Master Thesis

Towards sustainable parking: decision making of governmental and commercial stakeholders

Colophon

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Management summary

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility: in the 27 countries of Europe the transport sector is responsible for 19% of the Greenhouse gas emission. Parking is an important aspect of mobility in the context of the urban environment. Parking facilities, as elements of the built environment, provide users with spaces for their cars nearby their destinations, and is a source of revenue for government and market parties. Parking activities are located in the public domain (on-street and private domain (off-street) in garages, areas or near walkways.

Recently, attention is growing on sustainability in relation with parking. As a result, the parking industry and government are embracing a large number of developments ranging from sustainable innovations to environmental policy in the context of parking. The focus in this research lies with recent developments in the context of sustainable parking.

Given the high number of developments; differences of interests; and governmental policies in the field of mobility and parking, it is difficult for cooperating stakeholders to choose, invest in, or predict the effects of (long term) sustainable developments. Therefore, the most promising developments according to decision makers are required. A ranking of sustainable developments in parking is currently not available.

Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking. Municipalities (Government) enforce parking policy and Parking operators (market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved. Municipalities and parking organizations are considered key decision makers on developments in parking. Decision making in policy and business planning considers 'financial' and 'control aspects'. Public procurement in parking, a form of decision making during tendering, incorporate award criteria which consider qualitative and sustainable aspects in the tendering process next to traditional aspects like financial criteria.

A research framework is developed to answer the main research question: *"What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?".* A review of literature provides information on influential stakeholders, decision making criteria and recent developments regarding the four types of sustainable developments in parking. The key methodology in this research is Multi Criteria Decision Analysis (MCDA). This evaluation method combines criteria weights with evaluation scores of alternatives. In order to find the criteria weights, the Analytical Hierarchy Process (AHP) is adopted. The method requires decision makers in parking to prioritize decision criteria using pair wised comparisons. In an on-line questionnaire, experts of municipalities and parking operators are required to score the developments in a qualitative manner. Finally, Qualitative Dominance scores are used to synthesize weights and evaluation scores.

The decision criteria that emerged from literature are divided in four groups. The criteria-group 'Impact on business plan: financial aspects' consists of three sub-criteria: 'Investment costs', 'ROI' and 'Risk for the organization'. Criteria-group 'Impact on business plan: control aspects' consists of two sub criteria: 'influence of organization on development' and 'influence of development on business plan'. Effect criteria focus on the outcome of a

development. The criteria-group 'Mobility aspects' consists of sub-criteria: 'effect on parking demand city center' and 'effect on congestion city center'. Finally, criteria-group 'sustainability aspects' considers three sub-criteria: 'effect on energy usage', 'effect on amount of KM travelled and effect on amount of pollutants'.

Six developments are selected according to recently attractive themes in the parking industry. These developments are: 'Improving the sustainability of the existing parking stock'; 'Developing charging networks for electricity driven vehicles'; 'Introduction of electronical navigation, way finding and payment systems'; 'Increasing number of P+R and K+R areas in order to support Car-Sharing'; Introducing policy in order to enable flexible parking standards'; and 'Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping'.

Frequency analysis took place on all development evaluations in order to find similarities and differences between the stakeholder groups 'government' and 'market'. The group consensus, represented by the criteria modes, are compared per stakeholder group for each development.

The results of the research show a first priority for 'introduction of electronical navigation, way finding and payment systems' for the governmental and market stakeholder groups. 'Introducing policy in order to enable flexible parking standards' is prioritized second for the governmental stakeholder followed by 'improving the sustainability of the existing parking stock'. The latter is prioritized second by the market stakeholder.
The results of this research show which developments regarding sustainable parking are preferred most by the governmental stakeholder group and the market stakeholder group. On one hand, this research showed which developments are most promising regarding both stakeholder groups. On the other, the evaluation of the developments provide underlying criteria scores that affected the final prioritization. These underlying expectations of decision makers could be considered as strengths and weaknesses for the implementation of sustainable developments in parking.

Finally, an advice is presented for the most promising development. Given the legislative power, policy and sustainability targets of municipalities, governmental decision makers should stimulate the introduction of electronical navigation, way finding and propose fair sharing of investments costs, information and potential benefits by introducing an independent entity.

Acknowledgments

This thesis is the result of my graduation project, the final part of the master program Construction Management and Engineering. The topic of this thesis, parking, helped me to focus as it combines two of my interests: 'management of the urban environment' and 'parking'. During a part-time job at parking operator P1, I discovered an industry which seemed to involve multiple disciplines that are related to my master program. For example, urban design, planning, real-estate management and process management. Besides my personal interests, many people inspired and encouraged me to complete this thesis.

First, I would like to thank my graduation supervisors at Eindhoven University of Technology and Pink + Nelson: Peter van der Waerden for his guidance, academic drive, unlimited enthusiasm regarding the subject, and willingness to discuss 'parking' during a high number of extended meetings. Vladan Jankovic, for investing time and effort to review, support and guide the research project from a business point of view. Wim Schaefer, for safeguarding the entire process and enabling me to graduate in the field of parking.

Second, fellow graduate students and colleagues at Pink + Nelson for sharing knowledge and providing me a collaborative and energetic working environment at the faculty or offices in Eindhoven and The Hague.

Third, I would like to thank the experts in the field of parking which delivered the data for this research and provided insights in decision making of municipalities and parking operators.

Finally, friends and family that supported me in moral and practical ways during this research project. In particular, Eefje Bauwens, Erik van Kempen, Sander Koper, Menno Meeldijk and Sanneke Nelissen.

Approximately one year ago, one of my graduation supervisors noticed a sort of 'parking fever'. According to him, many people in the field of parking show signs of great enthusiasm and unlimited energy regarding the parking industry. It seemed to be highly contagious, satisfactory and sometimes elevating. During the research project, I have met a high number of interesting and passionate people at the university and graduation company. After finishing this thesis, I think the diagnose 'parking fever' fits me as well.

1   Introduction

In this chapter the topic of this thesis is introduced, followed by the problem statement and research goal. Next, the relevance of the research project for practice and science is elaborated. At the end of this chapter, a reading guide for the thesis is provided.

1.1 Sustainability and parking

Mobility in general, and car usage in particular have a negative impact on the environment due to the use of (fossil) fuels, and the emissions of particulate matter [fijnstof] and exhaust gasses including CO_2 (Q-Park NV, 2012a). The energy consumption in urban districts, related to traffic and mobility, accounts for almost 20% of the total of energy use in the urban environment (Energiebureau.nl).

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility: in 27 European countries the transport sector is responsible for 19% of the greenhouse gas emission. The situation in the Netherlands is even more extreme: the transport sector is responsible for 35% of the total emission. Overall, the transportation sector is responsible for 30% of all fossil fuel emissions in the European Union (European Union, 2007).

Parking is an important aspect of mobility in the context of the urban environment. Parking facilities, as elements of the built environment, provide users with spaces for their cars nearby their destinations. As a result, it affects urban planning, spatial use, the convenience of transportation and sustainability of the city is growing. Recently, attention on sustainability in relation with parking. For example way finding to a parking space: "On a daily basis, it is estimated that 30% of vehicles on the road in the downtown area of major cities are cruising for a parking spot and it takes an average of 7.8 minutes to find one" (Arnott, et al., 2005). As a result, the parking industry and government is embracing a large number of developments ranging from sustainable innovations to environmental policy in the context of parking.

Sustainable trends and developments in parking

This research is focused on recent developments in the context of sustainable parking. Developments, in this thesis also mentioned as trends, have been studied and the results are presented in chapter 2: 'Literature review'. In general, four types of sustainable developments exist (van der Waerden, 2012; Farla, et al., 2010; Q-Park NV, 2013a):

1. Sustainability by technological improvement of personal vehicles;
2. Sustainability by construction of sustainable buildings;
3. Sustainability by improving the efficiency of traffic and way finding;
4. Sustainability by mobility and parking policy.

Decision making

The increase of traffic congestion combined with a societal focus on environment and sustainability, lead to challenges in how mobility and parking have to be managed. For example, municipalities are eager to reduce traffic congestion for the improvement of the quality of life by solving problems related to pollution and noise (Giuffrè, et al., 2012). Governmental bodies like municipalities, national governments and the European Union

have "an important role to play in building a system of sustainable mobility, through regulatory policies, and strategic incentives and disincentives" (Vergragt & Brown, 2007).

A market party's willingness to embrace developments and innovation towards a more sustainable society is a function of the following aspects: its attitude towards cleaner technology (based on the party perception of environmental and economic risks); the pressure that the party perceives itself to be under; and the control the firm believes it actually has over the innovation of cleaner technologies (Montalvo, 2002).

The power of mobility and parking policy seems to lie with municipalities which are responsible for practical policy and control while changes in mobility rates could affect commercial assets like those of parking operators and investors. Municipalities try to find partners to finance for example P+R solutions. "The willingness of commercial parties to do an investment for a transfer point depends on how it affects the interest of the parties" (KpVV 2005).

Thus, societal and environmental changes have an influence on parking itself and policy related to parking: the way in which parking is being organized. Besides direct effects on policy, these changes influence behavior of stakeholders related to parking.

1.2 Problem statement

Integral projects introduce multiple stakeholders in parking related activities. Together, these stakeholders will develop the 'parking landscape'. Due to the high number of societal and technological developments, it seems to be difficult to anticipate on future developments (Vergragt & Brown, 2007). Even if a development is considered 'leading', stakeholders' decision making will influence the outcome. These difficulties were confirmed during informal discussions with experts at the graduation company.

Given the indicated developments; differences of interests; and governmental policies in the field of mobility and parking, it is difficult for cooperating stakeholders to choose, invest in, or predict the effects of (long term) sustainable developments. In order to successfully cooperate in a project, individual actors should be able to predict preferences and decision making of partners and competitors. Therefore, an analysis of attributes, characteristics, and decision criteria is required in order to enable stakeholders to anticipate in future developments. The problem statement is divided in two parts which are presented below.

1. The aspects, characteristics, and attributes of developments in the context of sustainable mobility are not clear. Most effects on mobility and sustainability are assumed but not quantified in detail.

2. Actors in mobility and parking embrace specific developments in the context of sustainable parking, but also need the cooperation of other stakeholders. Therefore, the most promising developments according to decision makers are required. A ranking of sustainable developments in parking is currently not available.

1.3 Research aim

The aim of the research is to get more insight into the decision making process of stakeholders regarding developments in the context of sustainable parking. In this paragraph the aim is explained in more detail.

As elaborated in the first part of the introduction, two important decision makers exist: Government and Market which serve the third stakeholder group: Society. The relationships between governmental and commercial parties which regulate, coordinate, and enforce mobility measures are explained in earlier in this introduction. Given these relationships, the focus lies on governmental and commercial stakeholders. Society can be considered as client or customer for market parties. In the decision making process society, as important interest group, is mostly represented by the government (May, 2003).

The available resources to conduct current research are limited. It is not possible to investigate all types of developments in the available time period. Developments in contexts of sustainable parking will be selected during the research process. A focus on important or elaborated developments will probably result in more detailed conclusions regarding these developments.

1.4 Relevance

Relevance of this research can be divided in theoretical and practical aspects. The relevance for theory describes the value of this research in the field of science while the applicability of this thesis is considered as relevance for practice.

1.4.1   Theory

As far as the author knows limited scientific research is available regarding the decision making in and evaluation of multiple sustainable developments in the field of parking. Limited literature is available on decision making in parking (e.g. Litman, 2013; May, 2003) and decision making regarding sustainable innovations (e.g. Montalvo, 2002). On the other hand, sustainable developments are individually assessed by researchers (e.g. Bakker, 2011; Dijk & Montalvo, 2011; Giuffrè, et al., 2012). A certain combination of both approaches could not be found during the preparation of this research.

This research aims to find criteria to compare and evaluate sustainable developments in parking with respect to the decision making process. Besides insight in criteria, developments could be evaluated using these criteria and help to select the most promising developments.

1.4.2   Practice

The parking industry continuously adopts new innovations and developments in parking (KpVV, 2013). Generally, these developments are initiated by financial benefits (efficiency), technological innovation, societal change or policy by legislators (e.g. Farla, et al., 2010; VROM, 2010; Montalvo, 2002).

In order to decide which developments should be implemented in business planning, developments have to be prioritized according to the stakeholders' interest. As stated in this introduction, governmental and market parties influence decision making in parking.

Therefore, it is necessary to find the influential criteria, current developments in parking and priorities of both stakeholder groups. Comparing these priorities, should provide the parking industry insight in the most interesting developments that are supported by both stakeholders. Consensus on priority could ease the decision making process and improve the financial benefits en outcome of adopted developments.

1.5 Reading guide
This thesis is structured in five chapters. In this first chapter, the introduction, the subject, problem statement, research aim and relevance of this research are introduced.

The second chapter, Literature review, describes the literature study. Relevant topics regarding the subject of decision making in sustainable parking are presented. The topic of 'Parking and mobility' is described first, followed by the identification of important stakeholders in parking. Relevant parking policy from mobility and environmental perspective is presented next which provides the first criteria to review developments. The paragraph 'Decision making in parking' describes the decision making process and decision criteria regarding business planning and policy development. Finally, recent developments and trends in parking are presented.

The research approach is presented in the third chapter. The research questions and research framework are presented first, followed by a description of the used methods and techniques. The paragraph 'Data collection' describes the process that is followed to obtain data for the analysis. The chapter concludes with the expected results of the research.

The third chapter, Analysis, elaborates the multi criteria decision analysis that is conducted on the research data. The chapter starts with a description of targeted respondents. An analysis on criteria weights using the Analytic Hierarchy Process is presented next, followed by the evaluation of developments. Finally, the combination of weight and evaluation scores is presented in the final paragraph 'Qualitative Dominance Scores'.

To conclude this research, the final chapter summarizes the research and presents the general conclusion in which research questions are answered. The final paragraphs 'Recommendations for practice' and 'scientific research' suggest further implementation of the results in practice, elaborates the most promising development and further research.

2   Literature review

This chapter presents a review of relevant literature regarding the topic of this thesis. In the following paragraphs the context of parking is explained. An extensive description of parking and mobility is given which is followed by a stakeholder analysis, and an overview of parking policy. In paragraph 'Decision making in parking', the decision making in policy and business planning in relation to sustainable developments in parking is explained. This section introduces criteria that influence the decision making process. Finally, developments in parking are discussed which are present in literature and practice.

2.1 Parking and mobility

Mobility is defined as "the possibilities an individual has to move and to use these possibilities. Possibilities in mobility consist of all kinds of roads including bus lanes, bicycle paths and footways; and all kind of parking facilities including bicycle stalls" (CROW, 2002).

According to the definition of mobility, parking can be considered as an important aspect of mobility in the urban environment. Mobility, the human movement in the urban environment, shapes urban areas and influences the economic strength, quality and livability of the built environment.

According to (CROW, 2002), goals of traffic planners related to parking are as follows:

- Regulate car use in congested areas to control accessibility and living conditions of these areas;
- Regulate the distribution of scarce space and stimulate economic development in central business districts;
- Regulate traffic flows;
- Regulate parking of employees and visitors of a variety of facilities (shops, schools, childcare, etcetera);
- Regulate user's and developer's costs;
- Regulate parking in relation to landscaping.

The goals stated above suggest that mobility and parking policy have a great influence in the development and processes in the urban environment. Q-park (Q-Park NV, 2012), market party and parking operator, focuses more on the aspect of parking in relation to mobility and is stating the function of parking more compact:

- Parking policy helps to effectively guide mobility behavior;
- Parking policy for selective accessibility of specific areas;
- Parking policy to invest in the quality of public space;
- Parking for consumer needs for example in the context of shopping;
- Parking as a source of revenue: a source of income for both municipalities and parking operators.

After comparing both definitions and goals for parking one could conclude that parking helps regulate mobility, provides services to customers, shapes the urban environment; and is a source of revenue for government and market parties.

