 4.2.4) represents the agreement over an attribute's importance (from 0 to 1, where 0 indicates the most differently weighted opinion) expressed by different expert groups.

Table 6-3 represents one example, the attribute support of the surrounding users/residents - (A17). Developers rated it with 7.51, governmental agencies with 6.11 and academia with 7.35. The differences in ratings correspond to low agreement between developers and governmental agencies (0.2504) as well as for the academia and governmental agencies (0.3308) but high level of the agreement between developers and academia (0.8525).

Table 6-3 Agreement matrix for the A17

A17	Developer	Governmental	Academia
Developer	1	0.2504	0.8525
Governmental		1	0.3308
Academia			1

Secondly, the standard statistical comparison tool One-Way ANOVA revealed the level of differences in the opinions between experts groups regarding attribute's ratings.

This analysis can be used to test whether differences between the statistics from the numerous samples are statistically significant. Comparing developers, government agencies, and academia by assuming equal variances, resulted in presented findings. Analysis proves that there is a statistically significant difference (Table 6-4) between the means of these three rating samples at the 95.0% confidence level. Even more, post hoc

multiple comparison (Table 6-5) evidences that governmental agencies have different opinion than two other groups regarding this specific attribute. This finding is the same as what was revealed in the agreement matrix.

Table 6-4 One-Way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28,216	2	14,108	9,133	,000
Within Groups	412,428	267	1,545		
Total	440,645	269			

Table 6-5 Post Hoc Multiple comparison Tukey (Tukey HSDa,b)

		Subset for alpha = 0.05	
	N	1	2
Governmental	38	6,461608	
Developer	188		7,383728
Academia	44		7,392165
Sig.		1,000	,999

In term of the attribute itself, the conclusion is that developers are more active at the market and realizing its target clients that are actually the surrounding users of the future redeveloped site. Different conclusions but the same procedure and methods are used to analyze all other attributes. In total, there are fifteen attributes that had the relative agreement degree below, equal, or minimally above 0.6 on the scale from 0 to 1, and there is the same number of attributes that ANOVA analyses significantly different at the 95.0% confidence level. Therefore, 68% of all attributes are not regarded similarly by the three different groups of experts.

Previously, we already made a distinction between the various types of developers. Here we will compare the independent developers and contractors as two most influential expert groups for the urban development. These two groups also had the highest response rate that makes following analysis more valid. The comparison procedure and methods are the same as for the previous groups. Relative agreement matrix indicated low level of agreement (0.3606) between these two groups. One-Way ANOVA analysis proved as well that there is a statistically significant difference (0.000) between the means of these two rating samples at the 95.0% confidence level. Regarding all attributes we have the following results: experts had lower agreement degree than 0.6 on eight attributes. Additionally, ANOVA indicated eight attributes that are significantly different at the 95.0% confidence level. The percentage of the attributes

that are not equally important for these two groups of the experts is 27.5% for both methods.

Ratings reveal the importance of brownfield attributes for different expert groups. Based on these ratings and two comparison methods we can conclude that groups of developers, governmental agencies and academia have different opinions on the importance of certain attributes. Evidently, developers and governmental officials have different perspectives on the urban development. Main goals of developers are maximization of the return on invested equity while minimizing time spent and risks. On the opposite, for the governmental officials unclear and conflicting goals are mostly common practice (Dowall, 1989). In addition, differences underline that developers are constantly scanning the market to evaluate the competition while governmental officials are only periodically present at the market (Dowall, 1989). The feedings from this survey evidence the still existing gap between developers and governmental agencies as stated in the reference from 1989. Apart from this plausible conclusion, our data collection and analysis reveals the differences within developer group. Independent developers and contractors differ on importance opinion for 27.5% of all identified attributes as reported. These eight attributes are all rated higher in independent developer group except one. The essential differences between these two groups are the location (accessibility and proximity) and the neighborhood covered by different attributes (neighborhood Image, surrounding users, and local users). These differences can be essential for making the land development policies by authoritative institutions. Also, when a firm is more reliable about the specific priorities of the other parties present at the market it can improve its own position.

6.5 Implications

This chapter provides an insight in the panel data collection, its procedure and the importance of certain brownfield attribute in regards to the development potential. That was accomplished by introducing appropriate hierarchical structure, including experts from the practice to validate and rate the identified attributes from the existing literature and an appropriate method (FDM with SAM) that support both of these two key principles of improvement.

As a result, attributes such as *embedded in the urban fabric* and *administrative support* emerged as very important in every panel in our survey, although they were completely missed in some other literature. In addition, some of the attributes (e.g. *potential for different land use*) did not have the same importance.

Additionally, this chapter shows that the diversification of expert groups is necessary in order to incorporate all attributes for the brownfield redevelopment. In addition, it gives the quantitative proof (by comparing their ratings) of the existing diversities among experts groups and their priorities. For an example, the attribute

embedded in to urban fabric is regarded as very important by independent developers and not by governmental agencies. This and similar differences can be critical or potential negotiation issues between the private and public parties.

A practical implication of the findings can be in development appraisal to help having a decision if a proposed development will be viable by understanding the future marketability and the future costs (Atherton, et al., 2008). Another important side of the development appraisal is determining which variables have the most effect. Our findings indicate these variables or attributes in relation to a brownfield on the urban district scale in the Netherlands.

The FDM has the ability to identify a huge variety of different variables and then downsize them to the manageable number assuring that all effective variables are included in development appraisal. This method also applies for policy-making. As more and more attention has been put on the quantifications of the decision and related parameters, various econometrics models are becoming present in policy-making. Regardless of the methodological and theoretical background of the models, they all have in common the search for the optimum number of the parameters. That number can be regarded as a trade-off between the robustness and the reality abstraction level of a certain model. In the Figure 6-3, the threshold value is such that establishes the optimum number of attributes for the input in discrete choice models often used in policy-making.

Using FDM also helps resolving uncertainty of the experts' sharp distinction in rating the attributes. With this characteristic, the method assures better quality results from the survey. Operationally, it dramatically shortens the time needed to gather the panel data comparing to the classical Delphi procedure.

Future research perspective can be improved by enlarging the number of governmental agencies and academia representatives. That will give more reliability on these groups' preferences toward the brownfield redevelopment attributes.

This chapter provided the input for the potential prescriptive models that support the guidance of a decision-maker within limited cognitive parameters (French, 2001) giving them a better understanding and insights in development process.

7 Actors' preferences of a brownfield potential: Experiment 2

7.1 Introduction

Previous chapter identifies attributes and assures that there is a significant difference over the preference across the different groups of actors.

As a follow-up, this chapter measures these differences based on previously identified attributes. Evidently, from the previous chapter, the typology of the developers influences the preferences of actors' groups. In order to have insight that is more precise in terms of the preferences' variation an additional research is necessary. The related measurement would require the knowledge of the respondents' basic characteristics. Knowledge, such as the experience approximated in the years of work and the involvement in brownfield redevelopment expressed in the number of projects, are important.

For this purpose a specific discrete choice model, the latent class model (LCM) is selected. The use of this specific model has been already indicated in the chapter describing the methodology (Chapter 4.3.5). As mentioned, the LCM can differentiate individual respondents' preferences. That model's main feature allows the creation of new classes that have unique part-worth utilities. By linking this model outcome with

the previous mentioned groups and respondents characteristics, an analyst is able to estimate the condition on the real market and label the potential new groups.

To estimate the model this research uses the stated preference data gathered through the on-line survey with the experts that belong to previously established groups of actors. In this chapter, a reader is informed about the standard, detailed procedure of conducting such an experiment, the analysis of the LCM, and finally identifying and labeling the classes derived from the real market conditions.

7.2   Experimental design for a brownfield redevelopment project

The literature overview of the existing experiments and related quantitative methods concerning the brownfield redevelopment has been thoroughly described in the previous chapter (Chapter 6.2). Besides, the same chapter covers the literature dealing with the problems, issues and major actors in the brownfield redevelopment. This chapter utilizes a discrete choice experiment in the context of the urban development. Several authors have already contributed to this topic (Alberini, et al., 2005; Blokhuis, 2010; Kemperman, 2000; Oppewal, 1995; Shearin & Lieberman, 2001). Within this topic, the specific use of a LCM is rather limited (Kemperman & Timmermans, 2006a, 2006b). This chapter contributes to the existing literature that studies the behavior of the major actors in the urban development by suggesting the use of a LCM.

To be able to estimate a LCM, a stated preference data is required. To collect the data, a discrete choice experiment design has been created. The general procedure how to conduct such an experiment has been described in chapter 4.3.2. In the following paragraphs, this general procedure has been adjusted to the specific case of a brownfield redevelopment and the relevant preselected attributes. Noteworthy to mentioned here is that this experimental design uses the previous findings (Chapter 6) to select the most appropriate attributes while the modification of these attributes are further discussed in the following subchapter 7.2.2.

7.2.1   Problem definition refinement

As indicated previously, this stage of the choice experiment addresses refinements of a problem definition. To be able to address the specific problem at this step, following paragraphs readdress the overall research problem (Chapter 3; Chapter 5). At first, an assumption is made that stagnation in a brownfield redevelopment can be fasten-up by public-private partnerships. Further, hypothesis underlines that in order to engage a developer as a representative of private parties, a municipality as a public party should offer an optimal deal. Therefore, the overall research goal is to find an optimal deal in these negotiations. To enable this contribution, this chapter specifies the classes that are present at the real brownfield redevelopment market by measuring their preferences and labeling the classes.

To be able to refine a problem definition, it is important to name the beneficiary of an experiment. Primarily, this single experiment has an explanatory role thus no specific beneficiary is identified. Although, related to the overall research goal and later applications the beneficiaries could be both the municipalities and the developers. More about the application of this model can be found in following chapters (Chapter 10.3.2; Chapter 10.3.3). An important part of a definition refinement is to describe the settings of a decision moment. Similar to previous experiment, the controlled settings of this experiment is reached by: (1) a proper brownfield definition (Alker, et al., 2000); (2) the indication of a development phase (initiative and land acquisition phase), (3) stated size of the site (1-10 hectares), (4) given the future land-use (mix-used), (5) specified region (the Netherlands), and (6) defined ownership of the land (owned by a municipality).

7.2.2 Stimuli refinement: Alternatives, attributes and attributes levels

At this stage of a choice experiment, it is important to establish all existing alternatives, the most important attributes and argue for the most appropriate levels of the attributes.

To start identifying the alternatives, at first it is important to make a difference between the term alternatives used earlier in the thesis (chapter 3.2.2) and the same term in the context of discrete choice models. Earlier in the text, the *alternative investment opportunities* were discussed instead of the choice alternatives. Each of these investment opportunities could be transformed into the experiment where one choice alternative corresponds to one of the investment opportunities. That would be a different problem definition thus out of the scope of this research. For example, an analyst could design an experiment in which respondent (e.g. developer) chooses between two choice alternatives a greenfield and brownfield site.

This experiment uses unlabeled or generic alternative choices (e.g. Hensher, et al., 2005). In this case, the only way to differentiate over the alternatives is via the attributes and their levels. Furthermore, two generic alternatives are introduced: *Brownfield 1* and *Brownfield 2*.

Although there are many approaches to select the most important attributes relevant to certain problem (Chapter 4.3.2), the attributes elaborated in this experiment derived from a fuzzy Delphi method (FDM). The FDM has been explained previously (Chapter 4.2) as well as the experiment and related findings. These findings represent the input for this experiment. However, some modifications were necessary, at the end that is the point of a refinement. These modifications are mostly related to the rules of thumbs that the most appropriate number of attributes for modeling is between 7 and 10 attributes (e.g. Hensher, et al., 2005). Concerning this rule, it was necessary to disregard the attributes that are not ranked within the top 10 out of 22 attributes established by the overall rankings with the FDM (Table 6-2).

In addition, some modifications were made within the established list. First, attributes *accessibility* and *proximity* were merged. This is due to the very high

correlation investigated on the same rating sample from the 35 respondents over the 22 attributes. As an aside, Kendell's tau correlation (Appendix C) is used as a standard statistical test for non-parametric dependencies, and specifically it measures rank correlation. The same reasoning and a same modification is employed for the attributes: *support of local users* and *support of surrounding users*. Secondly, the attribute *embeddedness in the urban fabric* was reformulated due to the correlation with the previous mentioned attribute. Further, the ownership was necessary to be defined as the context of the decision moment (Samsura, et al., 2010). Therefore, previously described attribute *ownership* (Table 6-1) has been formally removed. Although, its physical representation in the urban space – *parcellation* has been formulated as a new attribute. In addition, the attribute *current real estate market value* is completely removed. This is done because the pricing is regarded as a very specific part in discrete choice experiments and requires special treatment (e.g. Hensher, et al., 2005). Mainly due to the price-quality heuristics where a price acts as proxy for the quality. Although very relevant issue, this attribute is out of the research scope. Finally, one attribute is added - *building claim*. Having or not a building claim is an important part of development strategies within a public-private partnership. This attribute is specific for public-private partnerships in urban development thus it was not present at the previous experiment. Therefore, the table of attributes used for the further modeling is present below (Table 7-1).

Table 7-1 Attributes and their levels

Attribute	Description	Levels
Building claim (BC)	Contract that gives a priority right to a developer that participate in joint venture to build on serviced and parcellated land.	•available •not available
Potential for different land use (LU)	Defines a possibility that each land use may be realized to its extreme within the mix-used zoning plan.	•high •medium •low
Parcellation (P)	Defines a possibility to influence the size and the shape of all parcels on the land that will be redeveloped.	•high •medium •low
Location (L)	Location refers to the proximity and accessibility of a site. Where the proximity is a distance to the key city locations (e.g. CBD); and accessibility how good is the access to the site by car and public transport.	•excellent •moderate •poor
Embeddedness - infrstructural change (E)	Extent to which the redevelopment area can be integrated into the existing urban fabric.	•small •moderate •serious
Administrative support (AS)	Transparency and perceptions of continuity in governance, politics and the bureaucracy.	•excellent •moderate •poor
Synergy with surrounding users (S)	The extent to which the surrounding area inhabitants/users support the redevelopment.	•completely •occasionally •rarely

As presented in the table above, most of the attributes in this experiment have three levels. This is the minimal number of levels if an analyst wants to estimate non-liner relationship in the utility over the attribute. This relationship would stay unnoticed otherwise. In addition, this experiment uses an ordinal scale for the attributes' levels; thus, the description of the levels could be ambiguous to some of the respondents. In this case, having non-linear utility is highly advisable (e.g. Hensher, et al., 2005). Only the building claim attribute has two levels. These two levels represent the only two conditions that are present in the urban development partnerships: having or not having a building claim in a certain offer.

A special attention is given to the refinement of the alternatives, attributes and their levels. To support the importance of this stage of the experiment, the most quoted statistician axiom can be used: "garbage in, garbage out". The meaning is self-explanatory.

As an aside, to make a questionnaire easier for the respondents, an analyst could implement pictures and/or pictograms for each of the levels (e.g. Janssen, 2011). Unfortunately, required symbols in this experiment would either indicate linearity between the levels or bring confusion.

7.2.3 Experimental design consideration

This subchapter considers all the features influencing the size of an experimental design. As shown in chapter 4.3.2, the most general design - named full factorial design is usually too demanding. This is reflected either through the need for a large number of respondents or through the amount of time one respondent needs. In this research, there are six 3-level attributes and one 2-level attribute. Therefore, a full factorial design for an unlabeled experiment is L^A (L is number of levels and A is number of attributes) making it: 3^6 x 2^1 = 1458 treatment combinations. Evidently, the size of this experiment needs to be reduced.

Unlabeled choice treatment combination

As mentioned in previous paragraph, this experiment uses two unlabeled alternatives: Brownfield 1 and Brownfield 2. Although, it is technically possible to estimate each of these two function-utilities, it makes no sense since the alternatives are not recognizable. Therefore, the estimated utility corresponds to the general class of brownfields. Introducing unlabeled alternative has the following operational benefit. The degrees of freedom will be lower because only one constant parameter will be estimated independent of how many alternatives there are. In the case of unlabeled experiments, the orthogonality (Chapter 4.3.2) remains an important issue. Fortunately, an attribute that appears in more alternatives has to be only orthogonal within-alternative (e.g. Hensher, et al., 2005).

Reducing the numbers of levels

When reducing the number of attributes level experimental design is considerably smaller. Still this comes with the costs considering the amount of information that is gathered. Authors (e.g. Hensher, et al., 2005) suggested that two-level attributes can be used if there are linear relationships between part-worth utilities. In another case, the two-level attributes could be used when an experiment has the exploratory role. Neither of these two cases is present at this experiment, therefore the initial number of levels is not changed.

Main and interaction effects

Besides the levels of attributes, design size is significantly influenced by the analyst decision to investigate either the main effects only or the interaction effects as well. This experiment allows the following: (1) all attributes' non-linear main effect; (2) three non-linear two-way interaction effects in which two effects combine one 2 level and one 3 level attribute and one effect combines two 3 level attributes; (3) if we want to estimate also non-linear three-way interaction effect then we would have 28 degrees of freedom, more than possible with the promising experiment design that allows 27 degrees of freedom. Still, it is possible to estimate a linear three-way interaction effect. Formally, it can be expressed as follows in the equation (7.1).

$$
\begin{aligned}
V_i = \ & \beta_{0i} + \beta_{1i} \times f(X_{1i}) + \beta_{2i} \times f(X_{2i}) + \beta_{2bi} \times f(X_{2bi}) + \beta_{3i} \times f(X_{3i}) \\
& + \beta_{3bi} \times f(X_{3bi}) + \beta_{4i} \times f(X_{4i}) + \beta_{4bi} \times f(X_{4bi}) + \beta_{5i} \\
& \times f(X_{5i}) + \beta_{5bi} \times f(X_{5bi}) + \beta_{6i} \times f(X_{6i}) + \beta_{6bi} \times f(X_{6bi}) \\
& + \beta_{7i} \times f(X_{7i}) + \beta_{7bi} \times f(X_{7bi}) + \beta_{ki} \times f(X_{1i}X_{2i}) + \beta_{kbi} \\
& \times f(X_{1i}X_{2bi}) + \beta_{li} \times f(X_{1i}X_{3i}) + \beta_{lbi} \times f(X_{1i}X_{3bi}) + \beta_{m1i} \\
& \times f(X_{2i}X_{3i}) + \beta_{m2i} \times f(X_{2bi}X_{3i}) + \beta_{m3i} \times f(X_{2i}X_{3bi}) + \beta_{m4i} \\
& \times f(X_{2bi}X_{3bi}) + \beta_{ji} \times f(X_{1i}X_{2i}X_{3i})
\end{aligned}
\tag{7.1}
$$

Where V_i is the brownfield utility for the alternative i that is generic in this case; β_{0i} is a parameter not associated with any observed and measured attribute, called the alternative specific constant which represent on average the role of all the unobserved sources of utility. β_{1i} is the weight (or parameter) associated with attribute X_1 and alternative i; $f(X_{1i}X_{2i})$ is a two-way interaction between the attributes and β_{ki} is the interaction effect; $f(X_{1i}X_{2i}X_{3i})$ is a three-way interaction and β_{ji} related effect.

Required degrees of freedom

In general, degrees of freedom required for a model estimation depends on how the utility functions is formulated in equation (7.1). Still, there are the two simple equations that help to estimate the required degrees of freedom (Hensher, et al., 2005). Minimum treatment combination for non-labeled main effects assumed non-linear effects is *(L-1)*

x A + 1 where *L* is number of levels and *A* is a number of attributes. At the end of the previous expression, one additional degree of freedom (*+1*) is reserved for the random component. Additional expression is also required, it estimates the two-ways interaction terms from non-linear main effect: *(L1-1) x (L2-1)*. Based on these two expressions and assuming the following: (1) unlabeled alternative; (2) non-linear main effects for six 3 level attributes and one 2 level attribute; (3) non-linear two-way inter-effects, two effects for the combined attributes of 3 level and 2 level and one effect for the combined attributes of 3 level each; (4) One linear three-way interaction effect; (5) alternative specific constant; (6) one random component associated to the MNL model. These assumptions require 24 degree of freedom required in this experiment:

$$
\begin{aligned}
(2) \quad & (3\text{-}1) \; x \; 6 + (2\text{-}1) \; x \; 1+ \\
(3) \quad & +2 \; x \; (2\text{-}1) \; x \; (3\text{-}1) \; +(3\text{-}1) \; x \; (3\text{-}1) \; + \\
(4) \quad & + \; 1 \; + \\
(5) \quad & +1+ \\
(6) \quad & +1= \\
& = 24
\end{aligned}
\tag{7.2}
$$

7.2.4   Generating experimental design

According to the previously assumed degrees of freedom and given the seven attributes (one with two levels and the others with three levels each) that are used in a model, it is possible to generate an experimental design.

A search for an orthogonal array shows that the smallest number of treatment is 27 not 24 as calculated by the previous equation (7.2). To select a proper treatment combination this experiment utilizes already defined orthogonal designs (Hahn & Shapiro, 1966). Specifically, the experiment is registered by the experimental plan code - 39b (Hahn & Shapiro, 1966). This experimental plan satisfied the previous assumption that needs to be tested and the plan (Hahn & Shapiro, 1966) is chosen. The plan specifies which columns are to be selected from the orthogonal design table. In addition, the plan defines which attributes need to be placed in which columns in order to properly estimate two-way interaction effects. Therefore, the columns satisfying the orthogonality in this experiment are: 1, 2, 5, 10, 11, 12, 13.

Allocating the attributes is the next important issue. The allocation of the attributes comes as crucial for the ones that will be tested for two-way interactions. In this experiment, only three attributes can be estimated and they are allocated to the columns 1,2,5 in the previously mentioned orthogonal design (Hahn & Shapiro, 1966). Those attributes are building claim, potential different land use and parcellation (Table 7-2). Already defined orthogonal design assures that the main effects and three two-way interaction effects are *un-confounded* with each other.

Table 7-2 Attributes allocation and the treatment combinations in orthogonal code

Treatment combination	Attributes allocation						
	BC	LU	P	L	E	AS	S
1	0	0	0	0	0	0	0
2	0	0	1	1	2	1	2
3	0	0	2	2	1	2	1
4	0	1	0	1	1	2	2
5	0	1	1	2	0	0	1
6	0	1	2	0	2	1	0
7	0	2	0	2	2	1	1
8	0	2	1	0	1	2	0
9	0	2	2	1	0	0	2
10	1	0	0	1	1	1	1
11	1	0	1	2	0	2	0
12	1	0	2	0	2	0	2
13	1	1	0	2	2	0	0
14	1	1	1	0	1	1	2
15	1	1	2	1	0	2	1
16	1	2	0	0	0	2	2
17	1	2	1	1	2	0	1
18	1	2	2	2	1	1	0
19	0	0	0	2	2	2	2
20	0	0	1	0	1	0	1
21	0	0	2	1	0	1	0
22	0	1	0	0	0	1	1
23	0	1	1	1	2	2	0
24	0	1	2	2	1	0	2
25	0	2	0	1	1	0	0
26	0	2	1	2	0	1	2
27	0	2	2	0	2	2	1

7.2.5   Questionnaire design

In the previous stage of the experimental design, descriptive attribute-level labels were replaced with the coding structure in order to construct the statistically valid experiment. At this point, the cognitively meaningful attributes levels are attached to previously coded attributes' levels. Recall that each row is named a *treatment combination* and consists of attribute levels that are related directly to a set of attributes, which are in turn related specifically to a set of alternatives. Below is an example from the survey (Figure 7-1). Here each alternative is an independent treatment combination. In this experiment, there are two generic alternatives in the flowing choice set plus one *none* alternative. Each of the alternatives consists of seven attributes that are descriptive or qualitative (using the ordinal scale). In this case, having more than two alternatives would be hard choice task for a respondent. Besides this, the choice task is less time demanding when the respondent chooses between two alternatives compared to three or more thus this makes the whole survey more efficient.

Figure 7-1 Choice set example

As mentioned in the chapter describing the experimental procedure (Chapter 4.3.2), randomization of the choice sets is yet to be formally studied. Although it is ideal to have complete randomization, this was technically not possible. On the other hand, having one questionnaire with the same choice sets is not acceptable. Every experiment is unique and has certain boundaries. Due to the expected low response rate, this experiment is created to receive as much as possible responses per one respondent. In addition, in the latent class model (the type of model to be estimated) respondents are classified based on their individual choices in the experiment. In both cases, having a full treatment combination (1-27) per one respondent is regarded as beneficial. As argued previously the choice set consist of two alternatives. Since the number of treatment combination (27) is not dividable by two, thus one extra treatment is added forming now 28 treatment combinations per respondent. This extra treatment combination is randomly added from the existing set of treatment combinations (1-27) while all other 27 treatments are randomized. Finally, a single respondent has to answer on the 14 choice sets. One example follows (Table 7-3). On this principle, 27 unique questionnaires are designed, thus making 378 different choice sets in total. As an aside, the number of questionnaires (27) does not have any connection with the selected number of treatment (27). The same number in this experiment is a pure coincidence.

Table 7-3 An example of a choice sets and treatment combination per one respondent

Choice set	Alt1	Alt2
1	23	26
2	5	12
3	20	17
4	2	15
5	8	3
6	19	23
7	6	24
8	10	13
9	9	21
10	14	27
11	1	22
12	11	25
13	4	18
14	16	7

When the number of 27 questionnaires is reached, the survey automatically starts a new round with the same questionnaires. Such a randomization was enabled mainly due to the on-line survey tool. That allows automatically that every registered entry on the web page is served a new questionnaire. The employed on-line survey tool has an additional advantage and that is a full customization regarding the choice design.

7.3 Data collection

This subchapter describes the content and procedure of gathering the data sample. First, the sample size is described and the response rate is reported. All the data was gathered by the on-line survey *Berg Enquête System © 2007*. The on-line survey was available at the address: http://praatgraag.ddss.nl/Brownfields. This web page was opened for the experts from April to September 2011.

7.3.1 Sample size

The minimum requirement of this experiment is determined by the rule of thumbs that each alternative needs to be judged at least 30 times for less homogeneous groups. This is necessary to estimate reliably the assumed choice model (latent class model). Since 27 treatment combinations are created and each respondent filled in 14 choice sets with paired treatments, the minimum number of respondent is 29.

The similar groups of respondents to the previous experiment were investigated (Chapter 6.3.1): (1) independent developers; (2) contractors; (3) asset developers; (4) development agencies; (5) municipalities. All together, 111 experts completed correctly the experiment to the end. Only these respondents were included in the estimation of the latent class model. In further paragraphs, the group affiliation is partly estimated by the respondents' characteristics, more about this notion in the following subchapter.

7.3.2 Response rate

Similar as in the previous experiment, the most of the potential responders were contact through the personal e-mail (497) and through the company e-mail (73).

Additionally, a real estate fair PROVADA 2011 was attempted. Although, the flyers were distributed (500) in order to promote the survey, this did not have a significant increase in the number of visits on the web page of the survey (20).

In total, 563 experts visited the web page. Since only the 20 visits were due to the fieldwork, it is easy to conclude that all potential respondents reached by the e-mail visited the web page. Due to the various ways to approach the respondents, it is hard to estimate the success of the response rate based on initial invitation. Therefore, here it is the indicated repose rate just based on the visits on the web page - 19, 72 %.

7.4 Respondents characteristics

As mentioned previously, the respondents in this experiment have a different background. This section describes them.

7.4.1 Types of respondents

The type of respondent (respondent's background) is regarded in this experiment as a characteristic. This characteristic besides the others is used to established the class that correspondents to the behavior at the real market conditions. This is typical for any latent class model (LCM). However, the main input to established proper classes remains the individual choices of the respondents. This is the crucial feature of the LCM and results in labeling of these "new" classes.

In the following Table 7-4 represents respondent's profile frequencies respectively, as they respond in the questionnaire (1) independent developers; (2) contractors; (3) asset developers; (4) development agencies; (5) municipalities.

Table 7-4 Type of respondents

Type of respondent	Frequency	Percent
(1) independent developers	25	22,5
(2) contractors	29	26,1
(3) asset developers	16	14,4
(4) development agencies	15	13,5
(5) municipalities	26	23,4
total	111	100,0

7.4.2 Years of experience and brownfield experience

The histogram in the following Figure 7-2 shows that than major groups are respondents of 5, 10 but also 15 years experience this is probably due to the respondents averaging of their year experience.
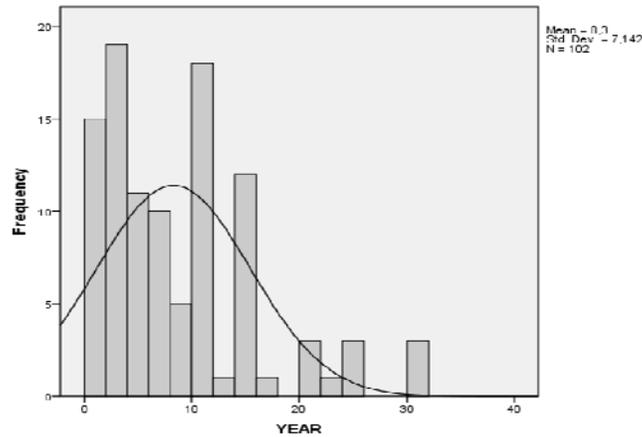
Figure 7-2 Histogram for years of experience

In order to use this parameter as variable in discrete choice two codes are use: (1) respondents have less then 10 years of experience (2) respondents have 10 or more years of experience. This distinction is made because the most of the responses gravitate to 5 years of experience and gradually dropping until the 10 years of experience. Then for the second group we have the same, the most respondents have the 10 years of experience and their experience drop until 30 years of experience. Based on this two-folded distinction, the respondents were coded as (1) and (2). These two groups have the following frequencies (Table 7-5). In addition, this table shows also the frequencies and percentages if a respondent has been involved in brownfield redevelopment project or not.

Table 7-5 Characteristics: Years and brownfield experience

Characteristic	(Code) Levels	Frequency	Percent
Years of experience	(1) < 10 years	66	59,5
	(2) ≥ 10 years	45	40,5
Brownfield experience	(1) Yes	43	38,7
	(2) No	68	61,3

In the following histogram (Figure 7-3), we can see that there are more experience persons involved in any brownfield redevelopment project. Obviously, with more years in practice there is a higher chance that a respondent was involved in a brownfield redevelopment project.
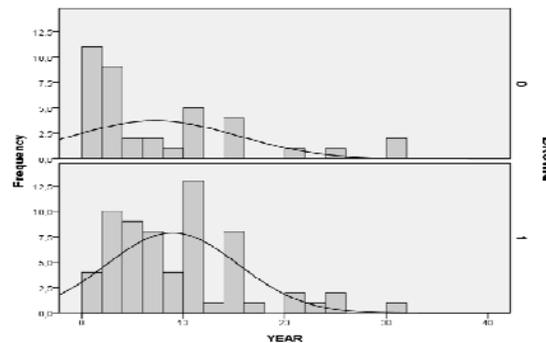

Figure 7-3 Histogram for years of experience and brownfield involvement

7.4.3 Cross tabulation

The following table (Table 7-6) represents the crosstabaulation between the type of respondents and their years of experience. It reports within the counted persons or frequencies and the percentages. The figure below (Figure 7-4) is related to the previous table where both the frequencies and percents are reported. This figure represents only the percentages of the years of experience within each of the respondents' type. Evidently, the types (3) - asset developers and (4) - development agencies, have more professional experience compared to the other types in this experiment. This finding is branch specific and relates to the fact that working within these two branches is usually not a starting career positions.

Table 7-6 Crosstabulation: Type of respondents vs. years of experience

Type of respondent	Frequencies			Percents		
	< 10y	≥ 10 y	Total	< 10y	≥ 10 y	Total
(1) independent developers	16	9	25	64	36	100
(2) contractors	19	10	29	66	34	100
(3) asset developers	8	8	16	50	50	100
(4) development agencies	6	9	15	40	60	100
(5) municipalities	17	9	26	65	35	100
total	66	45	111	/	/	/
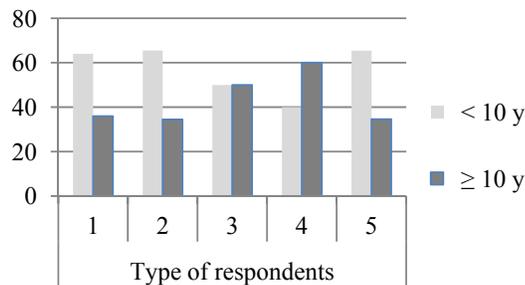
Figure 7-4 Crosstabulation: Type of respondents vs. years of experience

Similarly, below (Table 7-7) it is presented the crosstabulation between the types of respondents and the participation in brownfield redevelopment projects. There is a notable difference of brownfield project participation within the types (1) independent developer and (4) development agency. This is also regarded as specific characteristic for those two groups. Considering the group (1), there are not many "felix location projects" available. Therefore, developers are aiming for the reconstruction projects. On the other hand, one of the main goals of the group (4) is to boost the local economy and a reconstruction of a brownfield is one of the most possible actions. In addition, the minimal number of respondents experienced in the brownfield redevelopment is settled in the type (3). This is also type specific since the asset developers mostly adjust their portfolio primarily by acquiring already (re)develop sites or tend to develop a completely new site.

Table 7-7 Crosstabulation: Type of respondents vs. brownfield experience

| Type of respondent	Frequencies			Percents		
	No	Yes	Total	No	Yes	Total
(1) independent developers	7	18	25	28	72	100
(2) contractors	13	16	29	45	55	100
(3) asset developers	9	7	16	56	44	100
(4) development agencies	2	13	15	13	87	100
(5) municipalities	12	14	26	46	54	100
total	43	68	111	/	/	/
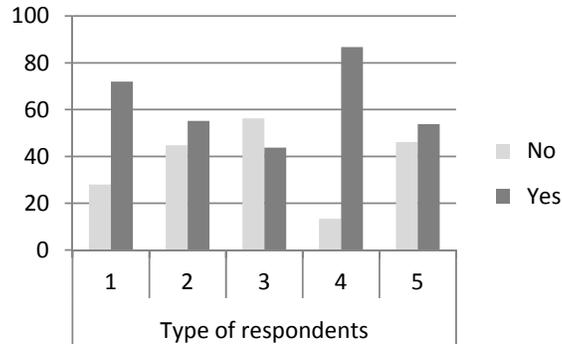
Figure 7-5 Crosstabulation: Type of respondents vs. brownfield experience

7.5   Latent class model estimation

As previously discussed (Chapter 4.3.5), a latent class model (LCM) detects the classes of respondents that have different preferences. Besides, it estimates the utilities for each class. Although the classes could have respondents with relatively similar characteristics, the preference could vary significantly from class to class. A single respondent is not strictly affiliated to one class. Contrary, each respondent is considered to have a probability of belonging to the certain class. If the solution fits the data very well, then those probabilities reach 0 or 1.

This research uses the econometric package *NLOGIT 4.0* (Greene, 2008) that allows estimating the LCM as well. In general, estimation has the following procedure. First, initially program selects random estimates of each class utilities. Secondly, the program uses each class utilities to fit the respondent's data, and estimates the probabilities of each respondent affiliation to that group. Afterward, using those probabilities as weights, program re-estimates the logit weights for each class and accumulates the maximal log likelihood over all classes. Finally, the program repeats previous two steps until the log likelihood improves and stops after the improvement is not significant any more (the convergence limit).

As a rule of the thumb, this model is estimated for the minimum of two classes up to five-class model. In addition, the estimations of these classes are compared to MNL model in order to assess the relative gain of introducing LCM.

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Coding

As argued previously non-linear coding performs better than the linear coding (Chapter 4.3.2). Still, there are two approaches, this research favors the effect coding over the dummy coding. In the case of dummy coding the base level (e.g. low) is actually not measured and we have only measured the average overall utility (Hensher, et al., 2005). This is not the case with effect coding and at the same time reason to be employed in this experiment. Below, the coding of a 3-level attribute is presented (Table 7-8).

Table 7-8 Effect coding for the attribute: future land use influence

Attribute level	LU1	LU2
High	-1	-1
Medium	0	1
Low	1	0

7.5.1 Model performance

In estimating LCM, the number of classes (*C*) cannot be pre-defined. Therefore, the statistical criterion must be used to select the optimal number of classes. In general, the selection of the number of classes is a tradeoff between the improvement in the log likelihood values and the augmenting number of parameters that are added. More specific, several authors suggested the following criterions: Akaike Informaiton Criterion - AIC (e.g. Kamakura & Russell, 1989) and Bayesian Information Criterion - BIC (e.g. Allenby, 1990). Still these criterions and are to be used as a guideline not as a must. Conventional rules to determine the number of classes do not exist. Rather, the arbitrary judgments play a role in the final selection of the number of classes (*C*). The calculations of these criterions are shown in the paragraph below.

The following model estimation is based on the sample size of 4,662 choices from the 111 respondents (*N*). The table below (Table 7-9) shows the performance for the models MNL and LCM up to the five classes. Where ρ^2 is calculated as *{1 - [LL / LL (0)]}*, AIC is calculated using *[-2(LL-P)]* and BIC is calculated using *{-LL + [P/2*ln(N)]}*.

Table 7-9 Model performance

Class #	Parameter #	ρ^2	AIC	BIC
1	14	0,21102	1,65892	1,70710
2	29	0,29885	1,57790	1,67771
3	44	0,31925	1,55239	1,70383
4	59	0,34055	1,52489	1,72796
5	74	0,35289	1,51709	1,77179

In this experiment, the log likelihood values are improving when the new parameters are added, as expected. That is evident when observing the third column (ρ^2) that increases from the base model (MNL) at 0,21 to 0,35 with the 5-class LCM. This information suggests that there is heterogeneity within the data. In addition, the value

distance between the ρ^2 of the MNL model and the 2-class LCM clearly indicates that the LCM outperforms the MNL model. Still, this information does not suggest how many classes there are although the improvement drops after the 4-class model.

Therefore, to indicate the number of classes additional information is needed. First the value of AIC is smaller as the number of classes increase thus indicating the minimal value with the 5-class model. However, the change in AIC value from the 4- to 5-class model is much smaller than the change between 3- to 4-class model and 2- to 3-class model. That suggests that adding the classes beyond the 4th do not gain much of the improvement. Secondly, the minimum BIC is associated with the 2-class model. It is noteworthy that the values significantly rise after the 4-class model.

It is more advisable to look at the value differences, rather then choosing a solution that provides the highest value of any of the criterions' statistics. Given the information in the previous table (Table 7-9), two additional figures were provided to support the previous argumentation. The first figure (Figure 7-6) pictures the tradeoffs between the number of parameters and ρ^2.
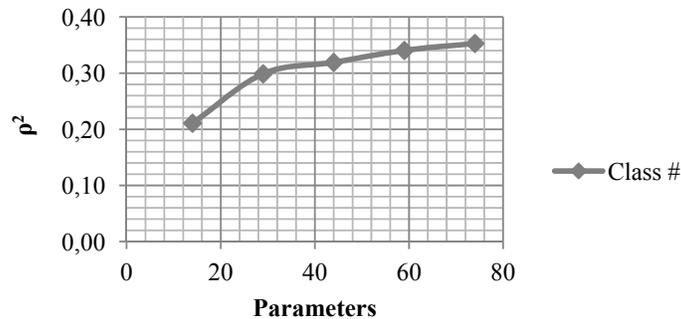
**Figure 7-6 Tradeoff between Parameter # and ρ^2**
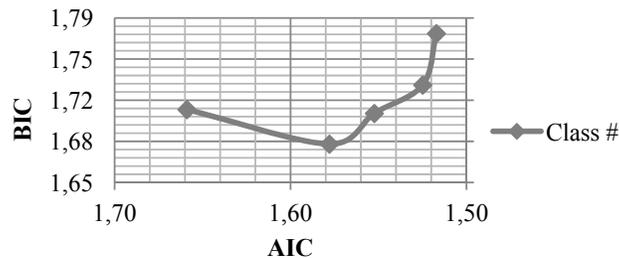
Figure 7-7 AIC and BIC

A second (Figure 7-7) represents the values of two criterions: AIC and BIC. That figure visually supports the previous argumentation that having more than the four classes does not provide sufficient improvement in performance. In addition, 2- and 4-class models outperform the 3-class model. This can be seen (Figure 7-6; Figure7-7) as

an obvious scatter from the smooth dependency behavior (between the number of parameters and ρ^2 value, and between AIC and BIC, respectively) especially related to the 3-class model. Still, to be able to establish the best choice for the model further information is necessary.

7.5.2 Relative class size

When choosing among the 2- to 5-class models, more information is available to make a better choice as an analyst. The following two tables (Table 7-10; Table 7-11) provide the patterns of estimated groups' size expressed as relative class size and the division of the respondents, respectively. For the lower table, each individual can be classified into the group for which he or she has the highest probability according to their utilities (Table 7-12).