Parking facilities

In order to achieve the presented goals for parking, the parking system consists of numerous facilities that accommodate drivers. The main types of parking facilities are (Litman, 2013):

- On street (curb) parking: designated parking spaces located within a road, usually in the curb lane;
- Surface parking: a parking facility directly on the ground (paved or unpaved);
- Structured or underground parking: multi-story parking structure including parking facilities within or under a building (parking, garage, parkade or ramp).

Parking policy in the Netherlands (CROW, 2012) resulted in a differentiation of parking activities and types (figure 1). In this figure 'parking' as general activity is divided into 'Public parking' and 'Private parking'. If parking solutions are available for the public it is defined as 'Public parking'. In contrast to public parking, 'Private parking' has a relationship to parking solutions which aim to support the private environment. For example, parking on private property that support residential buildings and offices. Given that private parking focusses on target groups related to the environment, the latter is not available or accessible for the public and privately managed.

The introduction of parking regulation has differentiated public parking in 'Regulated parking' and 'Unregulated parking'. Two important regulative options besides paid parking exist: permit and blue zones. Permits and blue zones result in more efficient use of parking space. Specific target groups (e.g. inhabitants of specific neighborhoods) are favored over other drivers by introduction of permits for parking. 'Blue zone parking' introduces time restrictions and decreases the amount of time available to park for individual drivers.

In addition to the two parking regulations described above, paid parking regulates the use of available parking spaces by tariff differentiation. Pricing of parking spaces aims to decrease the attractiveness of parking space. It is assumed that pricing mechanism could steer and direct the parking behavior of drivers (CROW, 2012). Paid parking activities are located at on- and off-street facilities. Off-street activities can be considered as public parking on a private domain, in garages or designated areas. On the other hand, on-street parking is located along the street in the public domain.

Parking market

The breakdown structure (figure 1) of parking showed diversification of paid parking activities. In addition to this diversification, Litman (2013) suggests two types of parking facilities determined by their financial characteristics:

- Priced (or metered): parking facilities where drivers are charged directly for use, including on street metered parking and off street facilities where drivers can pay by a certain time unit;
- Commercial parking: a paid-parking facility for car drivers. This type of parking is managed by a commercial party.
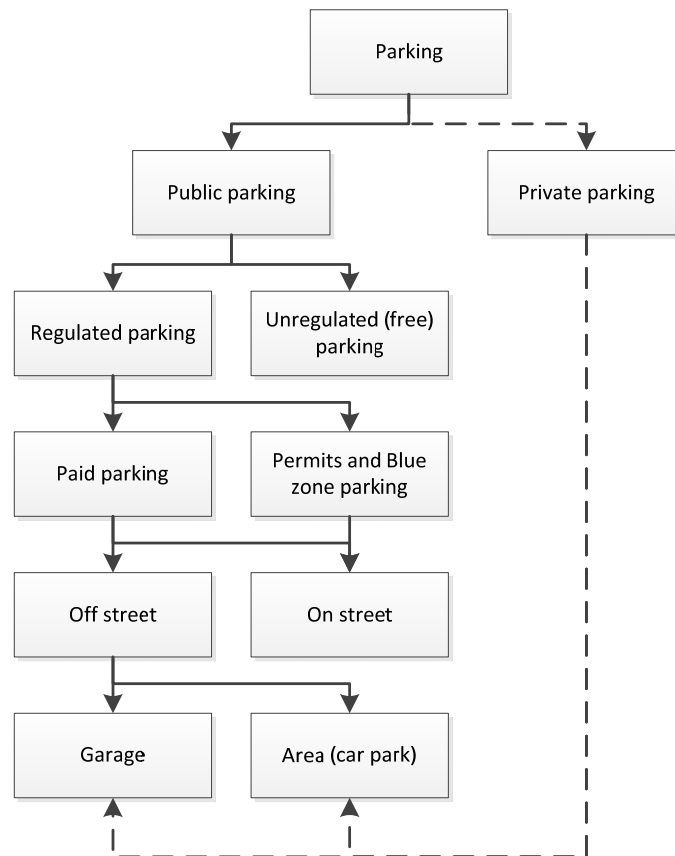
Figure 1: Parking differentiation (Bouwfonds REIM, 2012)

Both definitions include a certain payment from drivers for their parking activities and show the involvement of commercial parties. In the Netherlands, municipalities are allowed to outsource on- and off-street parking activities to commercial parties like parking operators (e.g., Q-Park, Interparking, and P1). Multiple options for outsourcing are available resulting in high or low financial risks for municipalities and (shared) ownership of facilities (CROW 2012).

As a result, governmental parties are able to regulate the on- and off-street domain assisted by contracted market parties. In the field of off-street parking, both government and market parties are active. Municipalities are able to manage off-street facilities by themself or assisted by a commercial party. Governmental parties who are involved in a Public Private Partnership entity are also allowed to be commercially active. A Public Private Partnership is a legal entity which shares are divided by governmental and private parties (see P1 Parkings., 2005). Commercial parties are often involved in off-street parking activities as real estate developer or parking operator.

Parking is a market in which commercial and governmental parties are involved. According to Bouwfonds REIM (2012) there is actually no general car parking market in Europe. The market should be seen as "the convergence of various local markets each with their own characteristics. The size of the European car parking market determines the supply of parking spaces" (Bouwfonds REIM, 2012).
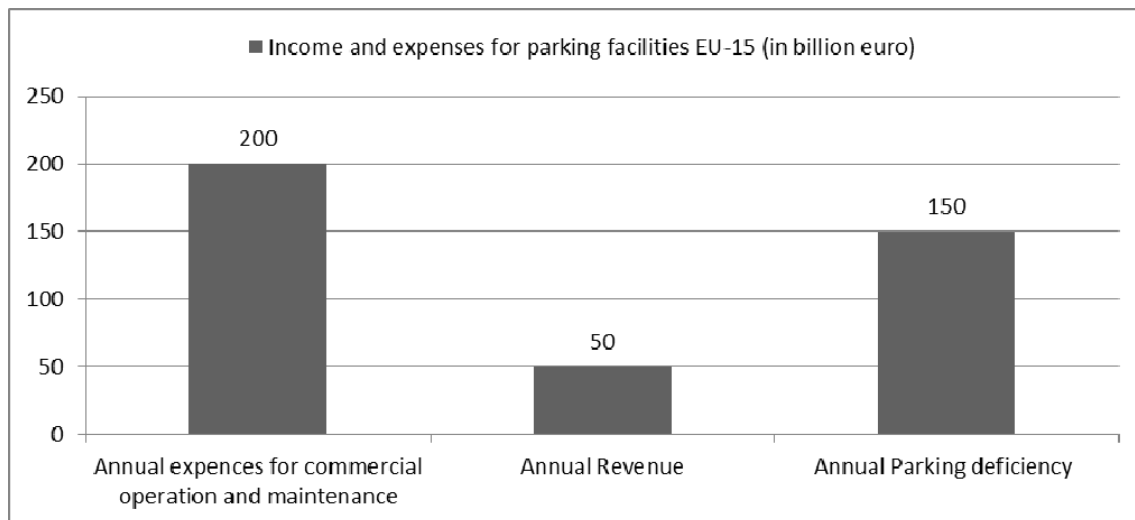
Q-park (Q-Park NV, 2012) published an analysis of the European Parking market. According to figure 2, 200 billion euro a year is invested in parking related activities and this results in a profit of 50 billion Euro a year. In figure 3 it is visible that 25% of 300 million parking spaces are regulated. "We estimate that some 60 million parking spaces are regulated by means of parking permits, blue zones and the like and between 12 and 15 million parking spaces by means of paid parking" (Q-Park NV, 2012). Concluding from both figures, the majority of parking spaces is not regulated and only five percent is regulated by paid parking.
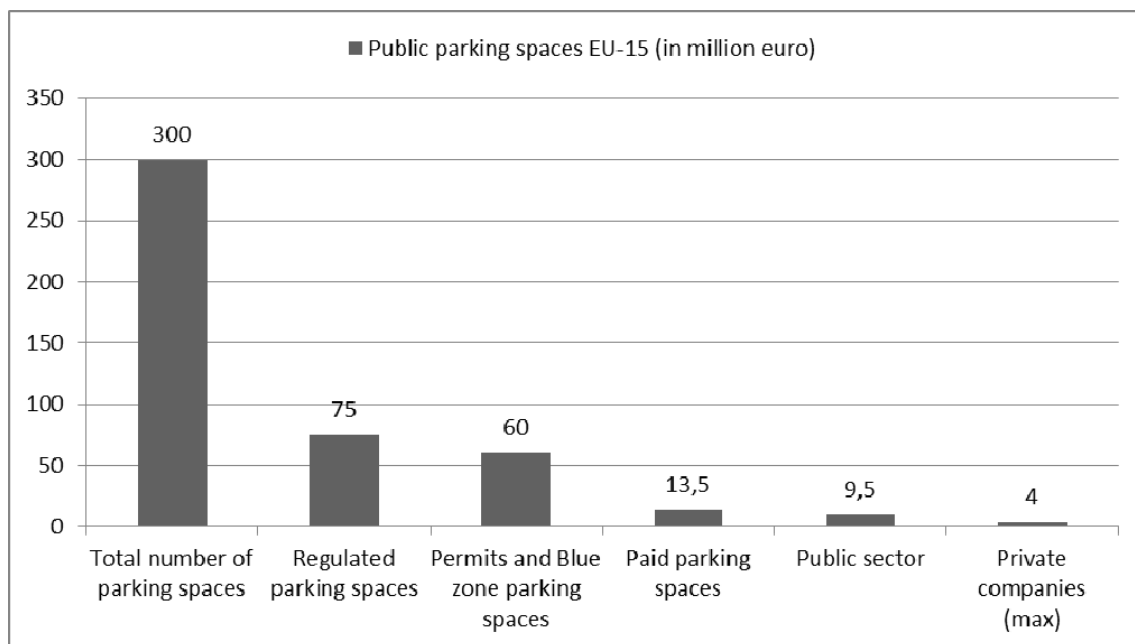
Figure 3: Public parking spaces in Europe (Q-Park NV, 2012)

2.2 Stakeholders in parking

As suggested in the previous paragraph, governmental and commercial parties perform activities in the field of parking. Both parties are considered as relevant stakeholders in the context of this thesis. Stakeholders are people or organizations with a specific interest in a project or subject. Interests, professional or personal, drive people and organizations to be involved in a project (May, 2003). For example, civilians can be affected by an implementation of a certain policy.

The European GUIDEMAPS project (May 2003) investigated typical stakeholders that are involved in transport decision making. In figure 4 below, involved stakeholders are categorized as Government / Authorities, Businesses / Operators, and Communities / Local neighborhoods. According to the research, roles of stakeholders can differ: decision makers make the formal decisions in a project; technical experts are involved in project design and deliver (technical) input to the process; and outside influencers can externally influence the decision making process.

Government / Authorities	Businesses / Operators	Communities / Local Neighborhoods
European Union	National Business Associations	National Environmental NGOs
Ministry of Transport	Major Employers	Motorist Associations
Other National Ministries	Regional and National Businesses	Trade Unions
Regional Government	Private Financiers	Media
Local Authorities	Local Business Associations	Local Authority Forums
Neighboring Cities	Town Centre Retailers	Local Community Organizations
Local Transport Authority	Small Businesses	Local Interest Groups
Other Local Transport Bodies	Transport Operators / providers	Cycle / Walking Groups
Other local Authority Bodies	Transport Consultants	Public Transport User Groups
Politicians		Transport Users
Other Decision-Makers		Citizens
Partnership bodies		Visitors
Project Managers		Citizens in Neighboring Cities
Professional Staff		Disabled People
		Landowners
		Transport Staff

Figure 4: Typical stakeholders involved in transport projects (May, 2003)

According to CROW (2012), the following stakeholders related to parking and mobility can be considered: governmental, market and society based. Governmental organizations develop and enforce parking policy. Market parties invest and deliver product and services for government and society. Society can be considered as user of the built environment. Similarities appear while comparing figure 4 to the stakeholder devision of CROW (2012). The first colum shows numerous governmental stakeholders on different (spatial) levels. Market parties are represented in the table by companies and related associations, while society consists of users, employees, and societal organizations. In this research the stakeholdertypes of CROW are used to group people and organisations involved with parking.

As described earlier in this chapter, parking policy regulates mobility; provides services to customers; shapes the urban environment; and is a source of revenue for government and investors (e.g., CROW, 2002; Q-Park NV, 2012b). These goals may result in differences of interest between policy makers, municipalities, and market parties. For example, differences can exist between investors and parking operators that are cooperating in the field of parking. The most important stakeholders and their interests regarding parking are indentified and described in the next section.

2.2.1   Stakeholder identification
Stakeholder groups related to parking have been presented at the beginning of this paragraph. Q-Park NV (2013a) performed an extensive investigation of stakeholders related to the companies activities. The table is presented in Appendix A which shows the groups of involved stakeholders and their goals. The following description presents the most important stakeholders and related interests in the context of this study.

Governmental stakeholders
As suggested earlier, governmental stakeholders can be divided by scale and type of relationship. Governmental stakeholders could be indirectly or directly involved.

European Union, National governments and regions. These three stakeholders are indirectly involved. The European Union sets goals with environmental and mobility policy that affects policy of member states like the Netherlands. The national government in the Netherlands develops policy on a national level and delegates local tasks to provinces (regions and municipalities in the Netherlands. Incentives on national level related to parking and mobility are: competitive power, accessibility, livability and safety. (Ministerie van Infrastructuur en Milieu 2012)

Municipalities in the Netherlands develop the practical and local policy for mobility and parking in so-called GVVP documents. As a result, municipalities are directly involved. Interests of municipalities are comparable with those of the central government. Q-park NV (2012b) has specified the related goals as: Parking policy to effectively guide mobility habits; Parking policy for selective accessibility; Parking policy for quality of public space; Parking for consumer needs; and Parking as a source of revenue Q-park NV (2012b).

Market stakeholders
The group market stakeholders can be divided in parking operators, service and hardware suppliers, consultancy agencies and investors (e.g. CROW, 2012; Q-Park NV, 2013a).

Parking Operators provide parking solutions for municipalities and invest in and manage parking facilities. The solutions that this stakeholder provides are the management of parking garages and other parking facilities for private proprietors and public entities; and services related to the management of public on-street parking spaces.
Parking management mainly consists in the maintenance and the supervision of parking spaces, located at the road side, in airports, hospitals, shopping centers, cities, hotels, etc. Some examples of organizations which operate internationally: Q-park, APCOA Parking, Interparking, P1 parking and PCH. Incentives of parking operators are mostly commercial. For example, financial revenue, fair competition, quality and endurance.

Service and hardware suppliers deliver secondary services and products to parking operators. The provided services and hardware consist of parking systems, guidance systems, payment systems, building services, transaction and payment service providers, booking services, cleaning services et cetera (www.vexpan.nl). Examples of service and hardware providers in the Netherlands are WPS, Skidata (parking systems) and Yellowbrick (mobile payment provider). Related incentives are innovation and research and development combined with commercial incentives similar to parking operators.

Consultancy agencies advise municipalities, parking operators and investors in the field of mobility and parking on topics like transport planning, traffic management, regional or urban development, GIS, modeling and simulation, public transport and environmental management. Examples of consultancy agencies in the Netherlands are Goudappel Coffeng, Royal Haskoning DHV, SPARK and Empaction.

Investors are generally interested in investments that result in profit and protection against inflation. For example, financial health of the investment and insensitivity to risks. The conventional procedure for parking garages is to annually index-link the rent in the rental agreement to match inflation. This indexation, by definition, means that parking garages offer protection against inflation (Bouwfonds REIM, 2012).

Society

Society could be represented by politics, social interest groups, institutes and users. These examples all represent in some way the users of the facilities.

Users can be considered as individual customers or business partners seeking parking solutions for their employees (CROW, 2012, Q-Park NV, 2013a). Important incentives for both groups are: fair prices, accessible parking facilities, quality and safety.

Stakeholders' relationships

Based on the information presented in this thesis, two stakeholders are enforcing parking policy: municipalities and parking operators. Both stakeholders develop practical policy with direct effects on investors and users. Consultancy agencies, the national government and European Union affect parking policy in a more abstract way by regulation, analysis and advise.

In figure 5, different relationships between stakeholders are visualized. As shown, parking operators and municipalities directly influence parking. Users are affected by the decisions made by both parties. The user is able to influence the parking operator or municipality cause by the customer relationship. The dashed area in the diagram shows third parties who have relationships with parking operators, municipalities and users. Therefore, these stakeholders are able to influence parking activities in an indirect manner.
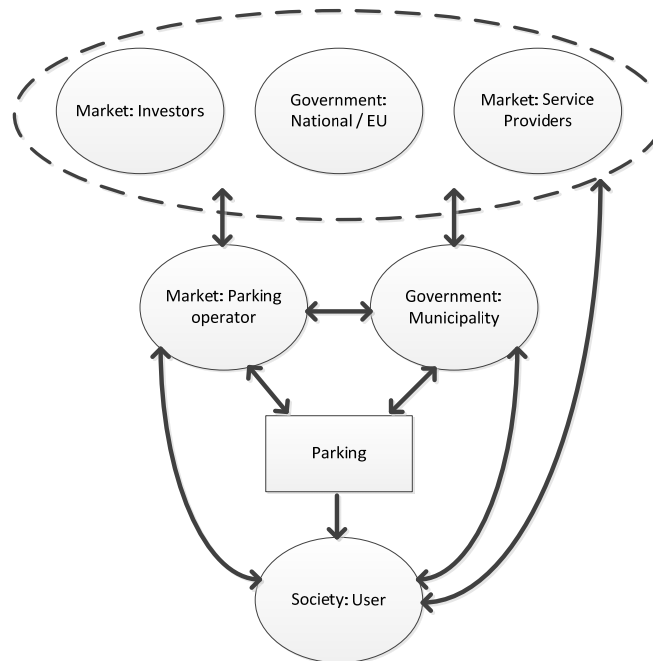
2.3 Parking Policy

In order to improve the built environment and solve problems resulting from the growth of car use and related parking; traffic planners in central governments, municipalities and consultancy agencies develop parking policy (CROW, 2012). Parking policy consists of legislation, rules, and strategies to manage the mobility of the urban environment.

In Europe, the development of parking policy can be described in seven phases (e.g., Dijk & Montalvo, 2011; Technical Committee on Transport, 2006):

1. No parking measures. This phase is acceptable until the level of parked cars has a negative impact on the attraction and quality of the area.
2. Parking regulation and control. This means that in some streets parking will become prohibited.
3. Time restrictions (free of charge). This results in more efficient use of available space from increased turnover of cars.
4. Paid parking. Parking tariffs become used as a key to control the use of parking spaces.
5. Resident parking schemes. An overflow of parkers to neighboring areas (often residential) will require resident parking schemes.
6. P + R facilities. These are developed as an alternative for or addition to parking supply in the city center.
7. Mobility management. It comprises various activities to tune the combination of private and public transport in order to provide an acceptable mobility-chain for travelers.

The enumeration above indicates the development of parking policy. It shows an increase in regulation of parking activities and describes the introduction of restrictive policy and paid

parking. Basic policy, like 'no parking measures', is sufficient until problems arise. Negative impacts of parking activities, that harm the surrounding environment, require more and more advanced policies.

2.3.1 Legal policy framework

The central government provides provinces and municipality with financial means and legislation to influence mobility. Goals of governmental traffic and transport policy are: decrease of mobility growth related to automobiles; enhance the livability and accessibility of the economic hotspots and facilities. In 'Structuurvisie Infrastructuur en Ruimte (SVIR)', the traffic and transport policy is covered in more detail.

The provinces of the Netherlands coordinate mobility policy of the municipalities. The provincial governance level translates the SVIR in the Provincial Traffic and Transport Plan (PVVP). This document is more specific and has a higher level of detail. Municipalities' policies have to meet the conditions in the PVVP. Regional Traffic and Transport Plans (PVVP) describe agreements in policies of a region. Municipality Traffic and Transport Plans (GVVP) describe guidelines for the municipality. Dutch municipalities are responsible to execute the parking legislation and policies by enforcement of parking policy. Land-use plans and the GVVP enable municipalities to: manage the number of parking spaces; regulate and enforce parking policy.

2.3.2 Policy for sustainable mobility

In attempt to reach sustainable goals related to mobility, the European Union developed SUMP: the 'Sustainable Urban Mobility Plan'. Sustainable Urban Mobility Plans help to manage urban areas more efficiently and prevents transport related problems. It is building on existing practices and legislation in the countries of the European Union.

The key targets in Sustainable Urban Mobility Plans (SUMPS) are (Rupprecht Consult, 2007):
- Involving citizens and stakeholders in decision making, implementation of policy and evaluation, complex planning issues;
- Improve sustainability: balancing economic development, social equity and environmental quality;
- Support an integrated approach of practices and policies between policy sectors, authority levels, and between neighboring governmental organizations;
- Focusing on achieving measurable targets embedded in an overall sustainable development strategy;
- Accounting transport costs and benefits, including societal costs and benefits.;
- Provide a method comprising the following tasks: scenario; definition of a vision, objectives and targets; selection of policies and measures; assignment of responsibilities and resources; implementing arrangements for monitoring and evaluation.

The KpVV, a Dutch NGO that supports knowledge on mobility and transport, compared legislation according to current Municipalities Traffic and Transport Plans (GVVP) in the Netherlands. It concluded that sustainable and energy aspects are not fully described in GVVPs (Kennisplatform Verkeer en Vervoer (KpVV), 2012).

According to KpVV (2012), the SUMP criteria visible in figure 6 should be included in mobility planning in order to reach the European sustainability requirements. As mentioned earlier in this paragraph, the Traffic and Transport Plans (GVVP) affects municipalities parking policy. Therefore, SUMP criteria, also could be used to improve the sustainability of parking activities.

Criterion (SUMP)	Objective
Ensure mobility system	Ensuring the accessibility offered by the transport system
Improve safety	Improving safety and security
Reduce air pollution	Reducing air and noise pollution, GHG and energy consumption
Reduce noise	Reducing air and noise pollution, GHG and energy consumption
Reduce CO2 emissions	Reducing air and noise pollution, GHG and energy consumption
Reduce energy consumption	Reducing air and noise pollution, GHG and energy consumption
Improve efficiency and cost effectiveness	Reducing air and noise pollution, GHG and energy consumption
Quality and attractiveness of living environment	Enhancing the attractiveness and quality of the urban environment

Figure 6: Sustainability criteria according to SUMP (KpVV, 2012).

2.4 Decision making in parking

In this paragraph decision making in parking is discussed. Decisions have to be made in order to reach defined objectives. Examples are decision making in policy, decision making related to business planning, and decision making in contracting.

Different approaches of transport decision making have been investigated by the European PROSPECTS project (May, 2003). In general, two approaches exist:

- 'Muddling through' approach: objectives are not formally specified and decisions are only taken when necessary;
- Rational / analytical approach: relies on data and formal analysis and often ignores practical realities.

These two extremes in transport planning have developed over time in more advanced decision making approaches differentiated by number of decision makers and type of process.

1. Vision led decision making: associated with an individual decision maker who has a view of the target and how this can be achieved.
2. Plan led decision making: associated with multiple decision makers (planning professionals) who follow a standard set of procedures.
3. Objective led decision making: associated with individual or multiple decision makers who focus on high level objectives, problem identification and barriers.
4. Consensus led approach: associated with the active involvement of decision makers of various stakeholder groups. The approach focusses to reach an agreement between stakeholders in all stages of the decision making process.

All of these approaches can be used by decision makers in parking. It shows a development from individual decision making to group decision making with incorporated stakeholders.

2.4.1 Decision making in policy and business planning

According to the general approach, 'rational / analytical decision making' relies on analysis of the subject. Litman (2006) suggested multiple techniques, objectives, and criteria to be used in transport decision making. The author considers economic evaluation important "to indicate how a proposed policy or program impacts market principles explicitly identify market distortion, and highlight opportunities to achieve transportation objectives" (Litman, 2006).

Financial aspects

Cost-Effectiveness, Benefit-Cost Analysis, Lifecycle Cost Analysis, and Multiple Accounts Analysis can be used for policy making and business planning. These types of economic evaluation methods use important financial variables such as:

- Costs: the investment costs for a project. For example, the lowest cost alternative is chosen related to the outcome of a measurement;
- Return On Investment (ROI): The ratio of the financial benefits per year divided by the cost. For example, a ROI of 25% is based on financial benefits of 250 Euro and costs of 1000 Euro;
- Net Benefits: accumulated benefits over time minus the sum of all costs;
- Risk: chance that an investment does not provide the expected benefits.

The variables that are listed above show an input variable (costs) and two output variables (ROI and Net Benefits). Risk considers the probability of the cost benefit analysis.

Control aspects

Dijk & Montalvo (2011) investigated the behavior of decision makers towards Park and Ride facilities using the theory of planned behavior. The theory is based on a behavior model which includes underlying intentions, attitudes, subjective norms and behavioral control (Ajzen, 1988; 1991). The model, for example a mathematical expression, is able to predict human behavior by defining the underlying aspects.

The method has proven itself in analyzing strategic planning and decision making regarding organizations' implementation behavior of technological innovations. The researchers suggest that willingness to implement a development is determined by three domains (e.g., Ajzen, 2006; Dijk & Montalvo, 2011; Montalvo, 2002):

1. Attitude towards a development: The perceived economic implications and perceived environmental effect resulting from the implementation of a development.
2. The perceived social pressure to implement a development.
3. The perceived control over the implementation of a development: in which way existing business planning is affected by the development and the controllability of a development by an organization.

Montalvo (2002) concludes that the first two aspects are visible in most decision making processes related to policy. The latter, perceived control, is an important additional aspect that has not have often been incorporated in decision making.

2.4.2 Public procurement in parking

As mentioned in the first paragraph of this chapter, governmental parties are able to contract commercial parties for operating parking activities. In case a government desires such an agreement, it has to use the instrument of public procurement. European public procurement guidelines force the Dutch government to develop legislation for the purchase of goods, services and the ordering of work by a public authority. The legislation aims to increase competition between enterprises, reducing prices, and guaranteeing better quality of services for citizens.

Legislation for public tendering in the Netherlands ('Aanbestedingswet', 2012) regulates the tendering process which includes an important element to influence the outcome of a tender: the award mechanism. Two contract award mechanisms exist to choose a winning offer from the competitors:

1. Lowest price: the offer with the lowest price will be accepted.
2. Economic Most Advantageous Tender (EMAT, NL: EMVI): the tender will be evaluated by criteria like quality, price, functional characteristics or environmental characteristics.

The Dutch government stimulates the use of EMAT in public procurement in order to increase the quality of governmental purchasing (PIANOo, Expert center for Tendering, 2012). The ministry of Infrastructure and the Environment developed specific guidelines to improve the sustainability. Specific EMAT criteria, presented in figure 7, can be used in the purchasing process of products, goods and services in the field of parking (Ministry of Infrastructure and Environment (VROM), 2010).

Criterion (EMAT for Parking)	Objective
Improve energy usage of parking equipment	Reduce climate change as a result of emissions
Improve energy usage of functional lightning	Reduce climate change as a result of emissions
Improve energy usage of facilities (installations etc.)	Reduce climate change as a result of emissions
Improve driving skills of personel ("het nieuwe rijden")	Reduce climate change as a result of emissions
Improve energy usage of vehicles	Reduce climate change as a result of emissions
Improve amount of emissions of vehicles	Reduce climate change as a result of emissions
Use of sustainbly generated electricity	Reduce climate change as a result of emissions
Introduce climate compensation measures	Reduce climate change as a result of emissions
Reduce traffic congestion	Impairment of local air quality
Stimulate operational use of low-emission vehicles	Impairment of local air quality
Reduce accessibility for high-emission vehivles	Impairment of local air quality
Increase use of sustainable material and re-use	Sustainable use of materials
Sustainable usage of materials in project operations	Sustainable use of materials
Reduce light pollution caused by facilities and vehicles	Improve local livability
Reduce noise caused by vehicles and passengers	Improve local livability
Reduce street litter [NL: zwerfvuil]	Improve local livability
Improve sense of security and safety	Improve local livability
Reduce risk and impact of collisions caused by vehicles	Improve local livability
Measurements to prevent leakage to soil and water	Reduce soil pollution
Optimal use of available urban spaces	Improve spatial use
Availability of internal environmental reporting system	Improve sustainability impact of supplier

Figure 7: EMAT criteria related to parking (Ministry of Infrastructure and Environment (VROM), 2010).

2.5 Developments and trends in parking

Developments are investigated using literature and reports from practice (e.g. Bakker, 2011; Geng & Cassandras, 2012; IPI (International Parking Institute, 2012)P1 Parkings, 2008; Q-Park NV, 2012a). All sustainable developments in parking are categorized. In general, four types of sustainable developments exist (van der Waerden, 2012; Farla, et al., 2010; Q-Park NV, 2013a): sustainability by technological improvement of personal vehicles; sustainability by construction of sustainable buildings; sustainability by improving the efficiency of traffic and way finding; sustainability by mobility and parking policy.

Sustainability by technological improvement of personal vehicles.
In this sub-paragraph, two important technology concepts related to personal vehicles are discussed. A wide range of hydrogen and electric vehicles is being developed to succeed the 'Internal Combustion Engine Vehicle' (ICEV). In a nutshell (according to Bakker, 2011): Hybrid Electric Vehicle (HEV); Plug-in Hybrid Electric Vehicles (PHEV); Battery Electric Vehicle (BEV); Fuel Cell Electric Vehicle (FCEV); and Extended Range Electric Vehicle (EREV). Fuel Cell technology is based on hydrogen. Current production methods to produce hydrogen fuel are highly energy consuming: electrolysis and chemical reforming (Vergragt & Brown, 2007). Electricity Driven Vehicles generate propulsion out of electrical energy using electric motors. Electrified propulsion is being promoted by industry and governments. On European level, goals have been set to change the automobile stock from combustion powered vehicles to electric powered vehicles.

Sustainability by construction of sustainable facilities
A sustainable building process contributes to a sustainable urban environment. This focus is visible in the construction sector. Some examples are the cradle to cradle principle, lifecycle analysis, and integration of heat pumps and solar energy in buildings. Parking facilities, built as part of the urban environment, could also contribute to a sustainable environment. The application of green facades and solar panels, considered as sustainable building elements, are more often mentioned in news items and publications (e.g. Q-Park NV, 2012).

BREEAM (Building Research Establishment Environmental Assessment Method) originally developed in the United Kingdom and practiced in the Netherlands as BREEAM-NL, is a certification method to determine the sustainability of construction projects. The method is currently used and further developed by companies in the field of construction and engineering. The parking industry could use methods like BREEAM-NL to build more sustainable facilities according to BREEAM. The industry is able to invest in sustainability of (existing) parking facility for example by integration of sustainable materials and charging points for Electricity Driven Vehicles (Q-park NV, 2011). This example is highly related to the first trend in sustainable developments: improvement of personal vehicles.

Sustainability by improving the efficiency of traffic and way finding
Car drivers take decisions based upon available information. It seems to be logical that congestion and searching time decreases if vehicles could be directly guided to available parking spaces. Research of Van der Waerden et al. (2011) shows the effectiveness of Parking Guidance Systems (PGS): "It appears that drivers are well aware of PGS but do not use it often. PGS influence drivers' travel choices, especially the choice of parking facility and the combined parking and route choice". Because of these proven and predicted effects;

governments installed systems that provide guiding information for car drivers (e.g. Geng & Cassandras 2012).

Current developments in communication technology enable providers to send car drivers personal information, routes, locations, and offers related to parking. All types of (IT based) information and guidance systems could be categorized as 'SMART'-activities and solutions. Examples presented in literature are SMART-parking, SMART-car or SMART-guidance (e.g. (Geng & Cassandras, 2012).