Table 7-10 Relative class size

Class #	Relative class size				
1	1,000	/	/	/	/
2	0,409	0,591	/	/	/
3	0,400	0,115[b]	0,486	/	/
4	0,316	0,313	0,165	0,206	/
5	0,321	0,166	0,060[a]	0,194	0,259

Table 7-11 Number of respondents

Class #	Number of respondents				
1	111	/	/	/	/
2	44	67	/	/	/
3	45	12[b]	54	/	/
4	35	34	20	22	/
5	36	19	7 [a]	21	28

For the ([a]) there is *not* a statistically significant difference at the 90.0% confidence level and this solution should be disqualified on this basis. Although for the ([b]) there is a statistically significant difference at the 90.0% confidence level, it is still less than the other estimated classes in every model. This is influenced by the smaller size of this group. Here it is noteworthy, to address the patterns that occurs over the 2-, 3-, and 4-class model. Following the relative size and even more the number of the responds within certain class, the splits are traceable starting from the lower number class to the higher number class. For example, the second group in the 2-class model splits into the group two and three in the 3-class model almost perfectly. That means that the preference of the group one in the 2- and 3- class model are almost the same. This is not the case when comparing the 2- and 4-class model. Here the group one from the 2-class model splits into the group three and four in the 4-class model. Moreover, the group two from the 2-class model splits into the groups one and two in the 4-class model. The split is not perfect but still traceable. Besides having a supportive roll in choosing the best

class model, these "splitting" patterns could be more important when labeling the identified classes.

7.5.3   Estimated parameters over the classes

Very important information is the estimated utilities provided by each solution. In the example below (Table 7-12), the estimated parameters of the MNL and 4-class LCM are presented. On the fist glance, aggregated (single class) MNL model indicate that all the attributes are statistically significant at the 95.0% confidence level. That is a good indication since each of the LCM model is further elaborated on the basis of the simple MNL model. To establish the proper classes the variable that indicates the general attitude toward the brownfield redevelopment (PSC) is observed at first. This is followed by the observation of the other attributes, elaborated further in the same table. The same procedure is repeated for every solution determined before in the text. Here only the 4-class model is presented.

Table 7-12 Estimated parameters

| Variable | MNL | | LCM - 4 class model | | | | | | | |
| | / | | Class 1 | | Class 2 | | Class 3 | | Class 4 | |
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
BC	**-0,220**	0,000	-0,209	0,138	**0,117**	0,046	0,022	0,861	**-1,253**	0,000
LU1	**-0,318**	0,000	**-0,371**	0,035	-0,083	0,252	**-1,020**	0,000	**-0,612**	0,000
LU2	0,079	0,194	-0,049	0,763	0,024	0,767	**0,564**	0,001	0,070	0,608
P1	**-0,239**	0,000	**-0,855**	0,000	-0,015	0,859	**-0,639**	0,000	**-0,447**	0,001
P2	0,048	0,434	0,105	0,504	**-0,163**	0,033	**0,518**	0,005	**0,322**	0,017
L1	**-1,196**	0,000	**-3,655**	0,000	**-0,493**	0,000	**-1,166**	0,000	**-1,620**	0,000
L2	0,077	0,225	**0,765**	0,000	-0,045	0,578	-0,086	0,623	0,275	0,060
E1	**-0,263**	0,000	**-0,731**	0,001	-0,083	0,304	-0,165	0,331	**-0,682**	0,000
E2	0,088	0,169	0,202	0,334	0,127	0,130	**0,335**	0,047	0,082	0,554
AS1	**-0,898**	0,000	**-1,105**	0,000	**-0,796**	0,000	**-2,453**	0,000	**-0,994**	0,000
AS2	**0,335**	0,000	0,365	0,062	**0,247**	0,005	**1,176**	0,000	0,174	0,203
S1	**-0,699**	0,000	**-0,882**	0,000	**-0,583**	0,000	**-1,426**	0,000	**-0,896**	0,000
S2	0,092	0,124	0,163	0,306	-0,020	0,805	0,175	0,296	**0,303**	0,021
PSC	**-0,619**	0,000	0,171	0,462	**-1,913**	0,000	**1,268**	0,000	**-1,374**	0,000

At first, it is important to formulate the variable PSC. As said previously this could be regarded as variable that indicates the general attitude toward the redevelopment of the brownfield. This refers to the *none option* in the every choice set task (Figure 7-1). The attitude can be positive or negative. This is indicated with the sign of the variables' coefficient. This variable is coded differently than the rest. Here the values in minus mean that it is negative to choose "none option" thus these respondents or a class are positive toward the brownfield redevelopment in general and vice versa. Additionally, the significance of the variable is also important. As for any variable if the coefficient is higher, the more affect the variable PSC has on the overall preference of a certain class.

For the class 1, the PSC variable is not significant. That means that this class of respondents regards the redevelopment as any development. This is clearer, when the location variable (L1) is observed as well. Its impact is far more important then any attribute in all other classes (-3,655). To illustrate this, simplified notion for this group can be used: "If the location is good it does not matter whether it is a brownfield or a greenfield investment". Class 2 and class 4, have a very positive attitude toward the redevelopment. Contrary, class 3 has a very negative attitude toward the brownfield redevelopment.

As an aside, for all solutions the 3 two-way inter effects and 1 three -way inter effect were found not significant. Therefore, they were not reported in the table above.

7.5.4 Crosstabulation over the 4-class model

Additional source of information certainly is provided with the respondents characteristics. By using the LCM, these characteristics can be used to set the additional variables for estimating any model. In this experiment, these solutions did not provide better performance. Still, the same characteristics provide very important information to link the respondent preference with their characteristics. This cannot be neglected especially when the LCM is used to assess the relevance of the new classes. The table below (Table 7-13) represent the cross tabulation of classes and the type of respondents, at first expressed by the counted number of respondents and then followed by the percentages. The figure related to the percentages is also presented (Figure 7-7). Similar as for the previous subchapter, the crosstabulations were investigated over all solutions and only the adopted solution is presented.

Table 7-13 Crosstabulation: 4 classes vs. types of repsondents

| Class	Frequencies					Percents				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Class 1	11	8	5	4	6	32	24	15	12	18
Class 2	6	9	3	7	10	17	26	9	20	29
Class 3	3	6	3	2	6	15	30	15	10	30
Class 4	5	6	5	2	4	23	27	23	9	18
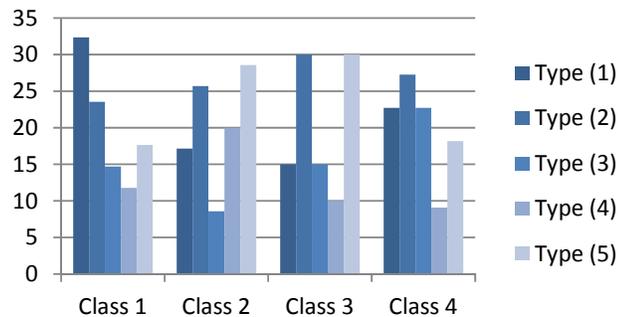
Figure 7-7 Crosstabulation: four classes vs. type of repsondents

The differences between the classes' characteristics in the regard of type of respondents are evident. The main difference is a division of public and private actors. In class 1 and class 4, private actors are dominant: (1) independent developers, (2) contractors, and (3) asset developers. While the class 2 and class 3 are dominated by the public parties: (4) regional development agencies (5) municipalities. The only respondent type that tends to have equally distribution over the class is the contractor (2). This is mainly due to their core competence. To be more precise, the contractors are in charge for the site construction and their development role is subordinated to this. In that task, they are hired either by a public or by a private actor. This is probably the main reason why the preferences of the contractors are equally spread within the identified public and private classes. Thus, the contractors behave in accord to these preferences. In addition, the preference in the first two stage of development for this type of respondents could be biased. This is mainly due to the reason that the contractors contribute to the whole (re)development process only at the late stages like in the realization phase (Table 2-1). Therefore, a bias can be reflected in the equal distribution of these respondents over the classes. Moreover, considering the contractor as the solely private actor should be diminishing.

In the terms of the years of experience of the respondents, all classes are balanced. That is evident by the frequencies and percentages in the table (Table 7-14) and percentages in the figure (Figure 7-8) below. Since this characteristic does not vary over the classes, it could not provide any information on how to label the identified classes.

Table 7-14 Crosstabulation: 4 classes vs. years of experience

| Class	Frequencies		Percents	
	< 10 y	≥ 10 y	< 10 y	≥ 10 y
Class 1	20	14	59	41
Class 2	20	15	57	43
Class 3	13	7	65	35
Class 4	13	9	59	41
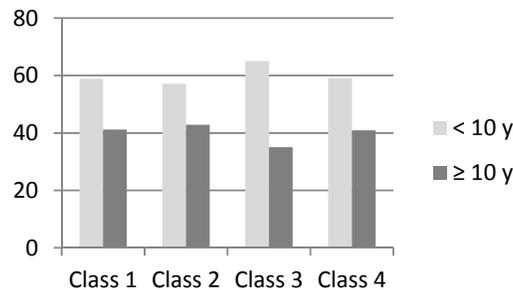
Figure 7-8 Crosstabulation: 4 classes vs. years of experience

Contrary to the previous characteristic, the involvement in brownfield redevelopment project is not equally spread over the classes (Table 7-15; Figure 7-9).

The class 2 and the class 3 share the similarities in this regard. In both classes, the percentage of respondents that have a brownfield experience is higher and very similar. That is 60% and 65% respectively. Classes 1 and 4 are both different from the previous two groups. Namely, the class 1 has almost 75% respondents that were involved in the brownfield redevelopment. Clearly, the most experience class in this respect. Contrary, the respondents in the class 4 are the least experience in the brownfield redevelopment. Due to the similarities in the classes 2 and 3 and their evident difference toward the classes 1 and 4 that are in addition completely different, this characteristic will have a role in labeling the identified classes. To be explained in the following paragraph.

Table 7-15 Crosstabulation: 4 classes vs. brownfield experience

| Class	Frequencies		Percents	
	No	Yes	No	Yes
Class 1	9	25	26	74
Class 2	14	21	40	60
Class 3	7	13	35	65
Class 4	13	9	59	41
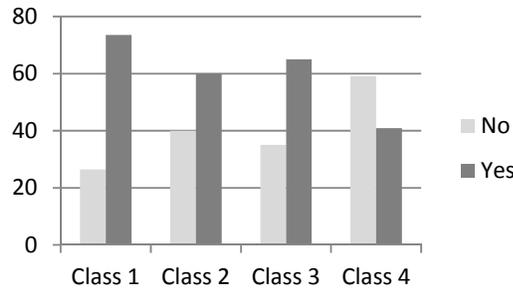
Figure 7-9 Crosstabulation: 4 classes vs. brownfield experience

7.6 The class labeling and their behavior in the built environment

If the goal of the analysis is the relevancy of the classification solution, the most important aspects to consider when choosing the classification solution is its interpretability. Contrary to this goal, if the analyst wants to determine the correct shares of the classes, then the accuracy of the share prediction should be a prior. For example, the tradeoff could be that with the higher number of classes the predictions are better. On the other hand, the lower number of the classes can support the better interpretability of the respondents' classes. Fortunately, this experiment provides relative high accuracy and valid identification of the classes. The 4-class LCM is adopted as the best solution. This is supported with the argumentations and explanation related to the model performance, relative class sizes, the utilities over the classes and the tabulations over the respondents characteristics. Although the model performance and the relative size influence the choice of the solution, these two indicators do not

contribute to labeling of the classes. Therefore, they would not be mentioned in the description of the newly identified classes. All labeled classes with the impact on each of the attribute levels, related part-worth utilities graphs and their range are presented in the following table (Table 7-16).

The class 1 is labeled as the *traditional-experienced private actor*. All attributes have a positive impact on the decision to join the redevelopment of the brownfield. That is the most evident when observing the part worth utilities in at the fourth column in the previously mentioned table. The far biggest importance (range 6,54) has the location attribute and it is the main reason to labeled this class as traditional. As earlier mentioned, the traditional development orientation on the location of the site is evident in many literature (e.g. Salvaneschi & Akin, 1996). This is also the largest class by a small margin (Table 7-10; Table 7-11). Traditional could be also regarded that the two of three negotiable attributes are not very important, the building calm is not significant and the future land-use has the small impact (range equals 0,79). The other impacts of the attributes are quite averaged. What amplifies the importance of the location attribute is the non-significance of the PSC variable (Table 7-12). As argued previously, for this class, now labeled as traditional experienced private actor it does not matter if there is a brownfield or some other project. It is noteworthy that this class is very experienced in the brownfield redevelopment projects (74% of all respondents within this class). Being involved in such projects and at the same time ambivalent toward the brownfield redevelopment, amplifies even more the traditional orientation toward the site location. This class is also regarded as experienced since the 75% of this class has been involved in the brownfield redevelopment, as mentioned. This class is regarded as private due to the crosstabulation results over the characteristics of the respondents' types.

Next, class 2 has been labeled as the *public proactive actor*. It is public due to the previously argued is the highest presence of the public parties and reconsidering the role of the contractors (page 91). The most import information about the proactive attitude toward the brownfield redevelopment is underlined by the variable PSC. As argued (page 90), this variable sign indicates that this class prefers to redevelop the brownfield site in most of the cases. If the PSC variable coefficient for this class (-1,91) is translated to range (3,82) it is clear it has the highest impact on the overall preference of this class. Besides, there are other three dominant attributes such as administrative support, synergy with surrounding users, and location. The existence of the first two also implies that this class realizes the policy importance and reflects the social awareness, respectively. Thus, it indicates nature that is more public. The third dominant attribute is a location, indicating that minimal market requirements need to be met. Other attributes are either not significant or has the low impact.

Similar to the previous, class 3 is also regarded as public and it is labeled as the *public reserved actor*. Argumentation to be labeled as a public class is very same as the

previous. It considers the crosstabulation of the type of respondents as well the range (impact) of the attributes. The major difference is in the class attitude toward the brownfield redevelopment. Contrary to previous class, this one is very reserved indicated also by the variable PSC (1,27). It is also noteworthy to mention, that the class 2 and class 3 also resemble almost perfectly in their experience in the brownfield redevelopment as well as the years of the experience.

Finally, the class 4 is labeled as the *private proactive actor*. The biggest difference toward the other private class is the variable PSC (-1,37). Its sign clearly indicates the positive attitude toward the brownfield redevelopment. Besides, it does not show the traditional preoccupation to the location. Rather, this class considers much more attributes in their overall preferences toward the brownfield redevelopment. The special attention has been put on the negotiable attributes.

Table 7-16 Class preferences

Attribute	Level	Class 1 - Private Traditional Part worth utility	Range	Class 2 - Public Proactive Part worth utility	Range	Class 3 - Public Reserved Part worth utility	Range	Class 4 - Private Proactive Part worth utility	Range
Building Claim	Not Granted	-0,21	0,42	0,12	0,23	0,02	0,04	-1,25	2,51
	Granted	0,21		-0,12		-0,02		1,25	
Land Use	Low	-0,37	0,79	-0,08	0,14	-1,02	1,48	-0,61	1,15
	Medium	-0,05		0,02		0,56		0,07	
	High	0,42		0,06		0,46		0,54	
Parcellation	Low	-0,86	1,61	-0,02	0,19	-0,64	0,76	-0,45	0,57
	Medium	0,10		-0,16		0,52		0,32	
	High	0,75		0,18		0,12		0,13	
Location	Bad	-3,65	6,54	-0,49	1,03	-1,17	2,42	-1,62	2,96
	Decent	0,76		-0,05		-0,09		0,28	
	Excellent	2,89		0,54		1,25		1,34	
Embeddedness	Big	-0,73	1,26	-0,08	0,21	-0,16	0,50	-0,68	1,28
	Medium	0,20		0,13		0,33		0,08	
	Small	0,53		-0,04		-0,17		0,60	
Administrative Support	Bad	-1,10	1,84	-0,80	1,34	-2,45	3,73	-0,99	1,81
	Decent	0,37		0,25		1,18		0,17	
	Excellent	0,74		0,55		1,28		0,82	
Synergy	Bad	-0,88	1,60	-0,58	1,19	-1,43	2,68	-0,90	1,49
	Decent	0,16		-0,02		0,17		0,30	
	Excellent	0,72		0,60		1,25		0,59	

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7.7 Implications

This chapter provides insights in the discrete choice experiment of the actors preference related to the brownfield redevelopment potential in the built environment. The extensive description of the experimental design underlines the significance of these experiments. Besides, the thorough procedure of identifying and labeling the latent classes assures that the major behavior of the differentiated classes is captured.

Experimental design is a large branch in the statistics. Every experiment is unique. This chapter provided a full procedural insight for a discrete choice experiment. A reason for such an extensive approach is its applicability in other chapters (Chapter 8.5; Chapter 9.2). As a result, LCM was estimated using the data collected from the discrete choice experiment. The LCM has the ability to identify different preferences on the individual level. In addition, it classifies the respondents based on their stated preferences. Therefore, in this experiment the LCM was successfully used. There were four identified classes of the main actors involved in brownfield redevelopment. Namely, these are labeled as the private traditional-experienced actor, the public proactive actor, the public reserved actors, and the private proactive actor.

Nevertheless, what are the benefits of the LCM output? In general, more and more attention has been put on the quantifications of decisions as a support tool for the policy-making. Regardless of the methodological and theoretical background of the models, in common is the search for the model that has the best balance between its robustness and its predictability. In this chapter, the model performance has been described in detail. A practical implication of the findings can be a support tool that assists municipalities in choosing the best partner for a brownfield redevelopment. On the other hand, if one of the private actors is the beneficiary, the findings can be used the form of the support tool for choosing the best brownfield to redevelop. These two applications are further explained in more detail (Chapter 10.4).

Similar as for the previous experiment, future research perspective can be improved by enlarging the number of respondents. That will give more possibilities in investigating the impacts of the respondents' characteristics. More specifically, it would be possible to estimate the LCM by using more attributes of the characteristics to classify and label the respondents.

As stated, this chapter provided the overview of the major actors' behavior in the brownfield redevelopment. In addition, this proposed model is a part of a larger hybrid model, which is consider representing the prescriptive interactive approach in decision-making theory.

8 Brownfield joint venture games: Experiment 3

8.1 Introduction

The previous experiment provides the insight on the diversity of different actors in the brownfield redevelopment. More precisely, the applied latent class model demonstrates the ability to predict and identify the real market behavior of different classes of actors with underling their characteristics.

This chapter introduces the concept of the game theory in order to improve the understanding of the interactions amongst previously identified actors. Instead of using a classical game theoretic approach, this chapter provides the findings based on the experimental game theory results. As a first part of the experiment, it was necessary to describe properly the game situation. Further, three out of seven previously elaborated brownfield attributes are treated as separate negotiation issues in the mentioned game environment. There are two types of games selected: a building claim game, and a future land use and parcellation game. Both games are presented in the extensive form. The players in both games are a public party and a private party. In the following text, these two parties are referred as a municipality (M) and a developer (D). The solution concept used for the game analysis is sub-game perfect Nash equilibrium (SPNE).

As mentioned, there is no standard procedure when the game experiments are used. This experiment consists of three main parts: (1) description, (2) validation, and

(3) estimation of preference. It ends with the analysis of the outcomes in which the solution concept, sub-game perfect Nash equilibrium (SPNE) is used. In addition, to collect the data an on-line survey tool is used and for the preference estimation, the fuzzy Delphi method is applied.

The result of this experiment explores whether the self-prediction of the respondents about the game outcome corresponds to the game-theoretic prediction. This gives the insight in the suitability of the application of game theory in predicting real-world actor behavior concerning the brownfield redevelopment.

In addition, based on the outcomes of the analyses, interventions can be designed and through them, various policies could be established. The eventual new policies would aim at supporting the cooperation between relevant parties, therefore, reducing the number of conflict occurrences and accelerating the real-world realization of the brownfield redevelopment projects.

8.2 Games in the urban development

The classical game theory has been largely criticized due to the notion of a *homo economicus*, a completely rational actor. Consequently, numerous authors suggested various interdisciplinary approaches. This perspective is also valuable for the games in the urban development. Therefore, in the following paragraphs the existing examples within this topic are addressed.

There are several aspects where the game theory has been applied within the urban development practice. The most general application would be the implementation of a policy or more precise the selection of the land development strategies (Samsura, et al., 2010). In addition, there is a big interest in pricing of any development that have been studied (Martínez & Henríquez, 2007; Mu & Ma, 2007).

Probably, the major game theory application in the urban development is the negotiation. The negotiation can provide a range of practical advices. For example, how to smooth lease contract negotiations and cultivate a social environment between the tenant and the landlord (Pfrang & Witting, 2008). An alternative advice would be how to allocate cost and benefits in brownfield negotiations (Liang, et al., 2008; Wang, et al., 2007). In addition, some authors were comparing the cost and benefits of brownfield redevelopment and greenfield development in order to support brownfield redevelopment with the valuable policies (Liang, et al., 2008).

Additionally, negotiation support tools could clarify interests, identify tradeoffs, recognize party satisfaction, and generate optimal solutions and better prepare a decision maker for the negotiation (Yousefi, et al., 2007). This author developed the negotiation tool for a brownfield redevelopment. With this tool, each negotiation party prepares separately in order to benefit the most. In addition, another approach has been

suggested where the role of the mediator is dominant. It helps the major parties to settle the negotiation (Blokhuis, 2010; Sounderpandian, et al., 2005).

Following the trend of introducing the public-private partnerships (PPP), more specific joint venture companies (JVC), the brownfield negotiation games has been studied as well (Glumac, et al., 2011; Wang, et al., 2007; Wang, et al., 2008; Yousefi, et al., 2007). Two games have been introduced in this chapter. Rather than described only, the games have been experimentally tested here.

8.3   The environment of a brownfield JVC game

To set up the game, at first it is necessary to define the institutional-economical environment. For this purpose, this research uses the present land development models in the Netherlands (Samsura, et al., 2010). It is noteworthy that these models do not have to do anything with the mathematical models. Rather, they are regarded only as the conceptual models of the land development. All conceptual models (Table 8-1) are characterized by the initial situation on the market related to the ownership, the defined parties that acquire the land, that service and reparcel the land, and the parties that acquire the building plots. The role of the municipality can be active within the conceptual models (1), (2), (3) or facilitative (4).

Table 8-1 Conceptual land development models (Samsura, et al., 2010)

Land development models	Initial situation on land market	Acquisition of the land	Servicing; reparcelling	Acquisition of building plots
(1) Public land development model	Original owners	Municipality	Municipality	PD; End users
(2) Building claim model	PD with intentions to build houses	Municipality	Municipality	PD with building claim
(3) PPP model	Original owners	JVC (including landowning PD)	JVC	PD with building claim
	PD with intentions to build houses	JVC (excluding landowning PD)		
4) Private land development model	Original Owners	PD; End users	PD; End users	End users

This chapter addresses an active approach from the government, specifically a public-private partnership (PPP) model of the land development. This choice was supported because it is very present practice in the Netherlands (e.g. Koppenjan & Enserink, 2009; Nijkamp, et al., 2002). More specific, a studied type of PPP is a joint venture company (JVC). The games in this chapter address a specific decision: to form the JVC or not. The municipality invites a developer to form a JVC for a single project of a brownfield redevelopment. In order to simplify the game, it is assumed that the municipality has already acquired the land. That is an exception of a PPP model since the acquisition is usually conducted by a JVC (Table 8-1). When formed, the JVC will service the land and deliver a detailed land use plan and parcellation. Therefore, the

final product of the JVC is the urban land with immediate possibility to sell the building plots.

Besides setting the game in a specific institutional-economical environment, the involved players based their decision to form the JVC or not on several other specific following conditions (same as described in chapter 7). At first, the responders should be familiar with the proper brownfield definition (Alker, et al., 2000). Secondly, the decision problem is limited to the initiative phase of a brownfield redevelopment (Table 2-1). Third, the size of a brownfield is in the range of one to ten hectares. Finally, it is assumed that different decisions would be made depending on the region. This research focuses on the Netherlands.

In addition, the delineation that is even more rigorous is made for the purpose of the statistically valid game experiment. All the respondents were introduced with the *game condition*. Recall all the attributes that were used to describe the actor's behavior in the brownfield redevelopment (Table 7-1). There are seven attributes in total. The first three are negotiable attributes: building claim, future land-use, and future parcellation. Now these attributes are used to design separate games. On the other hand, the *game condition* is described with the remaining four attributes: location, administrative support, embeddedness, synergy with surrounding users. Similar as in the previous experiment (Chapter 7.2.4), the orthogonal design is generated (Hahn & Shapiro, 1966) for these four attributes.

8.4 Game types

Recall the game methodological background (Chapter 4.4.3). There, it was delineated that the game analysis would be based on the extensive form. In this game representation, the players only act sequentially. In addition, contrary to the strategic form, the extensive form provides the flexible possibilities to design a game.

In one way, the games in the theory can be classified into the cooperative and non-cooperative, both matching the urban development decision-making processes (e.g. Bowles, 2004). Cooperative game theory deals with the situations in which groups of players already agreed to cooperate. These players aim for coordinating their actions, eventually resulting in joint profits. Because these joint profits often exceed the sum of the individual profits, cooperative game theory deals with the interaction of players within the binding agreements such as JVC. In this case, an interaction could address the division of the JVC's expenses and profits. However, most commonly some of the interactions are not a part of a binding agreement. This might be applicable to situations in which public and private parties negotiate about the division of risks or development potential before creating a JVC. On the other way, the game theory differentiates the conflict and the common interest games (e.g. Bowles, 2004). In a common interest game, the interactions have a pattern of a traffic jam that is a poor outcome therefore

avoiding it is beneficial for everyone. Contrary, in a conflict game, 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. For example, negotiating about the player's influence on a future land-use means more for one and less for the other. As an aside, these individual decisions can result in worse outcomes for all players compared to a coordinated decision.

In this section, two non-cooperative, conflict games are presented. In game theoretic literature, these two games are called: ultimatum and bargaining game. As mentioned in the introduction, each game represents the interaction between public (player M) and private actor (player D) related to one of the negotiation issues (an attribute) in the formation of a brownfield redevelopment JVC.

8.4.1   The ultimatum game: Building claim

The assumption is made that the ultimatum game can represent the negotiation on one issue: the availability of a building claim. This is mainly due to the compatibility of the game structure with the real negotiation on the building claim, more explanation follows in the next paragraph. Nevertheless, the building claim is one of the crucial characteristics for any conceptual land development model (Samsura, et al., 2010). Furthermore, the building claim game is set in the previously described environment (Chapter 8.3).

To select or design a game, the following postulate is used. The levels of an attribute (now a separate negotiation issue) need to be accommodated in the structure of the game. The reasons are two-folded. First, it assures that the game condition and negotiation issue are addressed in the same detail or manner. Secondly, it provides the necessary compatibility between game-theoretic framework and discrete choice models that is an important feature in a strategic choice model (Chapter 9). This postulate is addressed by setting each level as an action (see page 44) in the game. For example, the first negotiation issue, building claim has two levels: available, and not available. These levels are now actions: *BC*, and *NBC* (Figure 8-1).

Players description

Ultimatum game is regarded as 2x2 game. That stands for a game where there are only two players each having only two strategies. The focus is on only two groups of actors in whole brownfield redevelopment process. These are the municipality (M) and developer (D) that would potentially form a JVC. As an aside, the characteristics of these two players have been explained in the following subchapters (Chapter 8.6). Anyhow, the player *M* is an initiator of the game since we are investigating the type of active land development models.

Player information

Information of the players is defined as following. (1) Perfect: each player knows his position in the game tree and all players know the previous moves of the other players. (2) Certain: all players know the payoff of playing a particular strategy given the strategies of other players. (3) Asymmetric: players have different pay-offs. (4) Incomplete: a player does not know others pay-offs.

Strategy

The following figure (Figure 8-1) illustrates the game. At the first decision node, player M offers to player D a deal in which building claim is either available (*BC*) or not available (*NBC*). For both possible actions of player M, player D can accept (*a*) or reject (*r*) the deal on the succeeding decision node in the game. The game stops when the end nodes are reached.

This procedure practically explains the complete plan of possible actions (strategy by definition) of the players M and D. Their actions differ and a branch represents each action. A reader can notice that player M has two possible actions: *BC, NBC*. They define the plan of possible actions $Am = \{BC, NBC\}$, as explained in the chapter 4. Similar the actions of the player D are: *a, r* as a reaction on the *BC* and *a, r* as a reaction on *NBC*, they define the $Ad = \{a_{BC}, r_{BC}, a_{NBC}, r_{NBC}\}$. Note that because of the figure readability the actions a_{BC} and a_{NBC} are marked as *a*.

The payoffs are estimated empirically (Chapter 8.5.3; Chapter 8.7.2) with the fuzzy Delphi, a method that have been presented already. Rather than providing a game solution, this subchapter explains the game design. Therefore, the analysis of the game are described in the following subchapter (Chapter 8.7.2).
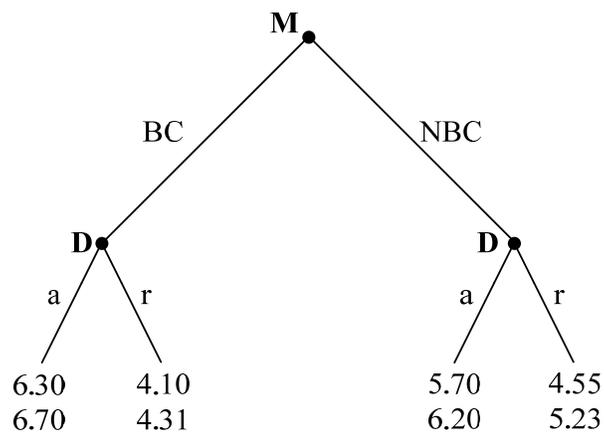

Figure 8-1 Ultimatum game: Building claim

8.4.2 The bargaining game - Future land use and parcellation

This game addresses two other negotiation issues: influence on the future land use and parcellation. A potential to influence future land use emerged as the most important attribute in the first experiment (Table 6-2). Parcellation together with servicing (land clean-up and infrastructure developing) is a stage characteristic for every land development model (Samsura, et al., 2010). The influence over a future land-use and parcellation has been expressed in the ordinal scale.

Similar as for the previous game, the postulate is that the mentioned levels of an attribute need to be accommodated in the structure of the game. Instead of matching the particular negotiation issue with the structure of an existing game (ultimatum game), the bargaining game has been designed from a scratch. First, three influence levels are identified for this issue: high (*H*), medium (*M*), and low (*L*), according to the mentioned postulate. The division between the levels of influence could be vaguely perceived thus a further elaboration is necessary. Notice now that the (*H*) influence means that a player can carry out any land use regulated by the mix-use zoning plan and completely determines the size and the shape of any parcel in the land that will be redeveloped. To underline, changing a zoning plan is not an option, but the levels of player's (e.g. developer) influence (*H*, *M*, *L*) express the potential to adjust the land use ratio within the mix-use zoning. Logically, medium influence grant a developer less and low influence minimal possibilities. Following figure describes the bargaining game (Figure 8-2). While, the players of the bargaining game are as well municipality (M) and developer (D). Their information is set to be equal as in the previous game.
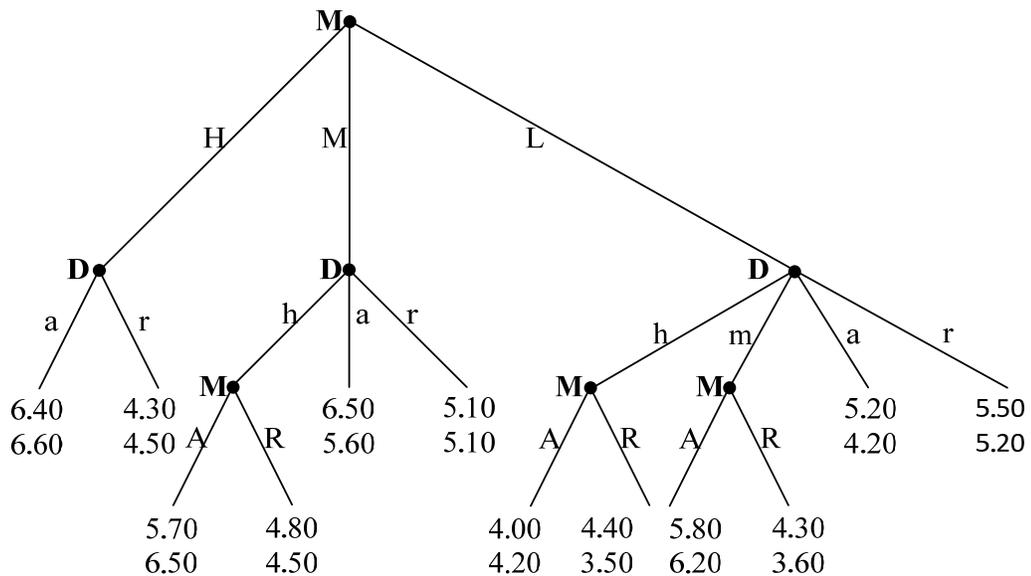

Figure 8-2 Bargaining game: Future land use and parcellation

Strategy

At the first decision node, player M offers to player D one of the deals *H*, *M*, or *L* linked to different influence on the future land use and parcellation. Now, for each of the possible actions of player M, player D can react differently on each of the decision nodes. The structure of the every sub-tree has been designed in a way that the highest level of influence can be reached no matter what was the initial offer from the player M (*H*, *M*, *L*). For example when the player M offers *H* then the player D can only accept (*a*) or reject (*r*) the deal on the succeeding decision node in the game. This is because the highest level of influence is already offered. However, if the player M offers *M* then the player D can ask for the highest influence (*h*) or either accept (*a*) or reject (*r*) the offer. If the player D ask for (*h*) There is one more succeeding decision node where the player M can accept (*A*) or reject (*R*) that offer. The similar is for the branch when the player M offers *L* at the initial node. In any case, the game stops when the end nodes are reached.

Same as for the previous game, this procedure practically explains the complete plan of possible actions that are the strategies of the players M and D. Their actions differ and a branch represents each action. A reader can notice that player M has nine possible actions in this game: *H, M, L, A, R, A, R, A, R*. They define the plan of all actions *Am*. Similar the actions of the player D are nine as well: *a*, *r* as a reaction on the *H*. Then *h*, *a*, *r,* as a reaction on *M*, and *h*, *m*, *a*, *r,* as a reaction on *L*. Together they define the plan of all possible actions for the player D, *Ad*.

Similar as for the previous game on the following figure (Figure 8-2) the payoffs are presented as well, still the solution will be addressed in the following.

8.5   Construction of the game-theoretic experiment

The benefits of using the experiment in the game-theoretic framework have been already discussed (Chapter 4.4.5). In brief, this experiment consists of three parts: (1) descriptive - designing the conditions within the game set environment; (2) validating the assumed structure of the game; (3) estimating the respondent's preference and predictions of the game outcomes. Finally, interpreting respondent's feedback with the SPNE can be regarded as a fourth part. The on-line survey tool is *Berg Enquête System © 2007*, same as for the previous experiment.

8.5.1   Description: Game condition state

As stated previously, the descriptive part of the game exists of fictive, changing negotiation settings, composed from a limited set of the important attributes: location, embeddedness, administrative support and synergy with the surrounding users.

Same as for the previous experiment (Chapter 7.2.4), the orthogonal design was employed to secure the statistical validity of this experiment. Each of the attributes that

are used in the description of a negotiation issue has three levels. Given these attributes, the full factorial design would suggest $3^4 = 81$ different decision moments. Instead, an orthogonal fractional factorial design is selected in order to reduce the number of treatments. The following design (Table 8-2) shows the attributes allocation over the nine treatment combinations (Hahn & Shapiro, 1966). Already defined orthogonal design assures that the main effects are un-confounded with each other thus provide a statistical validity. Each respondent react on only one treatment combination.

Table 8-2 Condition state: Attributes allocation and the treatment combinations

Treatment combination	Attributes allocation			
	L	E	AS	S
1	0	0	0	0
2	0	1	1	2
3	0	2	2	1
4	1	0	1	1
5	1	1	2	0
6	1	2	0	2
7	2	0	2	2
8	2	1	0	1
9	2	2	1	0

8.5.2 Game validation

As a second part of the game experiment, this research introduces the validation of game trees (Figure 8-3). This is preformed by a semi-structured questionnaire with the multiple-choice answers.

For both games, every decision node is textually described. For example, the first question in the experiment (Figure 8-3) corresponds to the initial decision node at the building claim game (Figure 8-1). In this example, the description is: *A municipality (as initiator) negotiates with a developer over the building claim. What are the possible negotiation options?* Given this description, every respondent states the possible actions (branches) at that decision node by filling the multiple-choice answers. For each question, there are two types of answers. The first type corresponds to all assumed actions at the specific decision node (building claim is available (*BC*) or not (*NBC*)). On the other hand, the second type checks if there is a missing action(s) at that decision node. In that case, a respondent chooses the answer "other". In addition, a respondent could provide the description of a missing action in the text line below every question.

The logic behind the validation is straightforward. A selected answer says that a certain branch exists, and vice versa. For the first type of answers, the ideal validation of a game tree would be that all respondents selected all of the multiple answers - meaning that they exist in the real market negotiation situations. Contrary, for the "other" type ideal would be that none of the answers were selected - meaning that there are no

missing actions. The results of the game validation are presented in the following subchapter (Chapter 8.7.1).

Figure 8-3 Game validation experiment

8.5.3 The preference and predictions of the game outcomes

The last part of this experiment is the estimation of the respondents' preferences and predictions over the game outcomes - end nodes in both of the games (Figure 8-1; Figure 8-2).

At first, the respondents give their estimation on the specific decision moment. This moment is set as a game condition (Chapter 8.5.1) in the given the institutional-economical context (Chapter 8.3). Further, a respondent reacts on the mentioned textually described game outcome. The descriptions are not the same as for the validation part. There the decision higher level nodes were described and split at the tree influence level, while in this experiment the path till the last actions or ending nodes are

described. For example, the following figure (Figure 8-4) describes the outcome 1 as: *A developer rejects the offer and stops the negotiation*. That corresponds to one end node of the ultimatum game. The first is when the player D plays *r* regarding the *BC* move of the player M. The second is when the player D plays *r* regarding the *NBC* move. The similar goes for every end node or action in both of the game trees.

Figure 8-4 Game rating and game choice experiment

Each respondent provides two estimations per outcome. The first one reflects the preference over an outcome while the second one provides the predictions of the most possible outcome. A preference is regarded here as a payoff, knowing the payoff it is possible to predict the game solution by using the SPNE. On the other hand, the respondents' prediction of the most possible outcome can be regarded as their opinion of the game outcomes. By comparing the SPNE solution with the estimated most probable outcome, it is possible to investigate whether the players are rational and if the real market behavior of brownfield redevelopment can be explained with the application of the game theory.

Method used to collect and estimate this data is a fuzzy Delphi method with SAM, described in detailed in the methodological part (Chapter 4.2), and also illustrated in the

experiment 1 (Chapter 6.3). Only difference to the previous experiment is that here the triangular fuzzy number is used because it is less demanding for the respondents (e.g. Klir & Yuan, 1995). Therefore, no further reference for this part of experiment is needed. Results are presented in the following subchapter (Chapter 8.7.2).

8.6 Data collection and respondents characteristics

The data in this experiment is collected together with the previous experiment (Chapter 7.3). Therefore, the used survey tool - *Berg Enquête System © 2007* and the period of the survey (April to September 2011) are identical. However, because of the duration of the questionnaire, the respondents' reply dropped. Following paragraphs report briefly on the changes in terms of the sample size, response rate, and distribution of the respondents' characteristics.

8.6.1 Sample size and response rate
This experiment relies on the FDM to collect and asses the respondents' observations. Therefore, the minimum requirements of this experiment is determined by the rule of thumb that each group of respondents should have 10-15 people each as recommendation in Delphi literature (Delbecq, et al., 1975).

The same groups of respondents were investigated as in the previous two experiments (Chapter 6.3.1; Chapter 7.4.1): (1) independent developers; (2) contractors; (3) asset developers; (4) development agencies; (5) municipalities. This experiment consists of two data collection parts in which the response rate is different. For the validation of the game trees, 86 respondents reacted. Thus, making the response rate 15,28% or 86 respondents out of 563 that visited initially the survey web page (Chapter 7.3). For estimating data, 43 respondents completed correctly the experiment to the end thus the corresponding response rate is 7,64%. The distribution of the respondents' characteristic is similar between these two parts of the experiment. Therefore, only the first part will be reported in the following paragraphs. Noteworthy is that under the player M the respondents (4) and (5) were included, and for the player D respondents' types (1), (2), and (3).