Sustainability by mobility and parking policy

Sustainability of mobility in an urban environment can be influenced by policy. Effects of mobility policy in the Netherlands have been presented earlier in this chapter. Park and Ride (P+R) solutions are an example of 'sustainability by policy'. Four types of P+R facilities exist (KpVV, 2005): 'Central P+R solutions' which are centrally located near central transport hubs like train stations; 'mixed P+R' which are located outside the city center and combine multiple functions with P+R; 'Regular P+R' focusses on basic P+R functionality outside the city; and 'Shuttle P+R' which stimulates remote parking at distance of the users destination.

In the Netherlands, approximately 200 of 280 train stations are equipped with a P+R parking to stimulate car drivers to park on transfer points outside the city hotspots (KpVV, 2010). A transfer point can be considered as location where one could shift from transportation method, for example change from personal vehicle to city bus. According to CROW / KpVV (2005), this type of policy aims to reduce inner city congestion in order to improve reachability, urban quality; and stimulate multi-modality (switching to a more efficient way of transport during travelling).

2.6 Conclusions

In this chapter, the topics of parking and mobility are introduced. Parking regulates mobility; provides services to users; shapes the urban environment; and is a source of revenue for government and market parties. Parking activities are located in the public domain (on-street and private domain(off-street) in garages, areas or near walkways. Only a small portion of the total of European parking spaces is regulated. Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking. Municipalities (Government) enforce parking policy and Parking operators (market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved.

Parking policy is enforced by the government in order to improve the urban environment and to reduce congestion in the city. Legislative powers are delegated to municipalities which develop a local parking policy. Awareness of sustainability problems related to transport resulted in policy for sustainable mobility.

Decision making in policy and business planning considers financial and control aspects. Public procurement in parking, a form of decision making during tendering, incorporate award criteria which consider qualitative and sustainable aspects in the tendering process next to traditional aspects like financial criteria.

Finally, sustainable developments and trends in parking are investigated, listed and categorized in four types of sustainable developments: 'Sustainability by technological improvement of personal vehicles'; 'Sustainability by construction of sustainable buildings'; 'Sustainability by improving the efficiency of traffic and way finding'; and 'Sustainability by mobility and parking policy'.

3   Research approach

In this chapter the research questions and methods are discussed that are used to solve the research problem as have been stated in the introduction. First, the research questions are presented. Next, the research framework is discussed, followed by a description of the used methods and techniques. Finally, the expected results are presented.

3.1 Research questions

The main question in this research is: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"

In order to answering the central question four sub-questions have been defined:

1. Which stakeholders are involved in the decision making process regarding to sustainable parking?
2. Which criteria can be used to evaluate developments regarding sustainable parking?
3. What are important developments in the context of sustainable parking?
4. What is the importance of selected criteria regarding developments in sustainable parking?

3.2 Research framework

In this paragraph the research framework is described. Figure 8 presents three phases in which the research problem and coherent questions are solved.

The review of literature can be considered as start of this research (Phase 1). It provides background information on the subjects parking, sustainability in parking, and decision making. Besides a description of the subjects and relevant mechanisms, the literature review is conducted to identify a number of current sustainable developments in parking; important stakeholders and their incentives, and decision criteria. These three elements will be used as key ingredients for the used research method in the next phase and answer the first three sub-questions.

Decision making in parking by governmental and commercial stakeholders is a complicated process. Together, parking operators and municipalities, led by specific incentives, decide over new developments in sustainable parking. An Analytic Hierarchy Process decision framework is built to capture decision criteria with respect to both stakeholders (Phase 2). The framework is used as a base for the next steps in the research. The second phase consists of Multi Criteria Decision Analysis (MCDA) based on the methods included in Analytic Hierarchy Process (AHP). Qualitative Dominance scores (QD) are used to synthesize the results.

When MCDA is used multiple criteria of alternatives can be considered comprehensively. The method combines criteria weights and evaluation scores of alternatives, resulting in a general value for each alternative. In order to find the criteria weights AHP is adapted to a specific quantitative form of multi criteria analysis. QD is used to evaluate the developments, on a qualitative base.

A questionnaire is used to gather data from governmental and commercial stakeholders in parking. Experts, working for both stakeholders, are asked to complete the questionnaire in which criteria weights are determined and developments are evaluated. After the synthesis and analysis of data results are available and developments are prioritized.

In the finalization phase (Phase 3) results from the literature review and Multi Criteria Decision Analysis are used to answer the research questions. Recommendations for practice and science will show the relevance of the research findings for both fields.
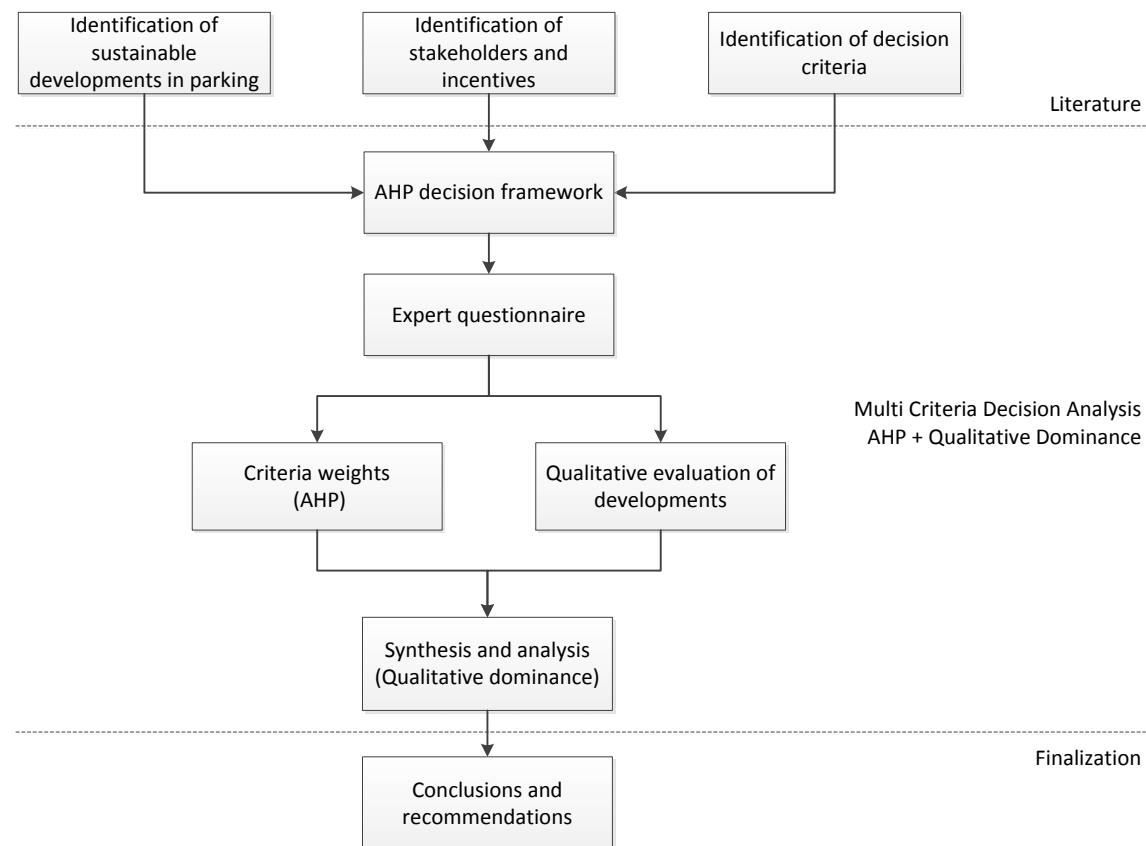
Figure 8: Research framework

3.3 Methods and techniques
The methods and techniques used in this research are explained in this paragraph. Some basics of the used techniques are considered standard, and shall not be explained in detail here. Decisions made and changes in aspects of methods can influence the outcomes. Therefore, these elements will be further presented.

3.3.1   Literature review
An extensive exploration of literature is presented in chapter 2. Results from this study are highlighted below and further analyzed.

Selection of stakeholders

Generally speaking decision making in parking is controlled by the government who develops policy and market parties that perform activities with facilities, services or products related to parking. Two parties decide directly on the implementation of new developments in sustainable parking: Municipalities (government) and parking operators (market). Other stakeholders, for example investors, are indirectly involved in this process. The direct and indirect relationships to the subject have been presented in this thesis (see figure 5). Therefore, this research focuses on municipalities and parking operators.

Selection of criteria

The literature reviw has shown that multiple decision criteria are available that represent stakeholders' incentives, sustainable goals in society, en presumed effects of developments. In this research, potential sustainable developments are evaluated to find differences and similarities in opinion between stakeholders.

Selection rules are used to find the most important criteria involved in the assessment of the developments in parking: criteria should be applicable to evaluate all types of developments; criteria represent incentives of both stakeholder groups; and vagueness of criteria has to be prevented.

Payoff and outcomes of developments related to the decision criteria can be divided as impacts and effects. The Cambridge dictionary describes impact as "*the strong influence that something has on a situation or person. E.g. the environmental impact of this project will be enormous.*" In contrast, the definition of 'effect': *Something that is produced by an agency or cause, result, consequence*; describes a more direct and intended result of a development.

The two definitions described above help to define the final decision criteria for this research. Impact criteria are used to describe the impact on the stakeholders' business plan: the 'financial aspects' and 'control aspects' that may be affected by the developments. On the other hand, effect criteria, are used to describe the outcome of a development regarding mobility and sustainability. The criteria, presented and described below, are selected from business planning and control criteria (figure 9 and 10), policy criteria and EMAT criteria for parking (figure 11 and 12).

Impact on business plan: financial aspects

Sub-criteria	Desciption
Investment costs for organization	Investment costs associated with adoption of development. (It is estimated in relation to normal investment pattern).
ROI for organization	The financial added value of a development compared to the associated costs. A high ROI equals an increased "profit".
Risk for organization	The probability of a negative financial effect occurring within a specified period or in specified circumstances.

Figure 9: Sub-criteria related to the financial aspects

Impact on business plan: control aspects

Sub-criteria	Desciption
Influence of organization on development	The degree of influence that can be exercised on the process and manifestation of a development by an organization .
Influence of development on businessplan	The degree of influence that a development has on the way the organization operates and generates revenues.

Figure 10: Sub-criteria related to control aspects

Effect on mobility aspects

Sub-criteria	Desciption
Effect on parking demand city center	The extent to which a development is affecting the on and off street parking demand in the city center.
Effect on congestion city center	The extent to which a development is affecting the congestion of traffic in the city center.

Figure 11: Sub-criteria related to mobility aspects

Effect on sustainability effects

Sub-criteria	Desciption
Effect on energy usage	The extend to which the energy use of traffic and facilities is affected by the development.
Effect on amount of KM travelled	The extend to which the amount of KM travelled in the city center is affected by the development.
Effect on amount of pollutants (CO2, NOX)	The extend to which the amount of polluting gases and substances related to traffic is affected by the development

Figure 12: Sub-criteria related to sustainability aspects

Selection of developments

The literature review provided a list of development in parking. The developments have been categorized by type of sustainable development. A recent publication (Kennisplatform Verkeer en Vervoer (KpVV), 2013) about noteworthy developments in parking provided six important developments. These developments are described below and reflect on a theme of the KpVV publication (2013).

1. *Improving the sustainability of the existing parking stock (Theme: Sustainability):* Replacement of facilities and equipment by new and more sustainable solutions, e.g. LED, innovations and efficient technology, at on-street and off-street parking locations.

2. *Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources):* A charging network at on-and off-street parking locations is introduced for hybrid and electric cars such as low and high voltage charging stations.

3. *Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT):* An electronic navigation and payment processing application introduced by payment providers offers customers the ability to navigate to an available on-or off-street parking location, to make a reservation and pay wireless.

4. *Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing):* The number of Park and Ride (P + R) and Kiss and Ride (K + R) areas with favorable rates and services increases for the purpose of Car-Sharing initiatives.

5. *Introducing policy in order to enable flexible parking standards (Theme: location specific parking standards):* The introduction of flexible parking standards which are strongly related to the function, the use and configuration of urban buildings in the immediate vicinity.

6. *Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment):* The number of properties in inner city areas with a store function decreases due to shrinkage and internet shopping.

3.3.2   Multi Criteria Decision Analysis

Decision making of organizations on complex topics as new (sustainable) developments in parking, require stakeholders to consider multiple criteria based on stakeholder specific incentives. Multi Criteria Decision Analysis (MCDA) can be used as approach to solve these kinds of problems.

The aim of MCDA is to guide the decision maker in determine the course of action that best achieves the long-term goals, by providing the decision-maker with some measure of consistency (Stewart, 1992). It is concerned with structuring and solving decision problems involving multiple criteria. In the case a number of alternatives are considered, each alternative can be described by its criteria. By using the weights of criteria multiplied by individual scores of alternatives on the criteria, an overall performance can be calculated. Therefore, MCDA can be used to find the best alternative for a decision maker or provide one with insights in the performance of criteria as part of an alternative.

In general, MCDA typically involves following steps (e.g., Ahmed, et al., 2012; Department of Communities and Local Government, 2009):

1. Establish the decision context;
2. Identify the options to be appraised;
3. Identify the objective and criteria;
4. Scoring: Assess the expected performance of each alternative against the criteria;
5. Weighting: Assign weights for each criterion and describe consequences;
6. Combine Weights and scores: calculate overall scores of alternatives;
7. Examine the results: compare the alternatives;
8. Sensitivity analysis: test to what extend the results are dependent of the chosen levels domains of criteria.

According to the framework that has been adopted in this research, a review of literature provides the information for the first three steps of the MCDA methodology suggested above. Step four till six are covered by using the Analytic Hierarchy Process (AHP). The combination of weights and scores is performed by Qualitative Dominance scores (QD). Finally, the analysis chapter in this thesis contains the examination of results and sensitivity of the research. In the next paragraphs, the used methods are explained in more detail.

3.3.3   AHP and pairwise comparison

The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions (Saaty, 1980). It was developed by Thomas L. Saaty in the 1970s, based on mathematics and psychology. The method has been extensively used in group decision making in a wide variety of situations, in fields such as government, business, industry, healthcare, and education (e.g., Vaidya & Kumar, 2004; Vargas, 1990). It is one of the most used multi criteria decision tools.

AHP is based on the idea that decisions are not only dependent on actual data and incorporates experience and knowledge of people in the decision making process (Vargas, 1990). The method is able to deal with quantitative as well as qualitative decision criteria and is based on six important steps (e.g., Han, et al., 2011; Saaty, 1980):

1. Identify the decision problem;
2. Decomposition, creating a hierarchy structure of the decision problem & relevant criteria (hierarchy element levels: goal, criteria, sub-criteria and/or alternatives);
3. Comparative judgment: establish the matrices for paired comparison and measure the weights of criteria;
4. Synthesizing when resulting priorities of the alternatives are established;
5. Check consistency of judgment;
6. Final decision.

The first step, identification of the decision, is performed earlier in this chapter. The central question of this research is altered to: *"What is the most promising development regarding sustainable parking?"*. In the second step, the previously selected criteria and developments are used and placed in a hierarchy. The hierarchy structure is available as figure 13(L). Saaty (1980) suggests to use pair-wise comparisons to perform comparative judgment on criteria according to the scale of Saaty (1980) varying from equal importance to extreme importance. For example, a task to compare Criterion X with Y on a nine point scale is is presented: *Criterion X [9, 7, 5, 3, 1, 3, 5, 7, 9] Criterion Y*. Respondents are required to choose one of the values. The answer '9' represents Extreme importance and answer '1' equally important.