8.6.2 Types of respondents, years of experience and brownfield experience
The following table gives an insight of the respondents' characteristics (Table 8-3).

Table 8-3 Type of respondents: Game validation

Type of respondent	Frequency	Percent
(1) independent developers	21	24,4
(2) contractors	26	30,2
(3) asset developers	13	15,1
(4) development agencies	12	14,0
(5) municipalities	14	16,3
total	86	100,0

The division of respondents between the player M and player D implicates that the current ratio 3:7 should be improved. Since the biggest concern is to have the minimum requirement of the number of experts per group (12-15 respondents per group for fuzzy Delphi method) and this requirement is met, the unfavorable ratio has been overlooked.

The overall experience in years and the brownfield experience of the respondents follow (Table 8-4). This information does not have solely the descriptive purpose but it is also used in the FDM calculation (Equation (4.5)).

Table 8-4 Characteristics: Years and brownfield experience

Characteristic	(Code) Levels	Frequency	Percent
Years of experience	(1) < 10 years	51	59,3
	(2) ≥ 10 years	35	40,7
Brownfield experience	(1) Yes	35	40,7
	(2) No	51	59,3

Overall, it is possible to validate the game trees in this experiment because the response rate is regarded as acceptable and the characteristic of the respondents tend to be representative of the reality.

8.7 Game experiment results

After the explained construction of the game theoretic experiment, the results are presented in the following text. As explained, there are three parts of this experiment. The part (1) is a descriptive part and has been previously explained (Chapter 8.5.1). Here only the results are described for: (2) the validation of a game tree and (3) the estimation of the respondents' preferences and predictions of the game outcomes. The game analysis concerns only the part (3) thus they are presented together.

8.7.1 Validated game tree

As explained a valid game tree assures that the game is correctly assumed and reflects the real market situations. For that purpose multiple answers were used to check if some action (branch) does exist or not (Figure 8-3).

In the following table, the first column lists the assumed and eventually new branches (Table 8-5). The list of branches is formed as the game tree is drawn, downwards starting with the root on top. For example, the first listed branch is BC. That is an action from the initial decision node when the player M plays *BC*. Further example, the branch BC_a denotes an action form the decision node when the player D plays *a* as a reaction on the player M previous move *BC*. In addition, all _OTHER branches refer to the eventual new branch starting from the certain decision node. The next column in the table reports if a branch is exists or not. Consequently, yes and no

are used in the consecutive way. Finally, the frequency and percent column shows the division of respondents in two groups (saying yes or no) where the total number of respondents for every branch is 86. Both the frequencies and percentages are estimated in the *SPSS*.

Table 8-5 Building claim: Game tree validity

Branch	Does exist?	Frequency	Percent
BC	No	13	15,1
	Yes	73	84,9
NBC	No	76	**88,4**
	Yes	10	11,6
OTHER	No	84	97,7
	Yes	2	2,3
BC_a	No	17	19,8
	Yes	69	80,2
BC_r	No	74	**86,0**
	Yes	12	14,0
BC_OTHER	No	73	84,9
	Yes	13	15,1
NBC_a	No	40	46,5
	Yes	46	53,5
NBC_r	No	55	**64,0**
	Yes	31	36,0
NBC_OTHER	No	69	80,2
	Yes	17	19,8

Note: with the bold letters are the branches that need to be reexamined due to the high percentage of the respondents replying that the branch does not exist.

Although at the first glance this is a negative feedback, the main reason for such a report is some data quality remarks. First, the estimation is not completely punctual since respondents were giving mostly mutual exclusive responses instead of multiple answers. Probably they were reacting in sense of most probable not in a sense of all possibilities (e.g. NBC). Secondly, "other" possibility (NBC_OTHER) indicated by the respondents in most of the cases do not correspond with the explained decision issue. Contrary, they are indicating that there are other negotiation issues which are every specific. This feedback is as expected, since every negotiation is a unique case. Therefore, separating each negotiation issue into the individual game makes sense.

Similar results but also the problems occur in the bargaining game. Tables are available at the end of the thesis (Appendix D).

8.7.2   Estimated results with the fuzzy Delphi

The last part of this experiment is the data collection and the estimation of the respondent's preferences about the negotiation outcome over a single negotiation issue. In addition, this subchapter provides the game analysis using the SPNE since it is directly connected to the respondents' preferences.

As explained, experimentally estimated game data provides the empirical evidence about the principles of strategic behavior on one hand, and the information necessary for any game analysis on the other (Crawford, 2002). For that purpose, a questionnaire based on the FDM is employed (Figure 8-4). As described previously (Chapter 8.5.3), each of the end nodes reflect the possible outcomes of a game. In the following tables (Table 8-6; Table 8-7), two different estimations are presented and both calculated with the FDM in the *Matlab®* program, same as for the experiment 1. The first column, describes the all end nodes or branches of the ultimatum game. The next column indicates if estimation relates to the player M or to the player D. The following three columns (W) represent the fuzzy number estimation of an outcome and the column (S) is a related defuzzified number. All calculations are the same as explained previously (Chapter 4.2.4). Still a distinction needs to be made between these two tables.

The Table 8-6 represents the estimation of the player's M and D general preferences over the building claim game outcomes. More technically, the general means a result that covers all nine treatment combinations discussed in the setting up a game theoretic experiment (8.5.1). In addition, the preference (S) are regarded as indication of the payoffs, this can be also traced in the game tree (Figure 8-1). After generating the payoffs, the game can be solved by the backward induction referring to the SPNE within the perfect information games. This is explained in more details in the methodological part of this thesis (Chapter 4.4.4). In the last column, indicated SPNE is marked with the *X*.

The Table 8-7 reports on the respondent's general opinion (same as previous) about the most probable outcome or end branch. Therefore, the *X* in this table refers to the highest score (S) for the most probable outcome. This score is presented separately for the player M and player D. These two score are not necessary the highest for the same end branch thus they could indicated a different game outcome expectations of two players.

Table 8-6 Building claim: SPNE

End Branch	Player	W = (a, b, c)			S	SPNE
BC_a	M	4.74	6.29	7.85	6.30	X
	D	5.37	6.51	8.22	6.70	
BC_r	M	1.78	4.17	6.34	4.10	
	D	1.74	4.26	6.93	4.31	
NBC_a	M	2.53	6.59	7.98	5.70	
	D	4.58	6.11	7.91	6.20	
NBC_r	M	2.61	4.50	6.53	4.55	
	D	2.78	5.34	7.56	5.23	

Table 8-7 Building claim: Most probable outcome

End Branch	Player	W = (a, b, c)			S	Outcome
BC_a	M	2.41	4.23	6.56	4,40	X
	D	2.24	4.47	6.79	4,50	X
BC_r	M	1.77	3.79	5.10	3.55	
	D	1.70	3.33	5.78	3.60	
NBC_a	M	2.27	4.41	6.22	4.30	
	D	2.41	3.97	5.92	4.10	
NBC_r	M	2.56	4.25	6.43	4.40	X
	D	2.61	3.97	5.78	4.12	

For the bargaining game same procedure is conducted. Same as for the validation part of this experiment, the results of this game are in the appendix (Appendix E).

Rationality test - comparing preferences and choices

When comparing the last column of the previous two tables (Table 8-6; Table 8-7), evident is a match between game theoretic solution underlining the SPNE concept, and the expected most probable outcome indicated by the both players separately. Two conclusions can arise from this perfect fit. The negotiation game is suitable to interpret the behavior of the real market negotiations. Moreover, the respondents are rational players since they can perceive their own but as well the other player's moves and strategies.

In addition, this finding could provide a base to check the possibility of reaching a different game outcome. In the game theoretical framework, this could be achieved with the interventions such as: (1) changing the information of the involved players, (2) changing the pay-offs, (3) changing the playing rules (Jost & Weitzel, 2008).

8.8 Conclusions

As the decision processes in urban development projects become more complex, there is a need to find the theories that can support the governance of such processes, for example through the interventions. Game theory can be applied successfully to urban development projects, resulting in a better understanding of players' interactive choice behavior and expected decision outcomes, along with the recommendations concerning the application of intervention strategies in the conflict situations. This is supported by the game-experimental approach described in this chapter. However, one should realize that game theory presents an abstraction. Not all of involution of real-life interaction processes in urban 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 completely mimic the real-world to every detail. Furthermore, a major critic of the classical game theory is the assumption

of completely rational players with complete information. To overcome partly the problems related to the assumptions of the classical 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.

9 Negotiable attributes: Experiment 4

9.1 Introduction

The previous chapter and experiment shows the relevance of applying game theory in the urban development studies in general. This chapter goes one step further in investigating the possibilities of the interactive prescriptive approach in the plural decision-making theory (Figure 2-5). The purpose of the experiment is to develop and validate a statistical model that combines the discrete choice and game theory, in the literature named as a strategic choice model (e.g. Signorino, 2003). Besides this method, there are already some studies regarding the modeling of negation in general (Beersma & Dreu, 1999; Harrenstein, 2004; Johnson & Houston, 2000; Jonker & Robu, 2004; Reuer & Koza, 2000; Riquelme & Rickards, 1992; Robu, et al., 2009; Shepherd, et al., 2000) but also in the urban development practice (Arentze & Timmermans, 2003, 2004; Cassiman, 2000; Pfrang & Witting, 2008; Tam & Thomas, 2011; Walker, et al., 2008; Wang, et al., 2007; Wang, et al., 2008; Yousefi, et al., 2007).

The main method used in this experiment is a strategic choice model. This method is considered as the most favorable since: (1) it addresses interaction between the players; (2) it provides the suggestions of the optimal deal on the negotiation issue; (3) it is a proven valid statistical model; and (4) it is possible to combine the results of a strategic choice model and a discrete choice models if the structure of the strategic

choice model is carefully designed thus resulting in hybrid model with greater applications potentials. A brief description of the procedure follows. This experiment collects the data through the on-line questionnaire. Further, the collected stated preference data have been rearranged on the basis of two groups of respondents (player M and player D). Initially, the data is estimated using the binominal probit models. More precisely four models are estimated for the two negotiable attributes and for two players separately. Next, estimated variable coefficients are transformed to the game tree payoffs. Finally, these payoffs are used as the input for a strategic choice model for the two games that represent the negotiable attributes. The experiment procedure of this experiment and its connection with the others parts has been previously described and illustrated in the form of the flowchart (Figure 5-2).

As mentioned the estimated outcome used as an input for a strategic choice model is collected with the same on-line questionnaire that is previously described (Chapter 7). The 111 professional respondents with different background although all from the field of the urban development filled in the questionnaire.

At first, this chapter provides an empirical evidence of the negotiation process in the brownfield redevelopment specifically concerning the issues of the building claim and the future land use and parcellation, which are all named negotiation attributes. In addition, the proposed models could provide a firm base (structure and procedure) for the similar attributes (with same number of levels) that need to be studied in the negotiation context.

9.2   Experimental design and data collection

There are two experimental designs that are used in this chapter. The first is used to construct a questionnaire (Figure 7-1) that collects the stated preference (SP) data. Such a data is necessary to estimate a binominal probit model for two groups of respondents (player M and player D). This questionnaire has been already used for the experiment 2 (Chapter 7). However, the experiment 4 uses now the preference data instead of the choice data from the same questionnaire. At the screenshot of this on-line questionnaire (Figure 7-1), it is possible to notice that the preference data is filled in by the drop down button. The experiment procedure is the same as in the experiment 2 and it has been previously explained in detail (Chapter 4.3.2; Chapter 7.2), therefore, no further text is provided in this chapter considering the experimental design and procedure. The second experimental design is used for the comparison between the results of this experiment and the results from the experiment 3. More specifically, the same treatment combination is used (Table 8-2) to estimate the predicted outcomes by a strategic choice model and by fuzzy Delphi method.

In addition, the same groups of respondents were investigated as in the previous three experiments (Chapter 6.3.1; Chapter 7.4.1; Chapter 8.6.2). These are: (1) the

independent developers, (2) the contractors, (3) the asset developers, (4) the development agencies, and (5) the municipalities. Since the same on-line questionnaire is used as in the experiment 2, the type of respondents and their characteristics are identical (Chapter 7.4). There are two sets of data as mentioned previously, one of the player M and one of the player D. Besides the same groups of participating respondents, the two experiments (3 and 4) have the same division of the data. For the player M, the respondents (4) and (5) were included and for the player D respondents' types are: (1), (2), and (3). Creating this sameness is necessary in order to compare the results of the experiments 3 and the experiment 4.

The response rate is also identical as in the experiment 2, which is 19, 72 %. A more detailed report on the response rate is given previously (Chapter 7.3.2).

Data transformation

To populate described game trees, this chapter employs the binominal probit model estimated with the previously mentioned preference data. Respondents are asked to rate the alternatives on an ordinal 5-level scale and further transformed to the binary data. This transformation has been already applied in the methodologically related studies (e.g. Bristow, et al., 2010). To be able to do this transformation, the recoding was necessary. It is done as shown in the table below (Table 9-1). Here, only the preferences (-1, -3) are regarded as not acceptable (0) and the others as acceptable (1).

Table 9-1 Recoding

Description	Ordinal code	Binary code
Very acceptable	3	
Acceptable	1	1
Neutral	0	
Not acceptable	-1	0
Very unacceptable	-3	

Due to the change in the coding, additional restrictions toward the data validity were implemented. Recall one choice set example (Figure 7-1), there besides the two non-labeled alternatives (Brownfield 1 and Brownfield 2), it was possible to choose a "none" option as well. The data restrictions were performed in the several cases. For example one case would be when a respondent chooses the "none" option and while at the same time he or she rated one of the alternatives in the choice set with either 0, 1, or 3. This is regarded as bad data, therefore discarded. Similar action is performed when the respondent chooses an alternative that she or he rated with -1 or -3. The following table (Table 9-2) provides the insight in the bad data concerning both groups of the respondents. All of this data are regarded as not correct, therefore, they were removed.

Although the percentages in some cases were very low (0,71 % and 0,77%) this intervention improved the estimation performance of a binominal model.

Table 9-2 Bad data

Respondents' action	Player 1		Player 2	
	#	%	#	%
Choosing "None" when rated 0,1or 3	47	4,10	108	5,50
Choosing "Alt2" when rated -1or -3	4	0,35	14	0,71
Choosing "Alt1" when rated -1or -3	4	0,35	15	0,77
Overall	55	4,80	137	7,00

9.3 Populating a game tree

As mentioned in the introduction, the binominal model estimations are used to populate a game tree. By populating a game tree, this chapter refers to assigning the payoffs for each of the game outcomes. Two games in the game theoretical jargon are interesting for this study: the ultimatum and the bargaining game. Both of them are explained in the previous chapter (Chapter 8.4). In both games, there are two identical players: the player M and the player D. Because there are two games and two different players, four different binominal probit models need to be estimated using the previously mentioned data set.

As shown in the table below, the variables used to estimate the models are not the same in the case of the ultimatum and the bargaining game. In both games, the variables that do not relate to the negotiable attribute for which a game is addressed or constructed have been removed. For example, the ultimatum game has been used for the negotiable attribute building claim, therefore the removed variables are: LU1, LU2, P1, and P2. This is due to two reasons. The first one is related to the game structure. For example, only the building claim attribute (thus linked variable BC) varies across the game outcomes since the levels of this attribute represent the actions in the game (Chapter 8.4.1). While the other attributes (location, embeddedness, administrative support, and synergy) participate in the utility as a condition state (Chapter 8.5.1). The similar input principle is for the bargaining game in which there are two negotiable attributes: the future land use and parcellation thus the variable BC has been removed. In this case, the bargaining game input are the attributes: future land use (LU1, LU2) and parcellation (P1, P2). These attributes' levels vary across the game outcomes and the other attributes are seen as a conditional part of the utility. The second reason is the possibility to use both of the strategic model estimations in a single application (Chapter 10.3). In that case, the results of these applications could be biased due to the repeated variables (the same variables in two models).

Noteworthy to mention is the meaning of the constant variable. It is a variable necessary to estimate statistically in any binominal model. In addition, it represents the

attitude toward the accepting a deal in general in the overall utility. This variable is mostly not significant across the shown four models. Except in the binominal probit model used as an input for the bargaining game for the player D. On that example, the constant could be explained that the player D (developers in a broader sense) has in general negative attitude toward a deal in brownfield redevelopment.

The model estimation for player M is based on the sample size of 776 observations from the 41 respondents (N_1). On the other hand, the sample size is 1329 observations from the 70 respondents (N_2) for the player D. The following table (Table 9-3) shows the estimations of the four binominal probit models. Where the McFadden pseudo R^2 is calculated as $\{1 - [\ln LL / \ln \ LL \ (0)]\}$.

Table 9-3 Binominal probit estimates for the ultimatum and bargaining game

	Ultimatum game				Bargaining game			
	Player M		Player D		Player M		Player D	
Variable	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
BC	-0,063	0,247	**-0,131**	0,003	/	/	/	/
LU1	/	/	/	/	**-0,170**	0,042	**-0,313**	0,000
LU2	/	/	/	/	-0,010	0,890	**0,137**	0,023
P1	/	/	/	/	**-0,143**	0,069	**-0,158**	0,011
P2	/	/	/	/	-0,103	0,166	0,056	0,346
L1	**-0,832**	0,000	**-1,174**	0,000	**-0,872**	0,000	**-1,246**	0,000
L2	0,090	0,217	**0,199**	0,001	0,109	0,145	**0,240**	0,000
E1	-0,093	0,205	**-0,135**	0,025	-0,097	0,189	**-0,152**	0,013
E2	-0,099	0,192	0,072	0,228	-0,097	0,212	0,079	0,194
AS1	**-0,743**	0,000	**-0,705**	0,000	**-0,783**	0,000	**-0,792**	0,000
AS2	**0,168**	0,022	**0,222**	0,000	**0,201**	0,008	**0,287**	0,000
S1	**-0,601**	0,000	**-0,468**	0,000	**-0,597**	0,000	**-0,482**	0,000
S2	**0,157**	0,032	0,112	0,062	**0,160**	0,033	**0,120**	0,048
Constant	-0,029	0,588	-0,016	0,716	-0,074	0,174	**-0,102**	0,023
LL null function	**-537,789**		**-921,174**		**-537,789**		**-921,174**	
Log likelihood	**-381,347**		**-582,817**		**-373,376**		**-573,940**	
McFadden Pseudo R^2	**0,291**		**0,367**		**0,306**		**0,377**	

As an aside, only the significant values are used in the further calculations in a strategic choice.

Transformation of variable coefficient to the payoffs

Still the part-worth utilities linked to the variable coefficient are not the payoffs in the game. Rather, these are the probabilities of accepting or rejecting a deal. In more detail, any *accepting* outcome is defined with the previously mention part-worth utilities. On the other hand, for any *rejecting* outcome of the game, it is assumed that the part-worth utility equals zero. These two utilities are calculated with the previously mentioned

equation (4.20), and in this form regarded as representation of the payoffs for a strategic choice model.

9.4 Strategic choice models

After having the game tree populated, it is possible to estimate now the strategic choice models. As underlined in the methodological background, the strategic choice is referred to the models that capture also the other actors (players) choices. More specific, there is exogenous and endogenous part of the strategic choice utility. The theoretical contribution to this notion was previously performed (Han, 2006) and it is expressed in the equation (4.23).

The most influential literature dealing with the statistically validated strategic models refers to the work of several authors (Bas, et al., 2008; Signorino, 1999a, 1999b, 2003; Signorino & Yilmaz, 2003; Soetevent & Kooreman, 2007). The procedure of the following two models resembles and follows the idea of some of the previous examples (e.g. Signorino, 2003).

9.4.1 Strategic probit model

Every game structure represents a unique strategic choice model. The two games are represented in this chapter by the two mathematical models. This subchapter provides the detailed insight in the model procedure to generate the game outcomes probabilities.

Ultimatum game - Building claim

In the figure below (Figure 9-1) the strategic choice model based on the ultimatum game structure is presented. The procedure of this model is defined with the equations starting from the equation (9.1) and ending with the equation (9.14). Here the options are denoted by a_j, choice probabilities as p_j, outcomes as Y_k, and players m's expected utilities for outcome y_k as $U^*_m(Y_k)$.
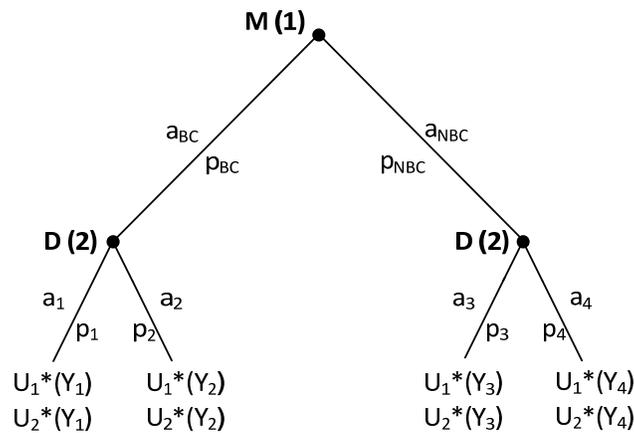

Figure 9-1 Strategic choice model based on the ultimatum game

It is assumed that the players are bounded rational. Therefore, the SPNE can be expressed by backward induction. The SPNE is:

$$y = \begin{cases} Y_1 \rightarrow U_2^*(Y_1) > U_2^*(Y_2) \wedge U_2^*(Y_3) > U_2^*(Y_4) \wedge U_1^*(Y_1) > U_1^*(Y_3) \vee \\ \quad U_2^*(Y_1) > U_2^*(Y_2) \wedge U_2^*(Y_4) > U_2^*(Y_3) \wedge U_1^*(Y_1) > U_1^*(Y_4) \\ Y_2 \rightarrow U_2^*(Y_2) > U_2^*(Y_1) \wedge U_2^*(Y_3) > U_2^*(Y_4) \wedge U_1^*(Y_2) > U_1^*(Y_3) \vee \\ \quad U_2^*(Y_2) > U_2^*(Y_1) \wedge U_2^*(Y_4) > U_2^*(Y_3) \wedge U_1^*(Y_2) > U_1^*(Y_4) \\ Y_3 \rightarrow U_2^*(Y_3) > U_2^*(Y_4) \wedge U_2^*(Y_1) > U_2^*(Y_2) \wedge U_1^*(Y_3) > U_1^*(Y_1) \vee \\ \quad U_2^*(Y_3) > U_2^*(Y_4) \wedge U_2^*(Y_2) > U_2^*(Y_1) \wedge U_1^*(Y_3) > U_1^*(Y_2) \\ Y_4 \rightarrow U_2^*(Y_4) > U_2^*(Y_3) \wedge U_2^*(Y_3) > U_2^*(Y_4) \wedge U_1^*(Y_1) > U_1^*(Y_3) \vee \\ \quad U_2^*(Y_1) > U_2^*(Y_2) \wedge U_2^*(Y_4) > U_2^*(Y_3) \wedge U_1^*(Y_1) > U_1^*(Y_4) \end{cases}$$

(9.1)

The probability that player D chooses action a_4 is:

$$\begin{aligned} p_4 &= Pr[U_2^*(Y_4) > U_2^*(Y_3)] \\ &= Pr[U_2(Y_4) + \alpha_{24} > U_2(Y_3) + \alpha_{23}] \\ &= Pr[U_2(Y_4) - U_2(Y_3) > \alpha_{23} - \alpha_{24}] \end{aligned}$$

(9.2)

As an aside, further in the text, for the both player (M and D) the nomenclature is 1 and 2, respectively. This is also mark on the previous figure where the game is presented in the extended form. For an example, the utility of the player D for the outcome (Y_4) would be written as: $U_2(Y_4)$.

If we let $\eta_{ijk} = \alpha_{ij} - \alpha_{ik}$, the we can rewrite:

$$p_4 = Pr[U_2(Y_4) - U_2(Y_3) > \eta_{234}]$$

(9.3)

Its probability density function:

$$p_4 = \int_{-\infty}^{U_2(Y_4) - U_2(Y_3)} \phi(\eta_{234}) \, d\eta_{234}$$

(9.4)

Where $\phi(\eta_{234})$ is normal density function ($\mu=0$, $\sigma^2=1$):

$$\phi(\eta_{234}) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\eta_{234}^2}$$

(9.5)

Similarly, the probability that player 2 chooses action a_2 is:

$$p_2 = \int_{-\infty}^{U_2(Y_2) - U_2(Y_1)} \phi(\eta_{221}) \, d\eta_{221}$$

(9.6)

Choice probabilities p_3 and p_1 are, of course:

$$p_3 = 1 - p_4 \tag{9.7}$$
$$p_1 = 1 - p_2$$

The probability that player 1 chooses action a$_{NBC}$ must be written in terms of her expected utility for choosing action a$_{NBC}$. As the error term comes in through actions than expected utility is:

$$U_1^*(a_{NBC}) = U_1(a_{NBC}) + \alpha_{1NBC} \tag{9.8}$$
$$= [p_3 U_1(a_3) + p_4 U_1(a_4)] + \alpha_{1NBC}$$

The agent's probability of choosing a$_{NBC}$ is then:

$$p_{NBC} = Pr[U_1^*(a_{NBC}) > U_1^*(a_{BC})] \tag{9.9}$$
$$p_{NBC} = Pr[p_3 U_1(a_3) + p_4 U_1(a_4) + \alpha_{1NBC} > p_1 U_1(a_1) + p_2 U_1(a_2) + \alpha_{1BC}]$$

Since utilities of the end action are the same as utilities of the outcome:

$$U_1^*(a_k) = U_1(a_k) + \alpha_{ik} \tag{9.10}$$
$$= U_1(Y_k) + \alpha_{ik}$$

We can derive the following formula:

$$p_{NBC} = Pr[p_3 U_1(Y_3) + p_4 U_1(Y_4) + \alpha_{1NBC} > p_1 U_1(Y_1) + p_2 U_1(Y_2) + \alpha_{1BC}] \tag{9.11}$$
$$= Pr[p_3 U_1(Y_3) + p_1 U_1(Y_1) - p_2 U_1(Y_2) - p_4 U_1(Y_4) > \alpha_{1BC} - \alpha_{1NBC}]$$

If we let $\eta_{ijk} = \alpha_{ij} - \alpha_{ik}$, the we can rewrite:

$$p_{NBC} = \int_{-\infty}^{p_3 U_1(Y_3) + p_4 U_1(Y_4) - p_1 U_1(Y_1) - p_2 U_1(Y_2)} \phi(\eta_{1NBCBC}) \, d\eta_{1NBCBC} \tag{9.12}$$

Where $\phi(\eta_{1NBCBC})$ is also normal density function ($\mu=0$, $\sigma^2=1$).

Similarly to the equation (9.7)

$$p_{BC} = 1 - p_{NBC} \tag{9.13}$$

Because the error terms are assumed independent, the outcome probabilities simplify to:

$$p_{Y_1} = p_{BC} p_1$$
$$p_{Y_2} = p_{BC} p_2 \tag{9.14}$$

$$p_{Y_3} = p_{NBC}p_3$$
$$p_{Y_4} = p_{NBC}p_4$$

Bargaining game - Future land use

The figure below (Figure 9-2) represents the strategic choice model based on the bargaining game that was previously designed and validated. Same as in the previous example, the options are denoted by a_j, choice probabilities as p_j, outcomes as Y_k, and players m's expected utilities for outcome y_k as $U^*_m(Y_k)$.
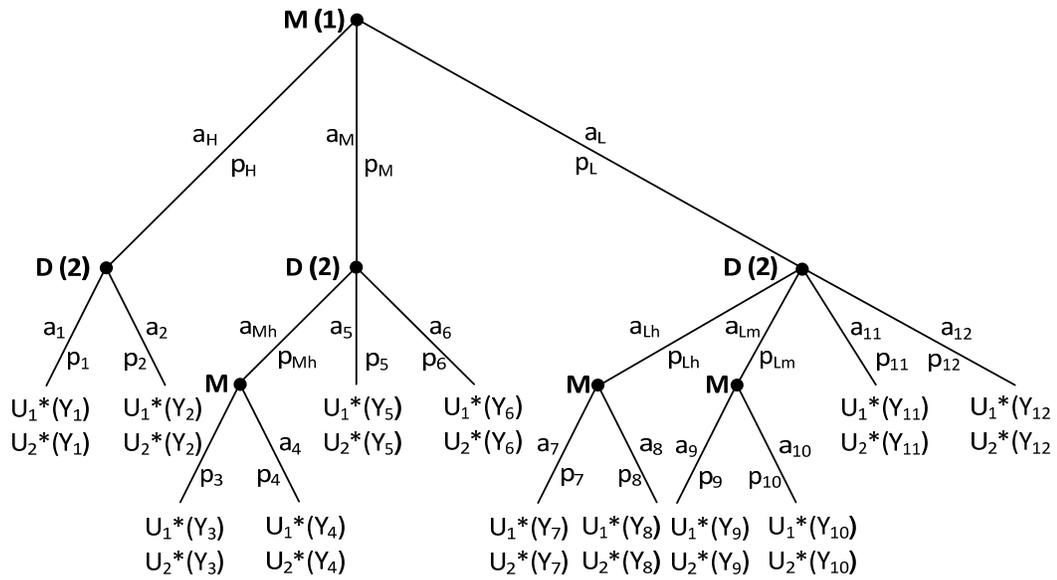
Figure 9-2 Strategic choice model for the bargaining game

It is assumed that the players are bounded rational. Therefore, the SPNE can be expressed by backward induction similar to previous game. Due to the game size the conditional expression is skipped.

Similar to the formula (9.4) we can estimate action probabilities from the ending decision nodes when the utilities are known. For example probability for p_1 is:

$$p_1 = \int_{-\infty}^{U_2(Y_1)-U_2(Y_2)} \phi(\eta_{221}) \, d\eta_{221} \tag{9.15}$$

In addition, the other action in the same node is similar to the equation (9.7):

$$p_2 = 1 - p_1 \tag{9.16}$$

The following probabilities are calculated in the same manner: p_3, p_4, p_7, p_8, p_9, p_{10}.

If we take an assumption that disturbances are independent of each other, then the equation of an action probability where there is more than two actions in a decision node simplifies to for example:

$$p_{Mh} = \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_5)} \phi(\eta_{5Mh})d\eta_{5Mh} \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_6)} \phi(\eta_{6Mh})d\eta_{6Mh} \qquad (9.17)$$

The estimation of the neighboring probability is similar as previous equation

$$p_5 = \int_{-\infty}^{U_2(Y_5)-p_3 U_2(Y_3)-p_4 U_2(Y_4)} \phi(\eta_{45})d\eta_{45} \int_{-\infty}^{U_2(Y_5)-U_2(Y_6)} \phi(\eta_{65})d\eta_{65} \qquad (9.18)$$

And a remain action probability in the same node is of course:

$$p_6 = 1 - p_5 - p_{Mh} \qquad (9.19)$$

Reaming action probabilities can be calculated by following the previous principles. The full calculation is provided in the appendix (Appendix F).

Because the error terms are assumed independent, the outcome probabilities simplify to, for example:

$$p_{Y_1} = p_H p_1 \qquad (9.20)$$

While other outcome probabilities are calculated in the same manner. As an addition, if assumed that the probabilities are mutually exclusive, then the probabilities of all possible outcomes with the certain level of influence can be estimated as follows:

$$p_{high} = p_{Y_1} + p_{Y_3} + p_{Y_7} \qquad (9.21)$$
$$p_{medium} = p_{Y_5} + p_{Y_9}$$
$$p_{low} = p_{Y_{11}}$$

9.5 A result

The table below (Table 9-4) represents the results of an ultimatum game (building claim specific) strategic choice model. The probability estimations of the game outcomes are generated for each treatment. Further, the treatments are described by the attributes that are regarded as a condition for the game (location, embeddedness, administrative support, and synergy). These attributes are also referred as the exogenous components in the strategic choice utility in the previous paragraphs. The strategic choice has been put on the trial on nine treatment combinations (exogenous components). These nine treatment combinations of the attributes and assigned levels are designed with the previously described orthogonal design (Chapter 8.5.1). These are represented in the

first two groups of columns (Treatment; Attribute levels) of the table below. The final column group (Game outcome probabilities) represents the game outcome probabilities for every of the four outcomes in the specified ultimatum (building claim) games.

When comparing the first and the last treatment combination, it is possible to realize that incising the attribute level implies the higher probability of successful realization of the deal. An additional finding while comparing the outcome probability of Y_1 and Y_3 is that the probability also tends to be higher when the building claim is a part of a deal. Based on the findings it is possible to conclude that the model performs well. As a reminder, the outcomes (Y_1) and (Y_3) indicate that the deal is accepted while the outcomes (Y_2) and (Y_4) the opposite. This is indicated also in the figure describing the ultimatum game in the extensive form.

Table 9-4 Ultimatum game: Outcome probability for nine treatments

Treatment	Attributes level				Game outcome probabilities			
	L	E	AS	S	pY_1	pY_2	pY_3	pY_4
1	0	0	0	0	0,101	0,393	0,098	0,408
2	0	1	1	2	0,213	0,282	0,193	0,311
3	0	2	2	1	0,207	0,289	0,187	0,317
4	1	0	1	1	0,293	0,211	0,263	0,232
5	1	1	2	0	0,284	0,216	0,258	0,241
6	1	2	0	2	0,271	0,226	0,248	0,255
7	2	0	2	2	0,393	0,116	0,369	0,122
8	2	1	0	1	0,291	0,212	0,262	0,234
9	2	2	1	0	0,343	0,164	0,314	0,179

The outcomes for the bargaining game are also estimated and they are present in the appendix (Appendix G).

9.6   Experimental validation of a strategic choice model

Although, it is possible to say that the model performs well, still this chapter provides an additional validation by comparing the game outcome, estimated on one hand with the strategic choice model and on the other with the with fuzzy Delphi method (Chapter 8). More specific, recall the previous nine treatments and their probable outcomes (Table 9-4). Now, these results were compared with the results from the experiment 3 (Chapter 8.7.2). Validation is supported by the comparison of the results based on these two data sets. Both results are based on the mentioned treatments that are generated through the orthogonal design.

In the table below (Table 9-5), there are three main columns. The first indicates in which experiment the results could be found (either in experiment 3 or in experiment 4). A second column refers to the employed type of measurement. In the experiment 3, both players (M and D) provides their preferences and the most probable outcome. While for the experiment 4, only the estimated game outcome probabilities are provided

by the strategic choice model. In the final column the results over the four different game outcomes are provided, expressed with different measurements.

Table 9-5 Ultimatum game: validation of a strategic choice for the Treatment 9

Experiment	Game measurement	Game outcomes			
		Y_1	Y_2	Y_3	Y_4
Experiment 3	P_1 preference	**5,389**	3,962	4,572	5,024
	P_2 preference	**5,028**	4,417	5,431	4,548
	P_1 most probable	**4,944**	3,929	4,722	**5,000**
	P_2 most probable	**4,056**	3,952	4,042	3,833
Experiment 4	pY_n strategic choice	**0,343**	0,164	0,314	0,179

In order to compare two different experiment results, two preconditions were defined. Although the number of the respondents is not the same in these two experiments, the uniform division (of respondents) enables two samples to be compared. It is achieved by the dividing the respondents into two groups (player M and player D) based on their characteristics and that division is performed in the same manner in both experiments. The second important issue is a treatment combination. Therefore, both experiments are estimated on the same nine treatments.

For the treatments 9, 8, 7, 6, 5 the strategic choice model performs very well. There is almost a perfect fit between two experiments. For example at the treatment 9 (Table 9-5), the game solutions are indicated with the bold letters. They all indicate that the game will end at the outcome Y_1. First in the experiment 3 by two measurements: SPNE given the both players preferences, and stated most probable outcome by both players. Secondly, the strategic choice model (experiment 4) also indicates the same outcome as the most probable. As stated previously, only the significant values estimated by the binominal probit model were used as the initial input for the strategic choice estimations

In the treatment 4 (Table 9-6), there is still a match between the SPNE measure and the indicated outcome of the strategic choice model. Although by a small difference, there is a mismatch within the experiment 3. The both players indicated that the most probable outcome is Y_3 while the outcome Y_1 has been a SPNE solution based on their preferences.

Table 9-6 Ultimatum game: validation of a strategic choice for the Treatment 4

Experiment	Game measurement	Game outcomes			
		Y_1	Y_2	Y_3	Y_4
Experiment 3	P_1 preference	**5,956**	3,962	5,889	4,395
	P_2 preference	**5,704**	5,095	5,185	4,825
	P_1 most probable	4,706	4,286	**4,983**	4,552
	P_2 most probable	4,537	3,760	**4,574**	4,021
Experiment 4	pY_n strategic choice	**0,293**	0,211	0,263	0,232

For the treatments 1, 2, 3 there is an evident mismatch between the strategic choice predictions and both measures in the experiment 3. For example, treatment 1 is presented below (Table 9-7). The characteristics for all these treatments are the low levels of the conditional attributes (exogenous part of utility). Therefore, a possible conclusion could be that the respondents tend to neglect the bad conditions of a certain deal in the negotiations thus not behaving completely rational.

Table 9-7 Ultimatum game: validation of a strategic choice for the Treatment 1

Experiment	Game measurement	Game outcomes			
		Y_1	Y_2	Y_3	Y_4
Experiment 3	P_1 preference	**5,556**	6,032	5,074	4,671
	P_2 preference	**5,445**	4,390	3,424	3,567
	P_1 most probable	**4,185**	3,984	4,019	4,000
	P_2 most probable	**4,511**	3,791	4,006	3,500
Experiment 4	pY_n strategic choice	0,101	0,393	0,098	**0,408**

9.7 Implications

Game theory provides a framework to gather empirical data and interpret the respondents' interactive behavior. On the other hand, an experiment indicates which parts of the basic theory are most useful in predicting and identifying behavioral parameters that theory does not reliably determine (Crawford, 2002). A way to overcome the problems and supplement the classical game-theoretic approach to the decision problem, a strategic choice model is introduced in this chapter.

As mentioned, this chapter provides an empirical example of the negotiation in the brownfield redevelopment by introducing a strategic choice model. More specifically, the negotiation in this chapter concerns the specific issues such as the building claim and the future land use and parcellation. They are all named the negotiable attributes accompanied with relevant levels. As the findings from this chapter suggest, the increasing in attributes levels leads to the higher level acceptance of a deal. This reflects potentials for interventions (Jost & Weitzel, 2008) in order to reach a certain outcome. As an alternative, these findings can be used to set a borderline for an attractive offer.

In addition, some future applications can be considered. As mentioned, the negotiation attributes have been represented as separate single strategic choice models. This implies that the proposed models could provide a firm base (structure and procedure) for the similar attributes (with same number of levels) that need to be studied in the negotiation context. Even more, this model can be merged with the other models relevant in the urban development, for example experiment 2 (Chapter 7). Such a hybrid model is the major contribution of this research. As already mentioned previously, this is barely established field of research and in this thesis, such a model is regarded as the prescriptive interactive approach in decision theory.

10 Using scenarios for public-private partnerships

10.1 Introduction

In the previous chapter, a strategic choice model has been introduced as a tool to understand and help tackling the negotiation issues relevant for the urban development. This chapter elaborates on the possible application using the previous model. In addition, applications will be proposed that are result of coupling two different models: the previously mentioned strategic choice and the latent class model. All applications introduced in this chapter are presented in the terms of scenarios. These scenarios are related to the different decision-making problems in the brownfield redevelopment processes where two different actors are beneficiary: municipality and developer.

"Visioning, forecasting, scenario generation, plan making, development planning are currently practices modes of planning that link present to the future" (Hopkins & Zapata, 2007). Each mode focuses on making and influencing choices which lead to concrete actions by bringing together information and ideas. In addition, that helps to understand and perceive numerous combinations of actions that can lead to anticipated outcomes. Noteworthy to mention here is that certain mode implies the usage of different tools and techniques. This chapter opts for the scenario mode of linking the present and future. Although well established in urban planning, the origins of the scenario making is in another branch, oil industry (e.g. Global Business Environment Shell, 2002, 2003). In this case, the decision makers generate and select the preferred

scenario, where the preferred scenario is chosen from the structurally different scenarios (Hopkins & Zapata, 2007).

Scenarios can be deployed in many cases relevant for the urban development practice (e.g. Barredo, et al., 2004; Hopkins & Zapata, 2007; Jantz, et al., 2004; Ratcliffe, et al., 2004). This chapter emphasizes the possibility of using the scenarios to create better public private partnerships (PPP) in the brownfield redevelopment. The benefits, obstacles and various forms of PPP have been previously discussed (Chapter 3.2.4; Chapter 8.3). Therefore, no further explanation is provided in this chapter.