Criterion
group-level

Criterion
sub-level

AHP decision framework

Financial Aspects

Investment costs for organization

ROI for organization

Risk for organization

Control Aspects

Influence of organization on development

Influence of development on business plan

Mobility Aspects

Effect on parking demand city center

Effect on congestion city center

Sustainabiliity Aspects

Effect on energy usage

Effect on amount of KM travelled

Effect on amount of pollutants (CO2, NOX)

Intensity of importance	Definition	Explanation
1	Equal importance	Two criterion contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one over another
5	Essential or strong importance	Experience and judgment strongly favor one over another
7	Very strong importance	Criterion is strongly favored and its dominance demonstrated in practice
9	Extreme importance	Importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between the criterion listed above

Figure 13: AHP decision framework (Left)   **Pairwise comparison scale (Right, Saaty, 1990)**

The third step also require the establishment of, reciprocal matrices that use the geometric mean of the respondents' results and the eigenvector method to find the weights of the criteria (Saaty, 1980). These methods are considered basic elements of the AHP methodology and could be automated using software packages like Microsoft Excel. In

The fourth step by Saaty (1980) is not necessary according to the research framework. The alternatives are evaluated separately from the AHP analysis. The sixth step, consistency check, is required to find Inconsistency occures in case a respondent is not able to review the criteria in a logical way. It could be cause by a lack of understanding of the criteria, not a clear view of their own priority or a too difficult task for the respondents.

The calculation of the consistency involves a number of basic steps (Saaty, 1990). The Principal Eigen Value resulted from reciprocal matrices. Next, the Consistency Index (CI) is calculated using the Principal Eigen Vector. Finally the Consistency Ratio (CR) is calculated using the Random Consistency Index (RI). According to Saaty (1980) The consistency of the results is acceptable in case the value is below 0,1 which represents 10%. The process of checking the consistency is also applicable using Microsoft Excel.

3.4 Data collection
In this research, data from experts related to the two stakeholder groups are collected using an internet based questionnaire. This paragraph describes the respondent selection and the design of the questionnaire.

3.4.1   Respondent selection
The previous paragraph presented the selection of two groups of decision makers in parking: Government and Market. Experts from both stakeholder groups are reached by using contact details of experts derived from address list of the graduation committee and graduation company.

3.4.2   Questionnaire design
A questionnaire is developed in order to find criteria weights and to evaluate the chosen developments. The questionnaire is structured according to figure 14 on this page. The questionnaire has been constructed using 'Berg Enquête System 2007', a digital survey tool developed by Eindhoven University of Technology. During data collection, the selected respondents received an invitation with a unique web address by e-mail.

The unique link guides the respondents to the questionnaire which started with a brief introduction on the topic and questionnaire itself. The diamond shapes in the figure below represent groups of questions of the questionnaire (Figure 14). The following groups of questions are presented: background variables, pairwise comparisons on group level, pairwise comparisons on sub-level; development evaluation; development evaluation of choice; and questionnaire evaluation. The first five groups of questions will be discussed in the following paragraphs. The latter, 'Questionnaire evaluation' is meant to receive comments on the subject and questionnaire, and collects contact details of interested respondents. After finishing the questionnaire, respondents are redirected to a page with information about the graduation program, committee, and author. This paragraph contains

some examples of elements used in the questionnaire. A complete version is attached to this thesis as Appendix H.
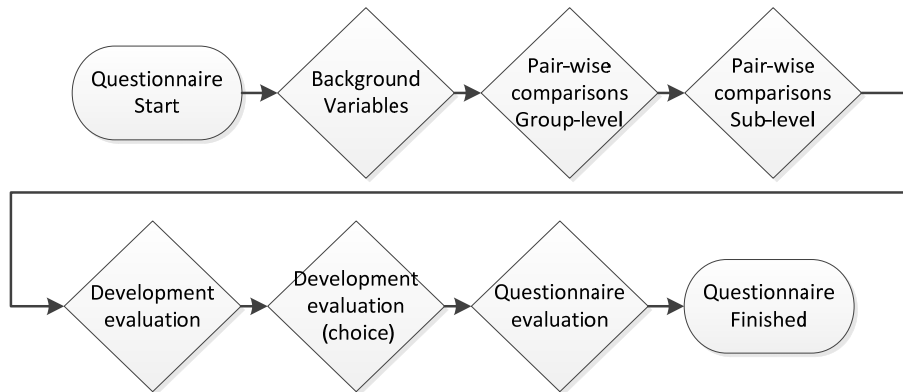
3.4.3 Background variables

The first question group aims to acquire information on the type and the organization of the respondent. First, the stakeholder-group, government or market, is derived by asking for which stakeholder-group the respondent is mostly working for. Next, the (spatial) scale (international, national, provincial and local) and the major activities of the respondents' field of work are questioned. The perceived level of sustainability and innovativeness of the respondents' organization is tested by evaluating two statements: "The organization to which I belong applies a sustainability policy in an active way" and "Innovation is an important value for the organization I work for". Respondents are asked to specify the sustainability and innovativeness of their organization by checking some exemplary topics and activities.

Besides gathering background information to be used in the analysis, the goal of this question-group is to activate a sustainable and innovative mindset that helps the respondents to answer the other questions in the survey.

3.4.4 Pairwise comparison of criteria

As suggested by Saaty (1980), criteria will be evaluated using pairwise comparisons between the criteria on-group and sub-level. As shown in figure 15, a matrix was developed in which respondents are able to express the relative importance of the criteria.

In general, values of pair-wise comparisons in AHP have a numerical scale as discussed in paragraph 3.3 (Saaty, 1980). Within this questionnaire variables are compared in order to capture the effects and impacts of certain developments in (sustainable) parking. As a result of the developed hierarchical model, respondents of both stakeholder groups are asked to compare criteria related to incentives of both groups.

Therefore, it has been decided to reduce the difficulty of the task by choosing a 7 point scale set of the original scale of Saaty (1980): *[7, 5, 3, 1, 3, 5, 7]*. To improve the understanding of the criteria used in this questionnaire all criteria are introduced introduces before the pairwise comparison matrices.

In onderstaande tabel wordt het gewicht van de criteria-groepen bepaald.Geef in de tabel aan welk van de criteria-groepen u belangrijker vindt of kies neutraal.

Situatie: Uw organisatie overweegt te investeren in een nieuwe ontwikkeling op het gebied van parkeren.

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Impact op businessplan: financiële aspecten	○	◉	○	○	○	○	○	Effect op duurzaam parkeren en mobiliteit
Impact op businessplan: controle	○	○	◉	○	○	○	○	Effect op mobiliteit
Effect op mobiliteit	○	○	○	○	○	◉	○	Impact op businessplan: financiële aspecten
Impact op businessplan: financiële aspecten	○	○	◉	○	○	○	○	Impact op businessplan: controle
Effect op mobiliteit	○	◉	○	○	○	○	○	Effect op duurzaam parkeren en mobiliteit
Effect op duurzaam parkeren en mobiliteit	○	○	○	○	○	◉	○	Impact op businessplan: controle

Betekenis symbolen:
0 Neutraal + Belangrijker ++ Veel belangrijker +++ Extreem belangrijker

Figure 15: Example of pairwise comparison matrix of questionnaire

3.4.5   Evaluation of developments

A matrix was developed to perform an evaluation of developments using the criteria previously discussed in the AHP model. The selected developments have been discussed in the paragraphs above. Respondents are asked to evaluate six developments from their own and opponent's point of view. As a result, the questionnaire provides expectations of both stakeholder-groups according to a single respondent that is related to one of those groups. This diversification of expectations enables one to compare the expectation of stakeholder 'X' with the perceived expectation of stakeholder 'X' from stakeholder 'Y'.

In the evaluation matrix expectations towards the selected sub-criteria are collected. Respondents are able to score a criterion on a three level scale in order to decrease the complexity and length of the questionnaire.

As mentioned earlier in this chapter, criteria are considered as 'impacts' or 'effects', based on the aspect that is influenced by a criterion. Therefore, the qualitative evaluation levels of impacts and effects are not equal. Figure 16 presents the levels that are available in case the criteria are labeled as 'Impact' or 'Effect':

Impact	Effect
High	Increase
Medium	Neutral
Low	Decrease

Figure 16: Scoring levels for impact and effect criteria

After scoring six developments, respondents are asked to add and score an additional development to complete the evaluation process. This optional evaluation intends to capture other important developments from the experts' point of view.

Invoeren van flexibele parkeernormen (thema: parkeernormen locatie specifiek)
Het invoeren van flexibele parkeernormen die sterk gerelateerd zijn aan de functie, het gebruik en de configuratie van de stedelijke bebouwing in de directe omgeving.

Geef in onderstaande tabel uw verwachting aan. In de kolom Overheid uw inschatting van de stakeholder "overheid" en in de kolom Marktpartij uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Hoog	Gemiddeld
Verwacht Return on Investment voor organisatie	Hoog	Hoog
Verwacht risico voor organisatie	Gemiddeld	Laag

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Groot	Gemiddeld
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Gemiddeld	Groot

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Verhoging	Verlaging
Verwacht effect op doorstroming in binnenstad	Neutraal	Verhoging

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Neutraal	Neutraal
Verwacht effect op aantal gereisde kilometers	Verlaging	Neutraal
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Neutraal	Neutraal

Figure 17: Development evaluation matrix of questionnaire

3.5 Expected results

The proposed Multi Criteria Decision analysis uses weights obtained by AHP and development evaluations. The combination of both elements results in a prioritization of developments. This paragraph describes the expected results from the research.

The proposed criteria of the 'impact': financial aspects and control aspects, are highly related to business planning. Mobility and sustainability aspects are more related to the output of a development in parking. It is assumed that the 'market' stakeholder has a high interest in the business aspects, in contrast to the 'government' stakeholder which, according to the literature review, highly considers output of policy.

In this chapter, sustainable developments are selected from a wide spectrum of developments. Some of the developments are related to policy development, a type of development that is mainly steered by the government. For example, the 'increasing number of P+R and K+R areas. The governmental stakeholder may prefer these types of development above others like product developments. On the other hand, parking operators are more involved in the management of existing parking facilities. Therefore, the market stakeholder group may prefer for example 'Improving the sustainability of the existing parking stock'.
Both stakeholders have less control over developments related to sustainability by technological improvement of personal vehicles, like the development of charging networks. This lack of control may result in a low priority for this type of sustainable development. A development that aims to improve financial benefits as well sustainable developments could be preferred by both stakeholder groups. For example, the 'introduction of electronical navigation, way finding and payment systems'.

3.6 Conclusions

The research approach is presented in this chapter. First, the research questions, research framework and related methods are explained, followed by the 'configuration' of the research: the selected criteria and developments and data collection. Finally, the research expectations are presented.

Central question in this research is: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?". In order to answer the central question, sub-questions concerning the stakeholders, selection of criteria and developments need to be answered. The proposed research framework adopts the conclusions on these sub-questions.

The key methodology in this research is Multi Criteria Decision Analysis (MCDA). The evaluation method combines criteria weights with evaluation scores of alternatives. In order to find the criteria weights, the Analytical Hierarchy Process is adopted. The method requires decision makers in parking to prioritize decision criteria using pairwise comparisons. The same decision makers are required to score the developments in a qualitative manner. Finally, Qualitative Dominance scores are used to synthesize weights and evaluation scores. As a result, the developments are prioritized regarding the criteria.

As mentioned in the previous chapter, municipalities and parking organizations are considered key decision makers on developments in parking. The used impact criteria emerged from the literature review and are selected considering stakeholders' interests. The criteria-group 'Impact on business plan: financial aspects' consist of three sub-criteria: 'Investment costs', 'ROI' and 'Risk for the organization'. Criteria-group 'Impact on business plan: control aspects' consist of two sub-criteria: 'influence of organization on development' and 'influence of development on business plan'. Effect criteria focus on the outcome of a development. The criteria-group 'Mobility aspects' consist of sub-criteria: 'effect on parking demand city center' and 'effect on congestion city center'. Finally, criteria-group 'sustainability aspects' considers three sub-criteria: 'effect on energy usage', 'effect on amount of kilometer travelled and effect on amount of pollutants'.

Six developments have been selected according to recently attractive themes in the parking industry. The selected developments are: 'Improving the sustainability of the existing parking stock'; 'Developing charging networks for electricity driven vehicles'; 'Introduction of electronical navigation, way finding and payment systems'; 'Increasing number of P+R and K+R areas in order to support Car-Sharing'; Introducing policy in order to enable flexible parking standards'; and 'Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping'.

Data collection among experts of the governmental and market stakeholders delivers the input for the analysis. An internet questionnaire is developed to collect background information on decision makers, enables respondents to prioritize decision criteria and evaluates sustainable developments in parking.

4   Analysis

This chapter describes the analysis phase of the research project. In the following paragraphs, elements of the data collection are analyzed. First, the respondents will be characterized by response and background. Next, AHP analysis delivers the criteria weights for the used sub criteria. In paragraph 'Development evaluation', the respondent evaluation of the suggested developments in parking is presented including a division by stakeholder. Finally, all selected developments in parking are prioritized and explained.

4.1 Description of respondents

As explained in the previous chapter, expert respondents are selected from two stakeholder groups: government and market. The first group is represented by experts of municipalities who can be considered as decision maker in the field of parking. The second group consists of decision makers at parking operators in the field of parking. Consultants could be divided into consultants who provide services to municipalities and consultants who provide services to parking operators. This division is presented in figure 18 below.
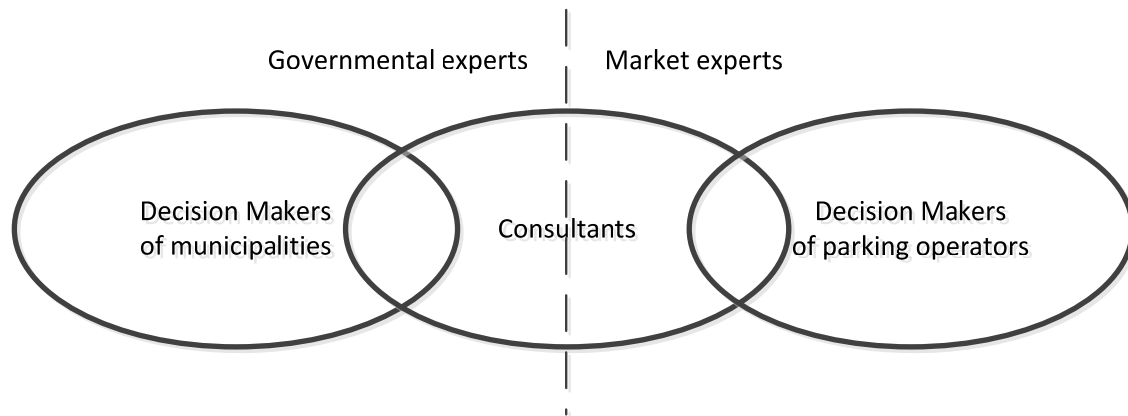
Figure 18: Division of respondents by type

4.1.1 Response rate

As explained earlier, three types of experts have been approached to fill in the questionnaire. In this section response rates by type are presented. First, the respondents have been invited by sending an e-mail invitation with an unique link. A reminder was send in case the respondents did not respond by a reply or activated questionnaire. The output of the questionnaire is described as 'usable pair-wise comparisons' and 'finished entire questionnaire'. According to the questionnaire design as presented in the previous chapter, respondents are guided through multiple question groups. Weights are established by pair-wise comparisons. Results of the questionnaire are usable if a respondent finishes the question groups with pairwise comparisons. A finished questionnaire results in criteria weights and development evaluations. The response rates can be derived from figure 19.

	Municipalities	Parking operators	Consultants	Total
■ Invitation send	39	28	42	109
■ Reminder send	18	20	27	65
■ Usable pair wised comparisons	15	16	16	47
■ Finished entire questionnaire	10	12	10	32
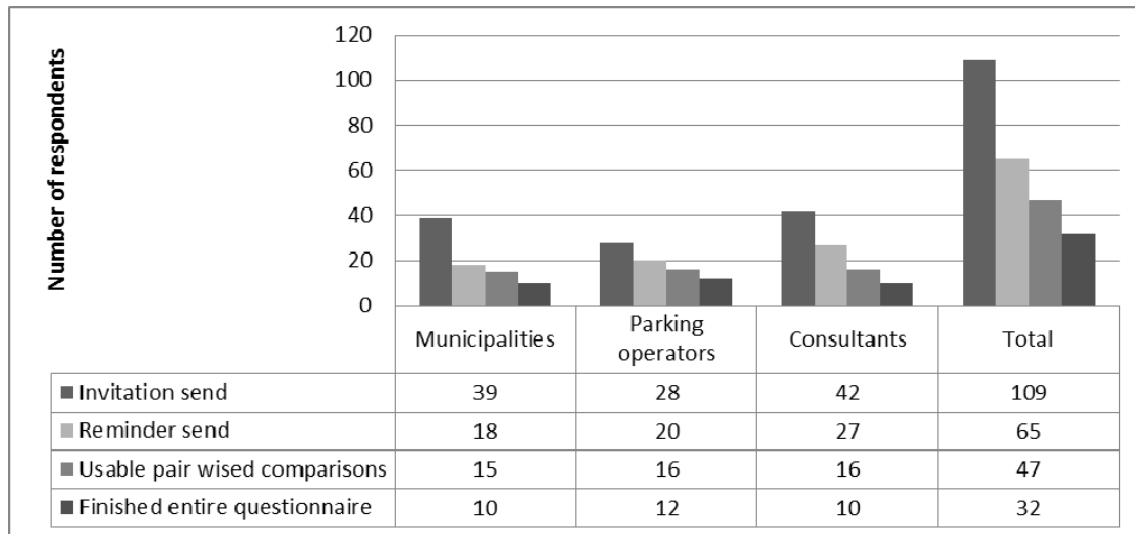
Figure 19: Data collection: number of reached respondents.

The goal, discussed in the previous chapter, is to reach at least 10 experts per type. To reach the goal 39 decision makers from municipalities were approached. 46% of the group did not respond and was send a reminder. Finally, the data collection resulted in 10 finished questionnaires (26%) and a total 15 (38%) datasets of experts from municipalities are usable to establish weights.

A group of 28 experts at parking operators was approached to fill in the questionnaire. 20 individuals (71%) received a reminder. The actions resulted in 16 sets (57%) of the questionnaires results with usable pairwise comparisons and 12 (42%) finished questionnaires. 27 (64%) of a total of 42 consultants received a reminder. It resulted in 10 (24%) finished questionnaires and 16 (28%) sets with usable pairwise comparisons.

At least 10 respondents from each type completed the questionnaire. In total the data collections resulted in 30% finished questionnaires of a total of 109 expert invitations.

4.1.2 Characterization of respondents
The selected respondents were allowed to consider themselves primarily as 'governmental' or 'commercial stakeholder'. From this point on, these two groups are named 'Government' and 'Market'.

In the questionnaire respondents have been asked to answer questions that provide information on their background. First the level of the working field of the respondents is considered. As shown in figure 19, decision makers from the group 'government' operate mostly on a local level while decision makers acting on behalf of the market (figure 21) in general work on national level. This outcome is consistent with the literature review performed in the first chapter. In the Netherlands, parking policy is developed by municipalities on a local level. Parking operators target the entire market in the Netherlands or beyond which is visible in figure 21. The national level is responsible for 77% and international level for 14%. The invited consultants, who work for government or market parties, may cause the share representing national and international level in figure 20.

Figure 20 (l) and Figure 21 (r): Level of working field (respondents related to government (left) and market (right)).

Besides information related to the level of the respondents working field, the experts were asked to specify their work related activities. In figure 22 is visible that most of the respondents perform activities like tendering/procurement, consultancy an operational management. A high number of respondents related to the government also selected the activity financial management. This respondent group represents civil servants and consultants who financially control the parking activities of a municipality. Based on this figure, one could conclude that the invited experts have knowledge of financial impacts and effects related to developments in parking.
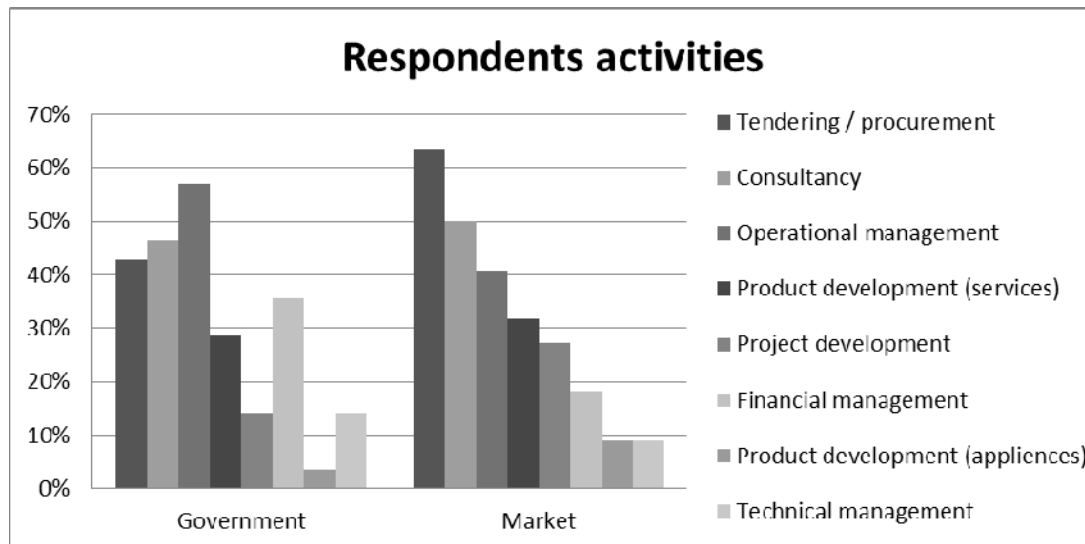
Figure 22: Respondents' professional activities.

4.2 AHP analysis

The criteria weights are based on results of the pairwise comparisons in the questionnaire. As discussed earlier in chapter 3, AHP involves pairwise comparisons, reciprocal matrices , the eigenvector method and a consistency check (Saaty, 1980).

All calculations used for the AHP analysis are considered basic steps of AHP. As a result, the analysis was performed using an automated Microsoft Excel sheet. The used methods and settings used during the analysis are named but not explained given de basic character of

the method. The consistency ration influences the number of usable datasets. Therefore, the consistency of the results is presented first and is followed by the criteria weights.

4.2.1 Consistency of results

The consistency check, suggested by Saaty (1980), is an important step within the AHP method. The Consistency Ratio (CR) is calculated using the Random Consistency Index.

The Random Consistency Index (RI) is introduced by Saaty (1980). It is used to divide the Consistency Index and depends on the number of criteria used in the analysis as result of the randomness caused by increasing complexity. In figure 23 the RI values are presented. In this research criteria are considered on group-level and criterion sub level. The Four criteria groups on group-level result in a RI of 0,90. For the groups: financial aspects and sustainability aspects 0,58 is used as RI because each group consists of three criteria. The consistency ratio for the two groups containing two criteria are not calculated because each comparison between two criteria is considered consistent.

n of criteria	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,90	1,12	0,12	1,32	1,41	1,45	1,49

Figure 23: Random Consistency Index (Saaty, 1980).

For each respondent the individual Consistency Ratios (CR) on group level and for Financial and Sustainability aspects have been calculated. Saaty (1980, 1990) suggests a maximum Consistency Ratio of 0,10. Saaty concluded that using the boundary of 10% inconsistency, the outcome is trustworthy. In literature (Coyle, 2004; Karlström, et al., 2002), the Consistency Ratio in AHP analysis is causing problems frequently. Therefore, Saaty suggests incorporating consistency checks during the data collection by confronting respondents with their consistency. Besides re-evaluating pairwise comparisons, it may be useful to reconsider the decision problem and used hierarchy model (Saaty, 1990).

Karlström, et al. (2002) suggest the use of a higher Consistency Ratio. A ratio of 0.15 seems acceptable and is used in practice. Based on the individual Consistency Ratios of all 47 sets that are usable for pairwise comparisons, a comparison was made for three consistency ratios: 0,10; 0,125 and 0,15 (figure 24).

CR (max)	Group level	Financial aspects	Sustainable aspects
0,100	30%	43%	34%
0,125	45%	70%	70%
0,150	57%	70%	70%

Figure 24: Comparison of CR from results of questionnaire.

In figure 25, percentages are presented of usable datasets from individual respondents. The standard consistency ratio of 0,10 (Saaty, 1980) results in 30% on group level, 43% (financial aspects) and 34% (sustainability aspects). This result is not satisfactory. Given the lack of possibilities to reconsider the questionnaire and pairwise comparisons, it was decided to increase the ratio until at least 50% of the respondents could be taken into account during the analysis. A consistency ratio of 0,15 is used overall to set this goal.

Figure 25 shows the number of consistent respondents per stakeholder group. It shows that the AHP analysis is based on at least 13 respondents per stakeholder group. It corresponds the goal of 10 respondents per group stated earlier in this chapter.

Stakeholder	Group-level	Financial	Control	Mobility	Sustainability
Government	13	18	26	26	17
Market	14	15	21	21	16
Total	27	33	47	47	33

Figure 25: Consistent respondents per stakeholder group.

4.2.2 Criteria weights

The output of the AHP analysis consists out of weights (priority vectors) on group and sub criteria level. First, the four criteria on group level are explained. Next, the results regarding the analysis of the sub-criteria are discussed.

As explained earlier in this paragraph, the analyzed data consist of individual response sets with a Consistency Ratios maximum of 0,15. Results of the analysis are presented overall and per stakeholder group. Please note that the weights are established by using the geometric mean of results of pairwise comparisons per stakeholder group. Therefore, values of all respondent are not to be considered an average of the two stakeholder groups.

Criteria group-level

The first range of pairwise comparisons aimed to find the criteria weights on group level. This level exists of two criteria of the 'impact' type and two 'effect' criteria. Differences have been explained in the previous chapter but are reiterated below.

In figure 26, the weights on group level are presented. The graph shows small differences between all stakeholders and the individual groups. Therefore, a table was included to provide more detailed information on the criteria weights.

	Financial aspects	Control aspects	Mobility aspects	Sustainability aspects
All	0,26	0,24	0,26	0,24
Government	0,26	0,23	0,27	0,24
Market	0,27	0,24	0,26	0,23
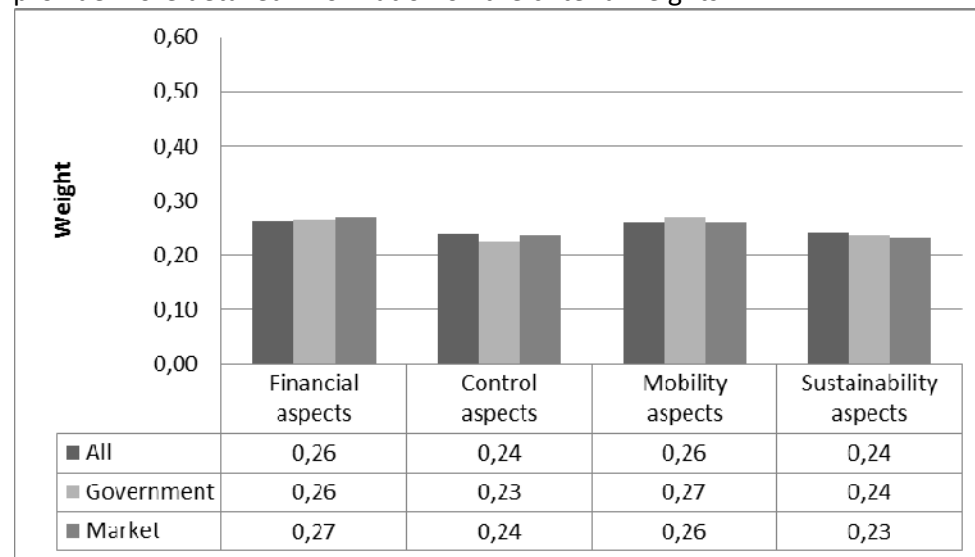
Figure 26: Weights of criteria on group-level.

The governmental stakeholder group considers 'Mobility aspects' (0,27) as the most important criterion followed by 'Financial aspects' (0,26). 'Sustainability aspects' is considered the third important criterion. The lowest priority is given to criterion 'Control aspects' (0,23).

The ordering of criteria is different for the market stakeholder group. It prefers 'Financial aspects' (0,27) above the other criteria. 'Mobility aspects' is ranked second with a weight of 0,26. The group considered 'Control aspects' as third criterion and 'Sustainable aspects' as lowest priority.

In general, 'Financial aspects' and 'Mobility aspects' are being considered the most important criteria in considering new developments in parking. The priority value of 0,26 shows that the priorities of both stakeholder groups regarding these criteria have been equalized. 'Control aspects' (0,24) and 'Sustainable aspects' (0,24) are also considered equally important by both groups.

Financial aspects

The criterion 'Financial aspects' was divided in three sub criteria: Investment costs for organization, Risk for organization and ROI (return on investment) for organization. As shown in figure 27, differences between weights of individual criteria are very little. This situation occurs for all respondents together and stakeholder groups as well.

The lack of difference may be caused by the design of the research in difficulty or information; understanding of the criteria by the respondent; or dissimilarities in the personal opinions of individual respondents. The final chapter of this thesis provides recommendations for further research.

	Investment costs for organization	ROI for organization	Risk for organization
■ All	0,3312	0,3348	0,3340
■ Government	0,3302	0,3368	0,3330
■ Market	0,3275	0,3355	0,3370
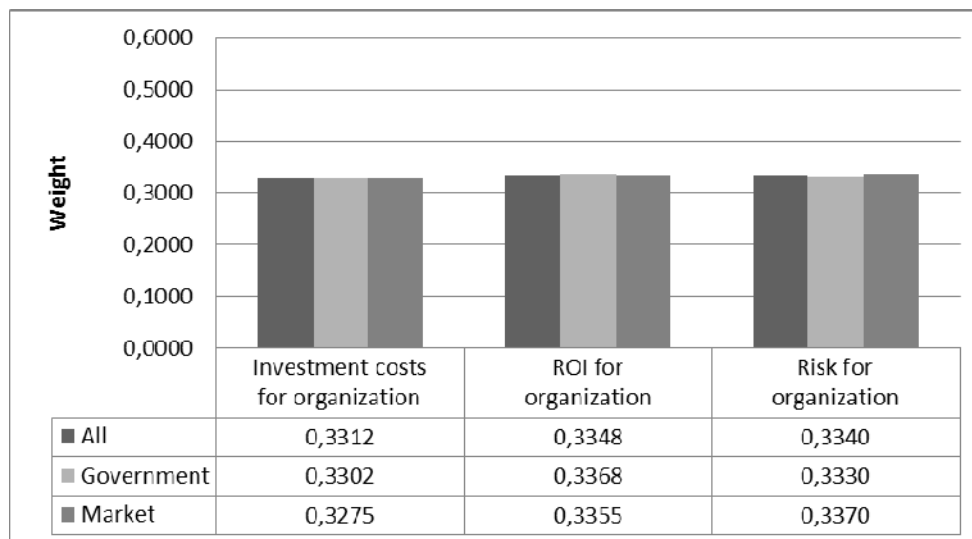
Figure 27: Individual sub-criteria weights of financial aspects.

Considering the remarks above, the prioritization of the criteria is rather weak. Although, similarities and differences in stakeholders' priority exist. 'ROI for organization' and 'Risk for organization' is considered by both stakeholders more important than 'Investment costs for organization'. The lower preference for this criterion may be explained by interdependency of the criteria. Risk and Return on Investment are taken into consideration to obtain funding

for an investment. The Market group prioritizes 'Risk for organization' (0,3370) above 'ROI for organization' (0,3355). The ranking is opposite for the governmental stakeholder group. It may be caused by differences in the allocation of risk. Commercial parties are directly affected by negative outcomes while responsibility lies with the political level in governmental organizations.

Control aspects

The criterion 'Control aspects' is divided in two sub-criteria. The influence of a development on the business plan is compared with the second sub-criterion 'Influence of organization on a development'. The first considers the impact on regular business. The second criterion assesses the ability for an organization to steer a development. Differences in weight of these criteria are visualized in figure 28.