Recently, the most of the applications dealing with the future of a brownfield redevelopment projects are in the form of a decision support tools (Blokhuis, 2010; Carlon, et al., 2007; Chen, et al., 2009; Mayer, et al., 2005; Shan & Xu, 1996; Sounderpandian, et al., 2005; Thomas, 2002; Wey & Wu, 2008; Yousefi, et al., 2007). As any decision support tool, they all imply the quantitative approach. Still the scope of the existing applications varies as well as the used methods within the decision support tool.

This chapter introduces a tool to generate and asses the different possible scenarios by applying and combining two different methods: latent class model and strategic choice model.

10.2 Coupling latent class model and strategic choice model

One of the ways to improve a *what-if* scenario is by combining the features of different models. Specifically, this subchapter encourages the parallel use of two models: latent class model (LCM) and strategic choice model.

On one hand, a LCM has the ability to identify and estimate the preferences of different classes of the respondents. Further, by labeling those classes, the analyst is able to identify class respondent preferences in the real market. For example, those preferences could represent the characteristics of the professionals in the brownfield redevelopment. On the other hand, a strategic choice model in this research provides the estimations of the most probable outcome for a certain negotiation attribute (building claim, future land use and parcellation). Such estimation depends on the interaction of two players (municipality and developer). Thus, the ability to incorporate the interaction in estimation is its main feature of the strategic choice model. By combining the features of these two models, an analyst would ideally be able to estimate the real market actors' behavior while incorporating their mutual interactions as well.

The coupling presented in this chapter is rather elementary although requires a predesigned compatibility. This compatibility refers to the reflection of the attribute levels in the LCM on the structure of suggested strategic choice models. This is achieved by assigning every attribute level as an action in the structure of the strategic choice model. As a result, the estimated outcome from the strategic choice can be

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directly translated into the certain attribute level. Therefore, the most probable result is used as an input in to LCM to determine the levels of mentioned negotiable attributes. The other attributes' levels are additionally set as different scenarios. Even with this basic coupling of the two models, it is possible to have different applications and potential decision support tools.

As an aside, it was possible to couple the strategic choice model and LCM because they both share the same dataset. Although some data are regarded as not valid for estimating the strategic choice, still the removed data is below the 5% (Table 9-2) thus coupling is regarded as valid.

10.3 Scenario application

In the paragraphs below, four potential applications are described. They are all in the form of a decision support tool based on the previously described hybrid model. The beneficiary of a decision support tools is either a municipality or a developer.

10.3.1 Application 1: Municipality chooses a policy

The first application is meant for a municipality. Municipality chooses the policy or strategy for a known brownfield. This application requires only implementation of the strategic choice model. By using this model municipality is able to make a tradeoff between the qualities of a known brownfield (described by the four attributes within the given conditions) and influence of a private party. More specific, model provides outcome probabilities (levels of influence) of a negotiable attributes (building claim, future land use and parcellation) given a known brownfield.

The municipality checks the acceptance probability of a certain brownfield alternative by a developer. The assumption here is that the developer shows the higher probability for choosing the mentioned alternative when it is more attractive to develop that site.

An example would be similar as the estimations provided in the previous chapter (Table 9-4) when negotiating about the building claim, and similar table (Appendix 4) when negotiation about the future land use and parcellation. As an aside, besides suggested nine treatment combinations any combination is possible that describes the best brownfield of the interest.

10.3.2 Application 2: Municipality chooses a developer

Although the beneficiary is the same as in the previous application, here a municipality deals with another decision problem, choosing a developer for a known brownfield. This procedure has two steps. In the first step, the strategic choice model estimates the probabilities of game outcome for the negotiable attributes (building claim, future land use and parcellation). As a reminder (Chapter 8.4.1; Chapter 8.4.2), a game action is an equivalent to a negotiable attribute level in discrete choice model. In this way, this

thesis assured the compatibility between a strategic choice model and LCM. Due to this compatibility, it is possible to use the outcomes of a strategic choice model to generate the most probable set of negotiable attributes' levels. The most probable levels are selected as the highest probability of the game outcome indicated by a strategic choice model. More precisely, a strategic choice model generates the levels of three (building claim, future land use and parcellation) out of total seven attributes. The other attributes (location, administrative support, embeddedness, and synergy) and their levels are given because a brownfield is known. In this way, all of the seven attributes have the specified levels. In the second step a LCM is employed. At this step, a municipality checks the acceptance probability of a previously generated alternative (seven attributes with specific levles) by two different developer types. The assumption here is that the developer showing the higher probability for choosing mentioned alternative is more attract to develop that site. This developer is better partner since municipality can negotiate better "operating" terms.

The table below (Table 10-1) is an example of a possible two scenarios which developer would accept to join the brownfield redevelopment project, produced in the excel.

Table 10-1 A scenario for selecting a developer

X_BC	X_LU1	X_LU2	X_P1	X_P2	X_L1	X_L2	X_E1	X_E2	X_AS1	X_AS2	X_S1	X_S2	X_PSC	BC	LU1	LU2	P1	P2	L1	L2	E1	E2	AS1	AS2	S1	S2	PSC	V_B	V_N	expV_B	expV_N	ΣV1	P_B	P_N
-1	-1	-1	-1	-1	0	1	0	1	-1	-1	1	0	1	-1,25	-0,61	0,00	-0,45	0,32	-1,62	0,00	-0,68	0,00	-0,99	0,00	-0,90	0,30	-1,37	2,09	-1,37	8,07	0,25	8,32	0,97	0,03
-1	-1	-1	-1	-1	0	1	0	1	-1	-1	1	0	1	0,00	-0,37	0,00	-0,86	0,00	-3,65	0,76	-0,73	0,00	-1,10	0,00	-0,88	0,00	0,00	2,21	0,00	9,16	1,00	10,16	0,90	0,10
X_BC	X_LU1	X_LU2	X_P1	X_P2	X_L1	X_L2	X_E1	X_E2	X_AS1	X_AS2	X_S1	X_S2	X_PSC	BC	LU1	LU2	P1	P2	L1	L2	E1	E2	AS1	AS2	S1	S2	PSC	V_B	V_N	expV_B	expV_N	ΣV1	P_B	P_N
1	-1	-1	-1	-1	0	1	0	1	-1	-1	1	0	1	-1,25	-0,61	0,00	-0,45	0,32	-1,62	0,00	-0,68	0,00	-0,99	0,00	-0,90	0,30	-1,37	-0,42	-1,37	0,66	0,25	0,91	0,72	0,28
1	-1	-1	-1	-1	0	1	0	1	-1	-1	1	0	1	0,00	-0,37	0,00	-0,86	0,00	-3,65	0,76	-0,73	0,00	-1,10	0,00	-0,88	0,00	0,00	2,21	0,00	9,16	1,00	10,16	0,90	0,10

Starting from the left to right the columns follows. The first group of columns reflects the levels of the attributes in effect codes (Table 7-8). The second group are the LCM estimation of the variables coefficient. Further columns are the expected part-worth utilities, ending with the probabilities for joining or not a brownfield redevelopment project. Looking at the table top-down, each scenario starts with the names of variables, related coefficients and calculated results. Obviously, within a single scenario levels of the attributes are identical. While the coefficients thus the results vary over two types of developers (traditional and proactive).

Any combination of levels is possible, only it is important that first the levels for non negotiable attributes (*X_L1, X_L2, X_E1, X_E2, X_AS1, X_AS2, X_S1, X_L2*) are insert first at the strategic choice model where the most probable levels of negotiable attributes (*X_BC, X_LU1, X_LU2, X_P1, X_P2*) are estimated. Now with this specified brownfield levels it is possible to estimated the probabilities based on the LCM coefficients. A reader can notice that the probability of accepting the upper scenario is higher for the proactive developer. Still when just the one parameter is changed, (building claim is not available) there is a higher probability that a traditional developer will accept the deal.

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Instead of only adopting the game outcomes with the highest probabilities indicating only one alternative, this decision support tool can be improved by introducing the simulation to generate a range of alternatives.

10.3.3 Application 3: Developer chooses a municipality

In this application, a developer can be supported to choose with whom to cooperate for a known brownfield. The procedure is very similar to the one in the previous application, only the beneficiary is changed.

10.3.4 Application 4: Developer chooses a brownfield

One of the applications of coupling two mentioned models is decision support tool that helps a developer to choose which brownfield to redevelop. This application consists of two steps as well. Again, in the first step a strategic choice model estimates the probabilities of negotiable attributes (building claim, future land use and parcellation). Although in this application, the most probable outcomes are estimated for two different alternatives (brownfields). At the second step, an analyst compares two different alternatives. Each alternative is defined with the seven attributes and specified levels. Amongst them, a strategic choice model generates the levels of three attributes, while the other four attributes and their levels are known (given condition). The highest probability of choosing certain alternatives of course represent the highest utility (estimated with the LCM) to that developer.

10.4 Conclusions

The practical applications of the two different methods are underlined. Both methods are the basis for creating scenarios, a mode in the planning practice linking the present and the future. There are four possible applications or decision support tools described in the previous paragraphs. All of these tools concern the negotiation in the brownfield redevelopment. More specific, each of the tools could be a potential decision support tool that helps decision makers to reach the optimal deal in the public private partnerships in the redevelopment of a brownfield. These four applications are worked out in excel and can be potentially transformed in four fully operational decision support tools, for example within the excel interface (Hensher, et al., 2005).

11 Conclusions, implication and discussion

11.1 A short research summary

Several important changes have recently influenced urban planning and the process of redevelopment. At first, the scope and scale of urban redevelopment projects has increased. Secondly, a traditional linear planning process from government to the building industries has been replaced by public-private collaborations that changed the characteristics of the developer and governmental bodies. These actors now have a major influence in urban development processes. Therefore, an important cause for stagnation in redevelopment of brownfield is the lack of consensus amongst key actors due to shared, overlapping concerns or individual conflicting interests.

The objective of this research is to analyze the actors' interaction in brownfield redevelopment processes and to offer recommendations concerning the optimal agreement in public-private partnership for these redevelopments.

The data is generated for the purpose of research. Therefore, the two on-line surveys were conducted. In both cases, the respondents were the experts from the branch of urban development.

The research framework focuses at: (1) the attributes of a brownfield; (2) the preferences of actor's groups; (3) the characteristics in the negotiation processes, regarding the two groups of actors.

Several research methods are used. First, in order to structure and prioritize the influential attributes a fuzzy Delphi method is used. Then, the stated choice experiments provide an insight in the individual preferences of actor groups. Consequently, the utility functions for public and private parties were created. These utilities are used both as an input for the game in game-theoretic environment and as a part of the finial application regarded as prescriptive interactive decision-making approach. The outcomes of the decision-making process are not only depending on an individual choice made, but also include the influence of the choices of an actor's opponent. Therefore, the focus is specifically on the games (game theory) aiming on finding possible strategies in negotiations for brownfield redevelopments. Conclusions that derive from the game theory analysis will be used as a calibration to improve a prescriptive model.

Little work has been done to develop the models that systematically relate the characteristics of a brownfield area to the behavior of actors, thereby giving an insight in the most important points of interest. The research implications are based upon previously mentioned methodology, thus the interaction between the selected actors is analyzed. In general, the outcomes of this research project will support decision makers to find an optimal deal in the negotiation concerning redevelopment challenge for a brownfield.

11.2 Implication in theory and practice

This thesis is structured in a way that each of the experiment has its own objective and implication. Besides, every experiment focuses on the different issues in the brownfield redevelopment; therefore the different methods and techniques are employed.

The first experiment provides an insight of the importance of certain brownfield attribute in regards to the development potential. As contribution, a new hierarchical structure is introduced. The survey included the experts from the practice to validate and rate the identified attributes in existing literature. The used method to collect and estimate the data is known as Fuzzy Delphi Method with the Similarity Aggregate Method (FDM with SAM). As a result, some attributes emerged as very important in every panel in the survey, although those attributes were completely missing in some of the other studies, while some other attributes have a different importance. Additionally, Experiment 1 shows that the diversification of expert is important. This is supported by a proof of their different ratings. A practical implication of the findings can be in development appraisal. The previous findings could help on a decision whether or not a certain development will be viable by understanding the future marketability and the future costs. The findings address only the attributes in relation to a brownfield on the urban district scale in the Netherlands. As shown previously (Figure 5-2), all

experiment are linked. In that regard, this experiment provided an input for a discrete choice model (Chapter 7.2.2).

This research employs a specific discrete choice model, a Latent Class Model (LCM). The LCM has the ability to identify a variety of different preferences on the individual level. In addition, it classifies the respondents based on their stated preferences. In Experiment 2, a LCM identified four classes as the main actors involved in brownfield redevelopment. The main actors are labeled as follows: (1) the private traditional-experienced actor, (2) public proactive actor, (3) public reserved actors, and (4) private proactive actor.

In the broader sense of this classification, the groups (1) and (4) can be interpreted as a developer (D) and groups (2) and (3) as a municipality (M). This insight provided the overview of the major actors' behavior in the brownfield redevelopment. Besides the explanatory role, these analyses can be used as a support tool for a policy-making. This goes with the current trend that more and more attention has been put on the quantifications of the decisions. Practically, an implication of the findings can be a support tool that assists municipality in choosing the best partner for the brownfield redevelopment by realizing different parties' preferences. This is also similar for the private actors, they can benefit too from such a tool.

In general, a decision process in urban development is becoming more complex due to the multi-actor involvement in the built environment. Game Theory can be applied to analyze the process of an urban development project, resulting in a basic understanding of players' strategic choice behavior and expected decision outcomes. Consequently, this can provide an insight in the actor's interaction concerning the brownfield redevelopment.

Experiment 3 supports the previous connotation on the example of a brownfield joint venture games. This experiment is relying on the game-experimental approach. The method used to collect the data is the Fuzzy Delphi Method (FDM), similar to Experiment 1. Further, this method is combined with the classical game-theoretic solution concept, sub perfect Nash equilibrium (SPNE). The aim of this experiment is to use the abstract representation of the actors' interaction as a tool to understand the behavior of the involved parties better. Although, this experiment dot not to completely mimic the real-world to every detail. A major critic of the classical game theory is the assumption of completely rational players. To overcome partly this problem, the concept of bounded rationality can be introduced by combining the game theory with the methods enabling a vector or multi-valued utility function.

Therefore, to overcome the mentioned problem and supplement the classical game theory, a strategic choice model is introduced in the Experiment 4. In general, a strategic choice model is based on the game theory analysis and related to the discrete choice models. The intention is clear: to improve behavior models. Experiment 4

provides an empirical evidence of the negotiation process in the brownfield redevelopment concerning specific issues. These issues are named the negotiation attributes and they have been represented with the separate strategic choice models. One is a building claim investigated on the structure of the *ultimatum game* and another is the future land use and parcellation designed as a *bargaining game*. Therefore, besides being able to estimate the impact of each of the negotiation attributes in, the proposed structure of the two strategic choice models could have a broader implication. Precisely, these models could provide a base for the similar attributes/issues that need to be studied in the negotiation context of urban development. This is mainly supported by the possibility to use the structure and the procedure of the proposed models for the other attributes/issues sharing the same number of attribute levels.

The research suggested some practical implications of as well. There are four possible applications all concerning the negotiation in the brownfield redevelopment. More specific, each of the applications could be a potential decision support tool that helps decision makers to reach the optimal deal in the public private partnerships concerning the brownfield redevelopment. They are shaped as a scenario mode in the planning practice where a beneficiary designs and selects the preferred scenario.

11.3 Discussion and future research

Together, all the experiments can be regarded as one unique research procedure (Figure 5-2) having as an entry the literature study of the most important actors and attributes in a brownfield and ending with a suggestion of a strategy or a policy in regards to the brownfield redevelopment negotiations in public-private partnerships. The mentioned procedure is referred as a hybrid model in this research because of the usage of different techniques and methods that are linked together. The use of that hybrid model should benefit from the combination of the predictive capabilities of the individual choice on one hand and on the other hand, the interactive analysis based on the game theory. Therefore, this research classifies proposed hybrid model as a quantitative, prescriptive-interactive decision-making approach. As already mentioned previously, this is barely established branch in decision theory, and this thesis contributes in this research direction.

Concerning the empirical findings, it can be improved by enlarging the data set in the future research. This is relevant for both of the surveys resulting in the four mentioned experiments. That will give more reliability on the brownfield redevelopment preferences of the selected actors. Besides reliable findings, the proposed enlarged database would provide a possibility to deliver new insights by using the same methods and procedure. For example, it would be possible to re-estimate the LCM (Experiment 2) by enlarging the number of the respondents' characteristics.

The future of this research lies in the domain of negotiation support systems (NSS) that would seek for good solutions given the problem of choosing the partner or an optimal agreement in the future PPP for a brownfield redevelopment project. Although there are valid existing proposals, on one hand the state of the art in the brownfield decision support tools does not incorporate mechanisms of interactions between actors nor does it deal with the performance indicators that are relevant to the multiple actors. On the other hand, the contributions for framing the possibilities of interaction (I. Mayer & de Jong, 2004; I. S. Mayer, et al., 2005) still are lacking the comprehensive statistical model. As any DSS, future NSS should consist of following three main features: (1) the database, (2) the model and (3) user interface. This research contributes only to developing a model base in the form of mentioned hybrid model. Thus, to have a fully operational NSS for the mentioned problem, more research and development needs to be conducted.

The first necessary improvement is a validation of the proposed hybrid model. It needs to be validated by the experts and consequently adjusted. The validation was not incorporated in this research mainly due to the practical constraint to set up a new survey or a set of individual interviews that also pre-requires generating an additional database of the relevant respondents. By the rule of thumbs, this would be necessary step, since the same respondents cannot be addressed to estimate the proposed models and validate their applicability. Obviously, all of the missing features need to be addressed such as the database and user interface. Regarding the data, a similar survey could be set in future addressing the preferences at a given time. In addition, a program that automates the support system needs to be developed as well. Evidently, further research is needed. However, the idea and the base model modeling part of the future NSS is the product of this thesis. A positive feedback of experts on the hybrid model assures the prospects of the future NSS.