	Influence of organization on development	Influence of development on businessplan
All	0,5231	0,4769
Government	0,5378	0,4622
Market	0,5382	0,4618
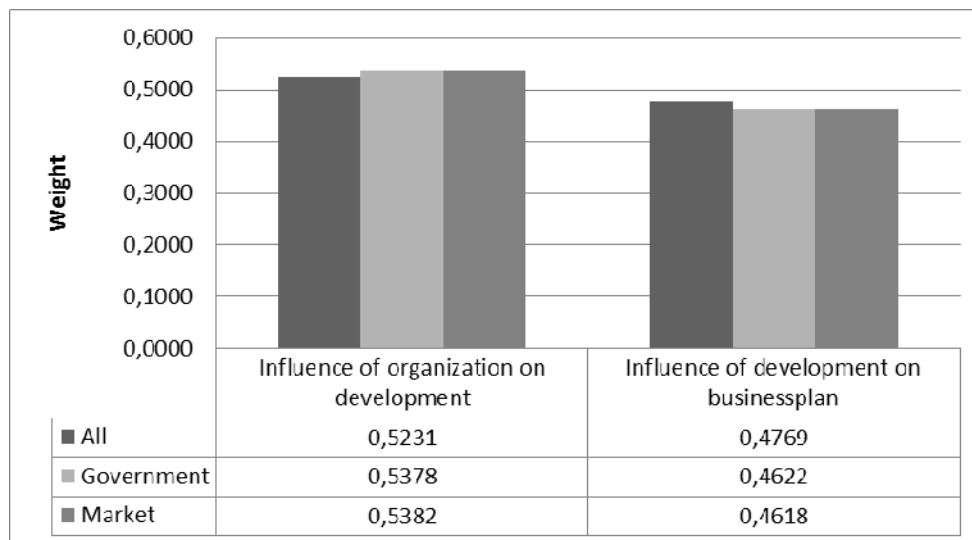
Figure 28:Individual sub-criteria weights of control aspects.

Figure 28 shows consensus on the prioritization of the two sub-criteria. The two groups consider 'Influence of organization on developent' more important compared to 'Influence of development on businessplan'. It is supported by the weights of 'Influence of organization on development': 'Market' 0,5382 against 0,5378 for the governmental stakeholder group.

Mobility aspects

The analysis presented in figure 29 shows similar results of the sub-criteria related to 'Mobility aspects'. The criterion is divided in two sub-criteria 'Effect on congestion in the city centre' and 'Effect on parking demand in the city center'. The latter is considered more important compared to 'Effect on congestion in the city centre' by both stakeholder groups.
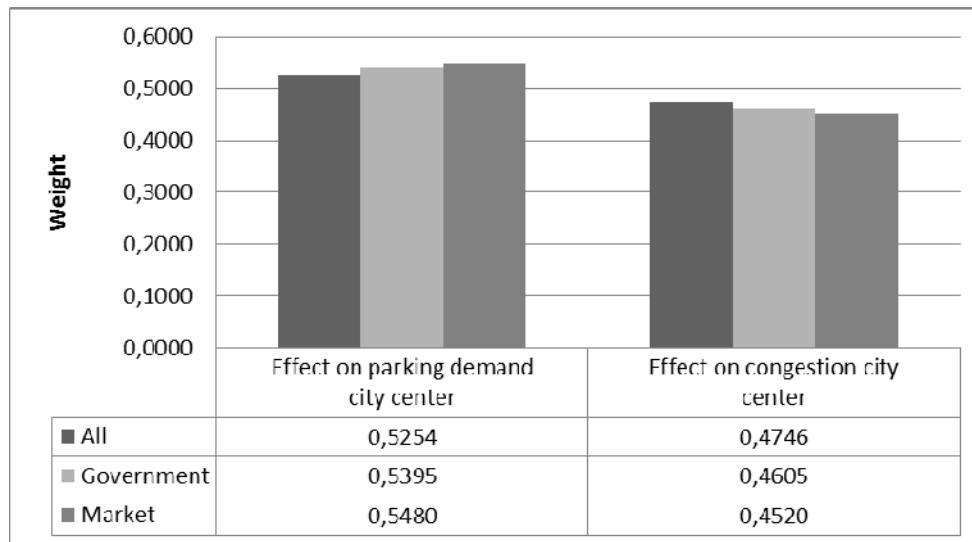
Figure 29: Individual sub-criteria weights of mobility aspects.

The weight of 0,5480 by the market stakeholder group for 'Effect on parking demand in the city center' is slightly higher compared to the weight by the governmental stakeholder group (0,5395).

Sustainability aspects

The 'Effect on amount of kilometers travelled', 'Effect on amount of pollutants' and 'Effect on energy usage' are sub-criteria of 'Sustainability aspects'. Although differences in criteria weights are very low, figure 30 returns a similar ranking of the criteria for both stakeholders.
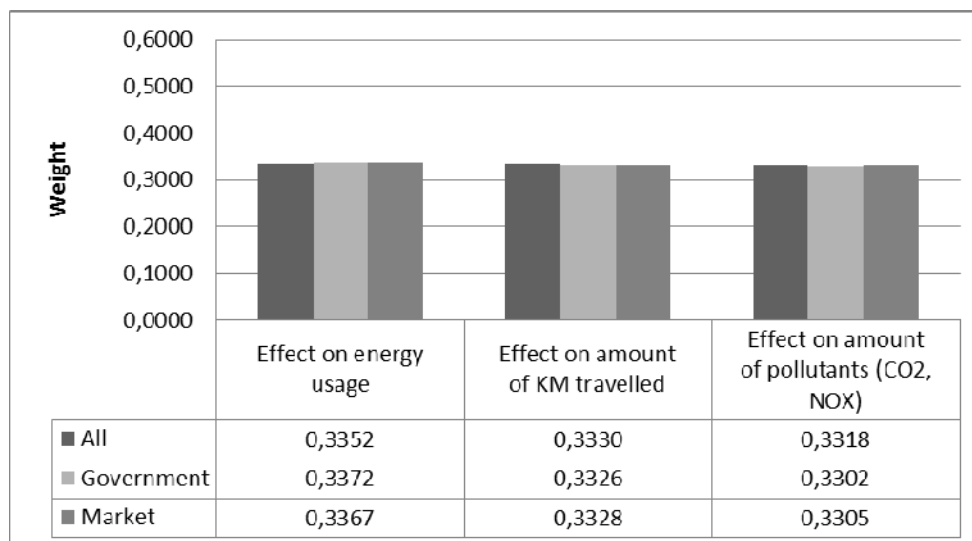
Figure 30: Individual sub-criteria weights of sustainability aspects.

The 'effect on energy usage' (Government: 0,3372, Market: 0,3367) is ranked as most important by both stakeholder groups followed by 'Effect on amount of kilometers travelled' (0,3326; 0,3328). The 'effect on amount of pollutants' has the lowest weights (0,3302; 0,3305).

4.2.3 Synthesizing the criteria weights

The final criteria weights are calculated by multiplying the individual sub-criteria weight by their corresponding criterion weight on group level. Appendix D shows the final criteria weights for all respondents and each stakeholder group. The final criteria weights of the governmental and market stakeholder groups will be used during the research in order to compare developments in parking.

4.3 Development evaluation

The six selected developments have been evaluated by experts in the questionnaire. This paragraph presents the results of the evaluation. In order to find evaluation scores by stakeholder group, the obtained results from the questionnaire have to be synthesized and analyzed.

4.3.1 Synthesizing individual evaluation scores

First, individual scores of respondents on the criteria have to be synthesized in group scores per stakeholder type. The ordinal scores are recoded before frequency analysis of the individual scores is applied.

As mentioned in the previous chapter, respondents were asked to score each criterion by choosing one of three ordinal levels. In case of impact criteria the levels are: High, Medium and Low are available. Effect criteria are scored as: Increase, Neutral and Decrease.

The outcome of an impact could be considered having a positive or negative impact on the subject: the value of a development for both stakeholder groups. Therefore, the coding scheme for each criterion could differ. For example, a high Return on Investment is viewed positive in contrast to an increase in energy usage which is considered negative. The coding scheme that was used to code al individual scores is available below in figure 31.

Criterion	Level	Outcome	Criterion	Level	Outcome
Investment costs for organization	High	-1	Parking demand city center	Increase	1
	Medium	0		Neutral	0
	Low	1		Decrease	-1
ROI for organisation	High	1	Congestion city center	Increase	-1
	Medium	0		Neutral	0
	Low	-1		Decrease	1
Risk for organization	High	-1	Energy usage	Increase	-1
	Medium	0		Neutral	0
	Low	1		Decrease	1
Influence of organization on development	High	1	Amount of KM travelled	Increase	-1
	Medium	0		Neutral	0
	Low	-1		Decrease	1
Influence of development on business plan	High	-1	Amount of pollutants	Increase	-1
	Medium	0		Neutral	0
	Low	1		Decrease	1

Figure 31: Coding scheme for criteria.

Next, frequency analysis took place on the scores for all criteria regarding development and stakeholder group.

As mentioned earlier in this paragraph, the individual scores have been coded into values -1, 0 and +1. The ordinal characteristic of the scores prevents one to calculate for example an average on group level. By analyzing the frequency of the individual scores and selecting the mode, it is possible to find the group consensus: the response of most of the expert respondents. For example, a set of values (-1, -1, 0, 1, 1, 1) results in a mode of '1'.

In statistics, the mode is the most frequent value that appears in a dataset. The ordinal scale that is used in the questionnaire prevents one to use other statistical techniques. For example, the arithmetic mean is not usable because it considers values as real numbers and the median requires a linear order of values.

The mode only selects the most frequently answered value. The value of the mode does not provide information about the variance of answers in the group. Therefore, the weighted sum (WgtSum) was introduced. The weighted sum multiplies the value of the three scale levels with the related frequencies. The calculation results in a positive or negative value. High positive or negative values show that the variance is low. A value close to zero suggests a high variance.

In the example below (figure 32), the frequency analysis of a criterion is presented. The respondents scored the investment cost for the organization for one of the developments. In 20 individual datasets 'High' was chosen. As explained in this paragraph it was coded as negative contribution (-1). 11 respondents chose 'Medium' (0) and five others 'Low' (1). The mode shows 'High' (-1) as group consensus. The variance, rather negative (-15), is showing that the consensus is supported by a high number of experts compared to the other options.

Criterion	# "-1"	# "0"	#"1"	WgtSum	Mode
Investment costs for organization	20	11	5	-15	-1

Figure 32: Example of frequency, mode and weighted average.

4.3.2 Comparison of evaluation scores between stakeholder groups

Frequency analysis took place on all development evaluations in order to find differences between the stakeholder groups 'government' and 'market'. The group consensus, represented by the criteria modes, are compared per stakeholder group for each development. Differences and similarities are reviewed in this section.

Improving the sustainability of the existing parking stock.
First, the development is presented that describes the replacement of facilities and equipment by new and more sustainable solutions (e.g. LED, innovations and efficient technology at on- and off-street parking locations.

Most of the respondents of both stakeholder groups (figure 33) score 'Influence of organization on development' (medium); 'Influence of development on business plan' (medium); 'Parking demand city center' (neutral); 'Congestion city center' (neutral); 'Energy usage' (Decrease); and 'Amount of pollutants' (decrease) equally.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	Medium	0	-6	High	-1	-10
ROI for organization	Low	-1	-5	High	1	10
Risk for organization	Low	1	7	Medium	0	0
Influence of organization on development	Medium	0	-6	Medium	0	3
Influence of development on business plan	Medium	0	4	Medium	0	-8
Parking demand city center	Neutral	0	-1	Neutral	0	4
Congestion city center	Neutral	0	9	Neutral	0	4
Energy usage	Decrease	1	14	Decrease	1	16
Amount of KM travelled	Neutral	0	7	Decrease	1	8
Amount of pollutants	Decrease	1	10	Decrease	1	14

Figure 33: Synthesis of evaluation scores for improving the sustainability of the existing parking stock.

Differences can be found for the impact criteria 'Investment costs', 'ROI', and 'Risk' for organization. Market respondents consider impacts on investment costs and ROI higher compared to respondents of the government stakeholder. Risk lies with the market party which score this criterion with medium, while the government stakeholder scores it as low.
The effect criterion 'Amount of KM travelled' is scored 'neutral' by the governmental stakeholder and 'decrease' by the market stakeholder. The weighted sum shows variance in favor of a positive outcome which suggests slightly more respondents chose neutron instead of decrease.

Developing charging networks for electricity driven vehicles.
The second evaluated development (figure 34) considers alternative energy sources and is described as: a charging network at on- and off-street parking locations is introduces for hybrid and electric cars such as low and high voltage charging stations.

Respondents of both stakeholder groups score all but two criteria the same way. The impact of the development is related to high investment costs; low return of investments; medium risk for both organizations; and medium influence on the development. Scores for 'Influence of development on organization differ. The governmental stakeholder (low) considers itself not affected, while the market stakeholder scores the criterion of 'medium' impact.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-11	High	-1	-5
ROI for organization	Low	-1	-13	Low	-1	-6
Risk for organization	Medium	0	2	Medium	0	1
Influence of organization on development	Medium	0	-3	Medium	0	-3
Influence of development on business plan	Low	1	8	Medium	0	4
Parking demand city center	Neutral	0	2	Neutral	0	5
Congestion city center	Neutral	0	2	Neutral	0	1
Energy usage	Decrease	1	8	Neutral	0	6
Amount of KM travelled	Neutral	0	-1	Neutral	0	-1
Amount of pollutants	Decrease	1	14	Decrease	1	13

Figure 34: Synthesis of evaluation scores for developing charging networks for electricity driven vehicles.

Effect on mobility ('Parking demand' and 'congestion' city center are scored neutral by both stakeholder groups. The same mode applies for the 'amount of KM travelled. Both stakeholder groups expect a decrease in the amount of pollutants resulting of this development. The score for criterion 'Energy usage' differs. The governmental stakeholder expects a decrease while the market stakeholder scores the criterion 'neutral'. The variance represented by the weighted sum suggest that the respondents for the market party favor decrease secondly.

Introduction of electronic navigation, way finding and payment systems.
Next, a development regarding the influence of IT is evaluated: An electronic navigation and payment processing application that offers customers the ability to navigate to an available on- or off-street parking location, reservations and wireless payments.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organization	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Figure 35: Synthesis of evaluation scores for introduction for electronic navigation, way finding and payment systems.

The effects (figure 35) of the development are considered highly sustainable given the mode 'decrease' for 'energy usage'; 'amount of KM travelled' and 'amount of pollutants. The weighted sum values suggest high consensus among respondents of each stakeholder group.

Both stakeholders expect high investment costs; a medium risk for the organization and a medium influence on the business plan. The effect on congestion in the city center is also scored as decrease by both stakeholder groups.

Differences can be found in evaluation scores of 'ROI for organization'; 'influence of development on business plan'; and 'Parking demand city center'. The two are scored 'low' by respondents related to the governmental stakeholder while expected 'medium' by the market party. Market parties expect the parking demand to grow.

Increasing number of P+R and K+R areas in order to support Car-Sharing.
The fourth evaluated development (figure 36) suggest an increase of the number of Park and Ride (P+R) and Kiss and Ride (K+R) areas for the purpose of car-sharing initiatives.

Both stakeholder groups scored all effect criteria ('parking demand city center' - 'amount of pollutants') as decreasing. For the impact criteria similar scores are presented for 'ROI for organization' (low); 'Influence of organization on development' (medium); and 'Influence of development on business plan' (medium).

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-8	Low	1	2
ROI for organization	Low	-1	-9	Low	-1	-5
Risk for organization	Low	1	2	Medium	0	-2
Influence of organization on development	Medium	0	4	Medium	0	-4
Influence of development on business plan	Medium	0	3	Medium	0	0
Parking demand city center	Decrease	-1	-13	Decrease	-1	-11
Congestion city center	Decrease	1	13	Decrease	1	6
Energy usage	Decrease	1	9	Decrease	1	9
Amount of KM travelled	Decrease	1	12	Decrease	1	10
Amount of pollutants	Decrease	1	13	Decrease	1	10

Figure 36: Synthesis of evaluation scores for increasing number of P+R and K+R areas.