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Appendix

Appendix A - Find intersection: flowchart with illustration

start

Find Intersection

a_1 in front a_2 — yes — a_2 in front c_1 — yes — c_1 in front c_2 — yes — give points: 2(1,1) 2(1,2) 1(1,3) 1(1,4)

a_1 / a_2 a_1 / a_2 c_1

no

c_2 in front c_1 — yes — give points: 2(1,1) 2(1,2) 2(1,3) 2(1,4)

no

c_1 cuts c_2 — yes — type 1 or type2 — 1 — give points: 2(1,1) 2(1,2) 1(1,3) P(x_{pi}) 2(1,4)

2

give points: 2(1,1) 2(1,2) 2(1,3) P(x_{pi}) 1(1,4)

no

a_2 cuts c_1 — yes — c_1 cuts c_2 — yes — give points: 2(1,1) P(x_{pi}) P(x_{pi}) 2(1,4)

a_1 a_2 c_1

no

c_1 don't cut c_2 — yes — give points: 2(1,1) P(x_{pi}) 1(1,4)

no

a_2 don't cut c_1 — yes — empty

a_1 cuts a_2 — yes — a_1 in front c_2 — yes — c_1 in front c_2 — yes — give points: 2(1,1) P(x_{pi}) 1(1,2) 1(1,3) 1(1,4)

a_1 / a_2 a_1 / a_2 c_2

no

a_1 cuts a_2 reverse — reverse value a_1 cuts a_2 c_2 in front c_1 — yes — give points: 2(1,1) P(x_{pi}) 1(1,2) 2(1,3) 2(1,4)

a_1 / a_2

no

a_2 in front a_1 — reverse value a_1 in front a_2 c_1 cuts c_2 — yes — type 1 or type2 — 1 — give points: 2(1,1) P(x_{pi}) 1(1,2) 1(1,3) P(x_{pi}) 2(1,4)

a_2 / a_1

2

end a_1 cuts c_2 — give points: 2(1,1) P(x_{pi}) P(x_{pi}) 2(1,4)   give points: 2(1,1) P(x_{pi}) 1(1,2) 2(1,3) P(x_{pi}) 1(1,4)

Appendix B - Flowchart symbol sheet

Flowchart Symbol	Name (Alternates)	Description
	Process	An operation or action step.
	Terminator	A start or stop point in a process.
	Decision	A question or branch in the process.
	Delay	A waiting period.
	Predefined Process	A formally defined sub-process.
	Alternate Process	An alternate to the normal process step.
	Data (I/O)	Indicates data inputs and outputs to and from a process.
	Document	A document or report.
	Multi-Document	Same as Document, except, well, multiple documents.
	Preparation	A preparation or set-up process step.
	Display	A machine display.
	Manual Input	Manually input into a system.
	Manual Operation	A process step that isn't automated.
	Card	A old computer punch card.
	Punched Tape	An old computer punched tape input.
	Connector	A jump from one point to another.
	Off-Page Connector	Continuation onto another page.
	Transfer	Transfer of materials.
	Or	Logical OR
	Summing Junction	Logical AND
	Collate	Organizing data into a standard format or arrangement.
	Sort	Sorting of data into some pre-defined order.
	Merge (Storage)	Merge multiple processes into one. Also used to show raw material storage.
	Extract (Measurement) (Finished Goods)	Extract (split processes) or more commonly - a measurement or finished goods.
	Stored Data	A general data storage flowchart symbol.
	Magnetic Disk (Database)	A database.
	Direct Access Storage	Storage on a hard drive.
	Internal Storage	Data stored in memory.
	Sequential Access Storage (Magnetic Tape)	An old reel of tape.
	Callout	One of many callout symbols used to add comments to a flowchart
	Flow Line	Indicates the direction of flow for materials and/or information

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Appendix C - Kendell's tau correlation over 22 attributes

Correlations

**, Correlation is significant at the 0.01 level (2-tailed).
*, Correlation is significant at the 0.05 level (2-tailed).

Appendix D - Future land use and parcellation: Game tree validity

Branch	Does branch exist?	Frequency	Percent
H	No	60	**69,8**
	Yes	26	30,2
M	No	56	**65,1**
	Yes	30	34,9
L	No	56	**65,1**
	Yes	30	34,9
OTHER	No	84	97,7
	Yes	2	2,3
H_a	No	24	27,9
	Yes	62	72,1
H_r	No	64	**74,4**
	Yes	22	25,6
H_OTHER	No	79	91,9
	Yes	7	8,1
M_h	No	40	46,5
	Yes	46	53,5
M_a	No	49	**57,0**
	Yes	37	43,0
M_r	No	78	**90,7**
	Yes	8	9,3
M_OTHER	No	82	95,3
	Yes	4	4,7
L_h	No	48	**55,8**
	Yes	38	44,2
L_m	No	59	**68,6**
	Yes	27	31,4
L_a	No	63	**73,3**
	Yes	23	26,7
L_r	No	63	**73,3**
	Yes	23	26,7
L_OTHER	No	84	97,7
	Yes	2	2,3
M_h_A	No	37	43,0
	Yes	49	57,0
M_h_R	No	49	**57,0**
	Yes	37	43,0
M_h_OTHER	No	75	87,2
	Yes	11	12,8
L_h_A	No	44	**51,2**
	Yes	42	48,8
L_h_R	No	38	44,2
	Yes	48	55,8
L_h_OTHER	No	77	89,5
	Yes	9	10,5
L_m_A	No	26	30,2
	Yes	60	69,8
L_m_R	No	54	**62,8**
	Yes	32	37,2
L_m_OTHER	No	77	89,5
	Yes	9	10,5

Appendix E - The future land use and parcellation: SPNE and the most probable outcome

End Branch	Player	W = (a, b, c)			S	SPNE
H_a	M	4,53	6,46	8,17	6,39	X
	D	4,30	6,77	8,80	6,62	
H_r	M	2,47	4,17	6,32	4,32	
	D	2,23	4,54	6,65	4,47	
M_a	M	4,08	5,71	7,45	5,75	
	D	4,07	6,81	8,65	6,51	
M_r	M	2,82	4,84	6,78	4,82	
	D	2,46	4,39	6,57	4,47	
L_a	M	4,71	6,69	8,15	6,52	
	D	3,34	5,85	7,65	5,62	
L_r	M	3,53	4,96	6,87	5,12	
	D	3,00	5,31	7,12	5,14	
M_h_A	M	2,22	3,79	6,12	4,04	
	D	2,26	3,93	6,36	4,18	
M_h_R	M	2,53	4,26	6,33	4,38	
	D	1,64	3,47	5,48	3,53	
L_h_A	M	4,37	5,80	7,22	5,80	
	D	4,04	6,42	7,99	6,15	
L_h_R	M	2,80	4,29	5,96	4,35	
	D	1,76	3,57	5,61	3,65	
L_m_A	M	3,47	5,12	6,98	5,19	
	D	2,27	4,23	6,19	4,23	
L_m_R	M	3,21	4,78	6,80	4,93	
	D	3,02	5,11	7,18	5,11	

End Branch	Player	W = (a, b, c)			S	Outcome
H_a	M	2,76	4,50	6,31	4,52	
	D	2,49	4,42	6,42	4,44	X
H_r	M	1,83	3,92	5,33	3,69	
	D	2,26	3,66	5,39	3,77	
M_a	M	2,44	4,01	5,99	4,15	
	D	2,47	4,17	6,07	4,24	
M_r	M	2,22	4,15	5,48	3,95	
	D	2,27	3,84	5,67	3,93	
L_a	M	3,08	4,59	6,43	4,70	X
	D	2,53	4,13	5,83	4,17	
L_r	M	2,58	4,12	5,39	4,03	
	D	2,72	3,88	5,77	4,12	
M_h_A	M	2,17	4,18	5,82	4,06	
	D	2,46	3,77	5,56	3,93	
M_h_R	M	2,09	3,43	5,35	3,62	
	D	2,22	3,44	5,22	3,63	
L_h_A	M	2,59	4,30	6,00	4,30	
	D	2,47	4,22	5,97	4,22	
L_h_R	M	2,24	4,22	5,73	4,06	
	D	2,24	3,56	5,39	3,73	
L_m_A	M	2,82	4,87	6,19	4,63	
	D	2,54	3,86	5,55	3,98	
L_m_R	M	2,50	4,82	6,27	4,53	
	D	2,66	4,05	5,87	4,19	

Appendix F - Strategic choice model for the bargaining game: calculation

We assume that the players are bounded rational. Therefore, the SPNE can be expressed by backward induction similar to the ultimatum game. Due to the game size the conditional expression is skipped. It is possible to estimate action probabilities from the ending decision nodes when the utilities are known. Those are the following probabilities: $p_1, p_2, p_3, p_4, p_7, p_8, p_9, p_{10}$.

$$p_1 = \int_{-\infty}^{U_2(Y_1)-U_2(Y_2)} \phi(\eta_{221}) \, d\eta_{221}$$

$$p_2 = 1 - p_1$$

$$p_3 = \int_{-\infty}^{U_1(Y_3)-U_1(Y_4)} \phi(\eta_{134}) \, d\eta_{134}$$

$$p_4 = 1 - p_3$$

$$p_7 = \int_{-\infty}^{U_1(Y_7)-U_1(Y_8)} \phi(\eta_{178}) \, d\eta_{178}$$

$$p_8 = 1 - p_7$$

$$p_9 = \int_{-\infty}^{U_1(Y_9)-U_1(Y_{10})} \phi(\eta_{1910}) \, d\eta_{1910}$$

$$p_{10} = 1 - p_9$$

$$p_{Mh} = Pr[U_2^*(a_{Mh}) > U_2^*(a_5), U_2^*(a_{Mh}) > U_2^*(a_6)]$$
$$p_{Mh} = Pr[U_2^*(a_{Mh}) > U_2(Y_5) + \alpha_5, U_2^*(a_{Mh}) > U_2(Y_6) + \alpha_6]$$
$$U_2^*(a_{Mh}) = [p_3 U_2(a_3) + p_4 U_2(a_4)] + \alpha_{Mh}$$
$$p_{Mh} = Pr[p_3 U_2(a_3) + p_4 U_2(a_4) + \alpha_{Mh} > U_2(Y_5) + \alpha_5, p_3 U_2(a_3) + p_4 U_2(a_4) + \alpha_{Mh} > U_2(Y_6) + \alpha_6]$$
$$p_{Mh} = Pr[p_3 U_2(Y_3) + p_4 U_2(Y_4) - U_2(Y_5) > \alpha_5 - \alpha_{Mh}, p_3 U_2(Y_3) + p_4 U_2(Y_4) - U_2(Y_6) > \alpha_6 - \alpha_{Mh}]$$

If we let $\eta_{ijk} = \alpha_{ij} - \alpha_{ik}$, we can rewrite:
$$p_{Mh} = Pr[p_3 U_2(Y_3) + p_4 U_2(Y_4) - U_2(Y_5) > \eta_{5Mh}, p_3 U_2(Y_3) + p_4 U_2(Y_4) - U_2(Y_6) > \eta_{6Mh}]$$

$$p_{Mh} = \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_5)} \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_6)} \phi(\eta_{5Mh}, \eta_{6Mh}) \, d\eta_{5Mh} \, d\eta_{6Mh}$$

If we take an assumption that disturbances are independent of each other, then the equation simplifies to:

$$p_{Mh} = \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_5)} \phi(\eta_{5Mh}) d\eta_{5Mh} \int_{-\infty}^{p_3 U_2(Y_3)+p_4 U_2(Y_4)-U_2(Y_6)} \phi(\eta_{6Mh}) d\eta_{6Mh}$$

$$p_5 = \int_{-\infty}^{U_2(Y_5)-p_3U_2(Y_3)-p_4U_2(Y_4)} \phi(\eta_{45})d\eta_{45} \int_{-\infty}^{U_2(Y_5)-U_2(Y_6)} \phi(\eta_{65})d\eta_{65}$$

$$p_6 = 1 - p_5 - p_{Mh}$$

$$p_{Lh} = \int_{-\infty}^{p_7U_2(Y_7)+p_8U_2(Y_8)-p_9U_2(Y_9)-p_{10}U_2(Y_{10})} \phi(\eta_{LmLh})d\eta_{LmLh}$$
$$\int_{-\infty}^{p_7U_2(Y_7)+p_8U_2(Y_8)-U_2(Y_{11})} \phi(\eta_{11Lh})d\eta_{11Lh} \int_{-\infty}^{p_7U_2(Y_7)+p_8U_2(Y_8)-U_2(Y_{12})} \phi(\eta_{12Lh})d\eta_{12Lh}$$

$$p_{Lm} = \int_{-\infty}^{p_9U_2(Y_9)+p_{10}U_2(Y_{10})-p_7U_2(Y_7)-p_9U_2(Y_9)} \phi(\eta_{LhLm})d\eta_{LhLm}$$
$$\int_{-\infty}^{p_9U_2(Y_9)+p_{10}U_2(Y_{10})-U_2(Y_{11})} \phi(\eta_{11Lm})d\eta_{11Lm} \int_{-\infty}^{p_9U_2(Y_9)+p_{10}U_2(Y_{10})-U_2(Y_{12})} \phi(\eta_{12Lm})d\eta_{12Lm}$$

$$p_{11} = \int_{-\infty}^{U_2(Y_{11})-p_7U_2(Y_7)-p_8U_2(Y_8)} \phi(\eta_{Lh11})d\eta_{Lh11}$$
$$\int_{-\infty}^{U_2(Y_{11})-p_9U_2(Y_9)-p_{10}U_2(Y_{10})} \phi(\eta_{Lm11})d\eta_{Lm11} \int_{-\infty}^{U_2(Y_{11})-U_2(Y_{12})} \phi(\eta_{1211})d\eta_{1211}$$

$$p_{12} = 1 - p_{11} - p_{Lm} - p_{Lh}$$

$$p_H = Pr[U_1^*(a_H) > U_1^*(a_M), U_1^*(a_H) > U_1^*(a_L)]$$
$$U_1^*(a_H) = [p_1U_1(Y_1) + p_2U_1(Y_2)] + \alpha_{1H}$$
$$U_1^*(a_M) = \{p_{Mh}[p_3U_1(Y_3)+p_4U_1(Y_4)] + p_5U_1(Y_5) + p_6U_1(Y_6)\} + \alpha_{1M}$$
$$U_1^*(a_L) = \{p_{Lh}[p_7U_1(Y_7)+p_8U_1(Y_8)] + p_{Lm}[p_9U_1(Y_9)+p_{10}U_1(Y_{10})] + p_{11}U_1(Y_{11})$$
$$+ p_{12}U_1(Y_{12})\} + \alpha_{1L}$$

$$p_H = \int_{-\infty}^{p_1U_1(Y_1)+p_2U_1(Y_2)-p_{Mh}p_3U_1(Y_3)-p_{Mh}p_4U_1(Y_4)-p_5U_1(Y_5)-p_6U_1(Y_6)} \phi(\eta_{MH})d\eta_{MH}$$
$$\int_{-\infty}^{p_1U_1(Y_1)+p_2U_1(Y_2)-p_{Lh}p_7U_1(Y_7)-p_{Lh}p_8U_1(Y_8)-p_{Lm}p_9U_1(Y_9)-p_{Lm}p_{10}U_1(Y_{10})-p_{11}U_1(Y_{11})-p_{12}U_1(Y_{12})} \phi(\eta_{LH})d\eta_{LH}$$

$$p_M = Pr[U_1^*(a_M) > U_1^*(a_H), U_1^*(a_M) > U_1^*(a_L)]$$
$$p_M = \int_{-\infty}^{p_{Mh}p_3U_1(Y_3)+p_{Mh}p_4U_1(Y_4)+p_5U_1(Y_5)+p_6U_1(Y_6)-p_1U_1(Y_1)-p_2U_1(Y_2)} \phi(\eta_{HM})d\eta_{HM}$$
$$\int_{-\infty}^{\substack{p_{Mh}p_3U_1(Y_3)+p_{Mh}p_4U_1(Y_4)+p_5U_1(Y_5)+p_6U_1(Y_6)-p_{Lh}p_7U_1(Y_7)-p_{Lh}p_8U_1(Y_8)-p_{Lm}p_9U_1(Y_9)-p_{Lm}p_{10}U_1(Y_{10}) \\ -p_{11}U_1(Y_{11})-p_{12}U_1(Y_{12})}} \phi(\eta_{LM})d\eta_{LM}$$

$$p_L = 1 - p_M - p_H$$

$$p_{Y_1} = p_H p_1$$
$$p_{Y_2} = p_H p_2$$
$$p_{Y_3} = p_M p_{Mh} p_3$$
$$p_{Y_4} = p_M p_{Mh} p_4$$
$$p_{Y_5} = p_M p_5$$
$$p_{Y_6} = p_M p_6$$
$$p_{Y_7} = p_L p_{Lh} p_7$$
$$p_{Y_8} = p_L p_{Lh} p_8$$
$$p_{Y_9} = p_L p_{Lm} p_9$$
$$p_{Y_{10}} = p_L p_{Lm} p_{10}$$
$$p_{Y_{11}} = p_L p_{11}$$
$$p_{Y_{12}} = p_L p_{12}$$

$$p_{high} = p_{Y_1} + p_{Y_3} + p_{Y_7}$$
$$p_{medium} = p_{Y_5} + p_{Y_9}$$
$$p_{low} = p_{Y_{11}}$$

Appendix G - Bargaining game: Outcome probability across the attribute levels

T.	Attribute level				Game outcome probabilities											
	L	E	AS	S	pY_1	pY_2	pY_3	pY_4	pY_5	pY_6	pY_7	pY_8	pY_9	pY_{10}	pY_{11}	pY_{12}
1	0	0	0	0	0,04	0,17	0,02	0,06	0,01	0,16	0,02	0,06	0,03	0,10	0,01	0,32
2	0	1	1	2	0,10	0,13	0,03	0,03	0,04	0,14	0,03	0,03	0,03	0,04	0,02	0,37
3	0	2	2	1	0,11	0,13	0,03	0,03	0,05	0,14	0,03	0,03	0,03	0,04	0,03	0,37
4	1	0	1	1	0,17	0,10	0,04	0,02	0,08	0,10	0,04	0,03	0,03	0,02	0,05	0,32
5	1	1	2	0	0,15	0,10	0,03	0,03	0,07	0,11	0,04	0,03	0,03	0,03	0,05	0,34
6	1	2	0	2	0,12	0,10	0,03	0,03	0,06	0,12	0,03	0,03	0,03	0,04	0,04	0,36
7	2	0	2	2	0,25	0,07	0,07	0,02	0,11	0,07	0,05	0,01	0,03	0,01	0,08	0,23
8	2	1	0	1	0,16	0,10	0,04	0,02	0,07	0,11	0,04	0,03	0,03	0,02	0,05	0,33
9	2	2	1	0	0,20	0,08	0,04	0,02	0,09	0,08	0,04	0,02	0,03	0,02	0,07	0,29

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Samenvatting (Dutch summary)

Strategische besluitvorming in de herstructurering van brownfields

De ruimtelijke planning en het herstructureringsproces van bedrijventerreinen zijn onlangs aan enkele belangrijke veranderingen onderhevig geweest. Ten eerste is de omvang van de ruimtelijke herstructureringsprojecten toegenomen. Ten tweede zijn de traditionele lineaire planningsprocessen vervangen door publiek-private samenwerkingen waarbinnen de rollen en de onderlinge afhankelijkheid van ontwikkelaars en overheidsorganen gewijzigd zijn. Binnen deze nieuwe kaders is de herstructurering van brownfields veelal problematisch; er treden veel conflicten op tijdens planprocessen. In dit onderzoek wordt beargumenteerd dat het gebrek aan consensus onder betrokken stakeholders een belangrijke oorzaak is van de optredende stagnatie binnen brownfield herstructureringsprocessen.

Het uiteindelijke doel van dit onderzoek is het voorspellen en analyseren van het optreden van conflicten in herstructureringsprocessen, alsmede het doen van aanbevelingen over optimale publiek-private samenwerkingsovereenkomsten voor de herstructurering van brownfields. Om dit doel te verwezenlijken is er een onderzoekskader opgesteld, welke is gericht op het specificeren en analyseren van: (1) de attributen van een brownfield; (2) de voorkeuren van de groepen van actoren; en (3) de kenmerken in het onderhandelingsproces tussen de twee groepen van actoren. Voor

het verzamelen van noodzakelijke data zijn er twee online enquêtes gehouden. In beide gevallen waren de geënquêteerden experts binnen een specifieke tak van gebiedsontwikkeling.

Voor dit onderzoek zijn verschillende methoden gebruikt. Ten eerste is de Fuzzy Delphi methode gebruikt om brownfield attributen te structureren en te prioriteren. Stated Choice experimenten verschaffen vervolgens het inzicht in de individuele voorkeuren van verschillende actor-groepen. Deze resulterende nutsfuncties zijn uiteindelijk gebruikt als de input voor de analyse van multi-actor besluitvorming, waarvoor de methode Game Theory is gebruikt. De resultaten van het besluitvormingsproces hangen niet alleen af van een individuele keuze maar ze bevatten ook de invloed van de keuzes van een tegenspeler. Het vinden van mogelijke consensusrijke strategieën in de onderhandelingen over de herstructurering van brownfields is het doel van deze laatste stap.

Tot op heden is er weinig onderzoek verricht naar de ontwikkeling van besluitvormingsmodellen waarin systematisch de kenmerken van de brownfield-terreinen en de herstructureringsplannen verbonden wordt met het gedrag van de betrokken actoren; een dergelijke verbinding kan inzicht geven in mogelijke bronnen van conflicten. Dit onderzoek draagt bij aan de ontwikkeling van modellen waarin de interactie tussen verschillende actoren binnen een complex probleemgebied wordt geanalyseerd. De resultaten van dit onderzoek ondersteunen besluitvormers en procesmanagers bij het vinden van een optimale overeenkomst in de publiek-private onderhandelingen omtrent de herstructurering van brownfields.

Curriculum vitae

Brano Glumac was born in 1980 in Belgrade, Serbia. He started his study at the Architecture Faculty, Belgrade University in 1999, where he received an equivalent to the Master of Science degree in Architecture and Planning. After graduating in 2005, he started working as an architect and urban planner until August 2006. Thereafter, he started a master study at the department of Architecture, Building and Planning, Eindhoven University of Technology. In 2007, he received his second Master of Science in Real Estate Management and Development.

In order to become a PhD candidate, he started working after the graduation as a research assistant involved in the elaboration of a research proposal together with the academic staff. Consequently, he became a PhD researcher in February 2008, now at the Real Estate and Urban Development group, the Department of the Built Environment, Eindhoven University of Technology.

His research interests focus on the strategic decision-making and market research in the field of real estate and urban development and application of the choice behavioral models. He is an author of several academic, professional and conference papers in these topics. In June 2011, he received the ERES 2010 (European Real Estate Society) Award for the Best Paper in Real Estate Development.