Differences between stakeholders can be found in the criteria 'investment costs' and 'risk' for organization (figure 36). Investment costs are considered high for the governmental party while low for the market party. The governmental stakeholder evaluates the risk as low compared to a medium score for the market party.

Introducing policy in order to enable flexible parking standards.
The fifth development that has been evaluated by respondents describes the introduction of flexible parking standards which are strongly related to the function, use and configuration of urban buildings in the immediate vicinity.

In figure 37, consistent answers for effect criteria (neutral) by both stakeholder groups are presented. Both stakeholder groups expect low investment costs for the organizations. The impacts of criteria 'risk for organization' and 'influence of development on business plan' are also considered medium by both parties.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	Low	1	12	Low	1	8
ROI for organization	Medium	0	1	High	1	3
Risk for organization	Medium	0	2	Medium	0	4
Influence of organization on development	High	1	11	Low	-1	-5
Influence of development on business plan	Medium	0	0	Medium	0	1
Parking demand city center	Neutral	0	6	Neutral	0	-1
Congestion city center	Neutral	0	2	Neutral	0	2
Energy usage	Neutral	0	-3	Neutral	0	4
Amount of KM travelled	Neutral	0	-3	Neutral	0	2
Amount of pollutants	Neutral	0	-3	Neutral	0	4

Figure 37: Synthesis of evaluation scores for introduction policy in order to enable flexible parking standards.

Differences can be found for criteria 'ROI for organization' and 'influence of organization on development'. The market parties expect a high return on investment compared to a medium score by the governmental stakeholder. A significant difference between government and market parties is visible for criterion 'influence of organization on development' which is scored 'high' for government and 'low for the market party.

Increasing number of functional changes in inner city built environment as a result of demographic change and internet.

The final development suggests functional changes of properties in inner city areas as a result of shrinkage and an increase of internet shopping.

As presented in figure 38, both stakeholder groups scored all criteria regarding this development the same. The 'investment cost' and 'ROI' for the organization are considered low, in contrast with s high expected 'risk for the organization. The 'influence of the organization on the development' is considered medium while the impact on the business plan by the development is score as 'high'.

All effect criteria ('parking demand city center' - 'amount of pollutants') are scored as decreasing. The presented weighted sums show a higher variance for all effect criteria compared with values for the impact criteria.

Criteria	Government Mode	Outcome	WgtSum	Market Mode	Outcome	WgtSum
Investment costs for organization	Low	1	4	Low	1	3
ROI for organization	Low	-1	-7	Low	-1	-8
Risk for organization	High	-1	-6	High	-1	-5
Influence of organization on development	Medium	0	0	Medium	0	1
Influence of development on business plan	High	-1	-6	High	-1	-5
Parking demand city center	Decrease	-1	-13	Decrease	-1	-11
Congestion city center	Decrease	1	12	Decrease	1	9
Energy usage	Decrease	1	8	Decrease	1	10
Amount of KM travelled	Decrease	1	13	Decrease	1	11
Amount of pollutants	Decrease	1	13	Decrease	1	12

Figure 38: Synthesis of evaluation scores for increasing number of functional changes in inner city built environment.

4.3.3 Sensitivity analysis

Limited sensitivity analysis is performed on the results of the development evaluation. As explained earlier in this paragraph, the calculation of the weighted sum was used to check the variance of the synthesis of the individual evaluation scores. The evaluated developments above show positive and negative modes in combination with values for the weighted sums close to the value of '0'. In those cases the consensus on the final criterion score is weak.

The chosen synthesis procedure affected the final evaluation scores. Other procedures could result in other final evaluation scores. The scope of this research, evaluation and prioritization of developments in parking and, is reflected best in the used procedure. More complex methods could be compared in continued research.

4.4 Qualitative dominance scores

As explained in the previous chapter, qualitative dominance scores enable one to use ordinal scores in multi criteria decision analysis. In this paragraph, qualitative dominance scores are used to rank the developments by considering the evaluation scores for each criterion and related weight.

This chapter presented the criteria weights of the individual criteria and the evaluation of developments. To conclude on the developments, these two elements are combined in dominance scores (Si) which rank the developments.

The method uses the outcomes for the criteria, presented in the previous paragraph, which represent the evaluation scores of the developments. The matrices that prioritize developments by ranking the criteria outcomes of developments are attached to this thesis.

4.4.1   Comparison of dominance scores between stakeholder groups

The AHP analysis, presented earlier in this chapter, resulted in criteria weights and evaluation scores that differ per stakeholder group. Below, priority and the dominance scores (Si) of the developments are presented. Firstly, the results for the governmental stakeholder. Secondly, the market stakeholders. Using this analysis, the stakeholders' priorities related to the developments could be compared against each other.

Developments prioritized by government

The governmental stakeholder considers the introduction of 'electronical navigation, way finding and payment systems' the by far most applicable development regarding the considered criteria (figure 39). The Si is significantly higher compared to the other scores. 'Introducing policy in order to enable flexible parking standards' (0,0054) is prioritized second, followed by 'improving the sustainability of the existing parking stock (-0,0019). The difference between the latter and the fourth ranked development 'increasing the number of P+R and K+R areas in order to support car-sharing' (-,0022) is little. The fifth priority is given to 'developing charging networks for electricity driven vehicles' (-0,0164). According to the governmental stakeholder, the 'increasing number of functional changes in the inner city built environment' (-0,0346) is the least-significant development in parking.

Development (prioritized by government)	Si	Rank
Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT)	0,0496	1
Introducing policy in order to enable flexible parking standards (Theme: location specific parking standards)	0,0054	2
Improving the sustainability of the existing parking stock (Theme: Sustainability)	-0,0019	3
Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing)	-0,0022	4
Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources)	-0,0164	5
Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment)	-0,0346	6

Figure 39: Developments prioritized by government.

Developments prioritized by market

The market stakeholders also considers the 'introduction of electronical navigation, way finding and payment systems' (0,0427) the by far most important development regarding the investigated criteria (figure 40). 'Improving the sustainability of the existing parking stock' (0,0161) is ranked secondly. The third priority is given to the 'increasing number of P+R and K+R areas in order to support car-sharing' (0,0131), followed with distance by the 'increasing number of functional changes in the inner city built environment (-0,0189) that is ranked fourth. The least-significant developments are 'Developing charging networks for electricity driven vehicles' (-0,0257) and 'introducing parking policy in order to enable flexible standards' (-0,0273), respectively ranked fifth and sixth.

Developments (prioritized by market)	Si	Rank
Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT)	0,0427	1
Improving the sustainability of the existing parking stock (Theme: Sustainability)	0,0161	2
Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing)	0,0131	3
Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment)	-0,0189	4
Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources)	-0,0257	5
Introducing policy in order tot enable flexible parking standards (Theme: location specific parking standards)	-0,0273	6

Figure 40: Developments prioritized by market.

4.5 Conclusions

The analysis of the research data consists of data collection, characterization of respondents, AHP analysis, development evaluation and dominance scores by both stakeholder groups, is presented in this chapter.

The approached expert respondents are selected from a group of decision makers from municipalities and parking operators. A third group, 'Consultants', was targeted which experts provide services to both key decision makers. A total of 109 respondents was approached. Approximately, 30% of the respondents finished the questionnaire. 45% of the respondents provided results that are usable for the prioritization of criteria. Background variables confirm that the majority of the experts are considered decision makers given their working field and professional activities.

AHP analysis is performed to find the weights of the decision criteria. First, a consistency check is carried out on the individual datasets of the questionnaire. It appeared, a consistency index of 0,15 is necessary to incorporate at least 10 respondents per stakeholder group. The AHP analysis on the stakeholder groups results in criteria weights that slightly differ from each other. Small differences in priority are presented for the 'criteria-groups', 'control aspects' and 'mobility aspects'. On criteria-group level, municipalities prefer the 'effect on mobility' above others while parking operators consider 'financial aspects' of more importance. Consensus is reached for 'control aspects'. The 'influence of the organization on the development is considered more important compared to the 'influence of the

development on the business plan'. It emerged from the results for 'mobility aspects' that both stakeholder groups consider 'effect on parking demand in city center' more significant compared to 'effect on congestion in city center'.

Differences between the stakeholders' evaluation scores are presented on a high level of detail. The Qualitative Dominance scores for the governmental and market stakeholder result in a first priority for 'introduction of electronical navigation, way finding and payment systems'. 'Introducing policy in order to enable flexible parking standards' is prioritized second for the governmental stakeholder followed by 'improving the sustainability of the existing parking stock. The latter is prioritized second by the market stakeholder. A third position is given to 'increasing number of P+R and K+R areas in order to support car-sharing'.

5 Conclusion and recommendations

This chapter concludes on the results of this graduation research. First, the results are summarized. Next, conclusions are presented and discussed. Finally, this chapter provides recommendations for practice and science. In the paragraph with the recommendations for practice an advice is given that addresses implications related to the highest prioritized sustainable development in parking.

5.1 Summary

Parking regulates mobility; provides services to users; shapes the urban environment; and is a source of revenue for government and market parties. Parking activities are located in the public domain (on-street) and private domain (off-street) in garages, areas or near walkways. Only a small portion of the total of European parking spaces is regulated. Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking. Municipalities (Government) enforce parking policy and Parking operators (Market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved.

Which stakeholders are involved in the decision making process regarding to sustainable parking?

Municipalities and parking organizations are considered key decision makers on developments in parking. Decision making in policy and business planning considers financial and control aspects. Public procurement in parking, a form of decision making during tendering, incorporate award criteria which consider qualitative and sustainable aspects in the tendering process next to traditional aspects like financial criteria.

Which criteria can be used to evaluate developments regarding sustainable parking?

Impact criteria emerged from the literature review are selected considering stakeholders' interests. The criteria-group 'Impact on business plan: financial aspects' consists of three sub-criteria: 'Investment costs', 'ROI' and 'Risk for the organization'. Criteria-group 'Impact on business plan: control aspects' consists of two sub criteria: 'influence of organization on development' and 'influence of development on business plan'. Effect criteria focus on the outcome of a development. The criteria-group 'Mobility aspects' consists of sub-criteria: 'effect on parking demand city center' and 'effect on congestion city center'. Finally, criteria-group 'sustainability aspects' considers three sub-criteria: 'effect on energy usage', 'effect on amount of KM travelled and effect on amount of pollutants'.

The AHP analysis on the stakeholder groups results in criteria weights that slightly differ from each other. Small differences in priority are presented for the 'criteria-groups', 'control aspects' and 'mobility aspects'. On the level of group-criteria, municipalities prefer the 'effect on mobility' above others while parking operators consider 'financial aspects' of more importance. Although differences in priority are not very big, both stakeholder groups rank the criteria differently on group level. The most important criteria for stakeholder group 'market' is 'financial aspects'. It can be explained by the financial incentive to drive for parking operators a business which is represented by this group. The governmental stakeholder is more interested in the output of a development given by 'Mobility aspects' as most important aspect and a higher priority of 'Sustainable aspects' compared with 'Control aspects'.

Consensus is reached for 'control aspects'. The 'influence of the organization on the development is considered to be more important compared to the 'influence of the development on the business plan'. It emerged from the results for 'mobility aspects' that both stakeholder groups consider 'effect on parking demand in city center' more significant compared to 'effect on congestion in city center'.

What are important developments in the context of sustainable parking?
Six developments have been selected according to recently attractive themes in the parking industry. The selected developments are: 'Improving the sustainability of the existing parking stock'; 'Developing charging networks for electricity driven vehicles'; 'Introduction of electronical navigation, way finding and payment systems'; 'Increasing number of P+R and K+R areas in order to support Car-Sharing'; Introducing policy in order to enable flexible parking standards'; and 'Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping'.

What is the importance of selected criteria regarding developments in sustainable parking?
Frequency analysis took place on all development evaluations in order to find similarities and differences between the stakeholder groups 'government' and 'market'. The group consensus, represented by the criteria modes, is compared per stakeholder group for each development. Results of this development evaluation are available in chapter 4: Analysis. An overview of all developments is available in Appendix E.

5.2 General conclusion
The selection of decision criteria and sustainable developments in parking are important results from this research. The selected criteria can be used to evaluate and characterize sustainable developments. The results, summarized in the previous paragraph, answer the sub-questions in this research. These sub-questions provide the basic elements that are required to conclude on the main question in this research: *"What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"*

The main question is answered by the priorities resulting from Qualitative Dominance scores, as presented in the previous chapter. The Qualitative Dominance scores for the governmental and market stakeholder show a first priority for 'introduction of electronical navigation, way finding and payment systems'. 'Introducing policy in order to enable flexible parking standards' is prioritized second for the governmental stakeholder followed by 'improving the sustainability of the existing parking stock. The latter is prioritized second by the market stakeholder. A third position is given to 'increasing number of P+R and K+R areas in order to support car-sharing'.

Important similarities and differences are present if the priorities given by the governmental and market stakeholders are compared (Figures 39 and 40). 'Introduction of electronical navigation, way finding and payment systems' is prioritized first by both stakeholder groups. 'Improving the sustainability of the existing parking stock' is also considered highly important considering its third rank by the governmental stakeholder and second rank by

the market stakeholder. The 'increasing number of P+R and K+R areas in order to support Car-Sharing' is high ranked by both stakeholders given it's little difference in dominance score(by government) compared to the previously ranked.

The development 'Introducing policy in order to enable flexible parking standards' is ranked second by government, while considered the least-significant development by the market stakeholder. The fifth rank, by both stakeholders, is given to 'developing charging networks for electricity driven vehicles'. Relatively high difference in prioritization is present for the 'increasing number of functional changes in the inner city built environment'. This development is ranked fourth by the market stakeholder while regarded least-significant by the governmental stakeholder.

5.3 Recommendations for practice

The results of this research showed which developments regarding sustainable parking are preferred most by the governmental stakeholder group (represented by decision makers of municipalities) and the market stakeholder group (represented by decision makers of parking operators). The rankings of developments by both stakeholder groups show the 'introduction of elektronical navigation, way finding and payment systems' as highly preferred. The prioritizations confirms the high number of related developments the parking industry such as the integration of parking information (Servicehuis Parkeer en Verblijf Rechten), mobile payment services and reservation services of parking operators.

On one hand, this research showed which developments are most promising regarding both stakeholder groups. On the other, the evaluation of the developments provide underlying criteria scores that affected the final prioritization. These underlying expectations of decision makers could be considered as strengths and weaknesses for the implementation of sustainable developments in parking. In this paragraph, advice is presented based on the most significant development in sustainable parking.

Implementing electronic navigation, way finding and payment systems

The development that is considered most promising by both stakeholder groups is: 'the introduction of electronic navigation, way finding and payment system'. The development describes the introduction of a single application which enables users to navigate, find routes to specific parking destinations and provides reservation and wireless payment services (KpVV), 2013).

Relevant question and consequences emerge: Who is going to develop the application? What is the business case related to the application? What kind of information has to be shared to provide these services? The advice that considers these questions is presented below and based on the evaluation scores of both stakeholder groups (figure 41).

Criteria	Government Mode	Market Mode
Investment costs for organization	High	High
ROI for organization	Low	Medium
Risk for organization	Medium	Medium
Influence of organization on development	Medium	Medium
Influence of development on business plan	Low	Medium
Parking demand city center	Neutral	Increase
Congestion city center	Decrease	Decrease
Energy usage	Decrease	Decrease
Amount of KM travelled	Decrease	Decrease
Amount of pollutants	Decrease	Decrease

Figure 41: Synthesis of evaluation scores for introduction of electronic navigation, way finding and payment systems.

Strengths

Both stakeholder groups agree on the effects of the sustainability aspects: Energy usage, the amount of KM travelled and the amount of pollutants are expected to decrease together with the 'congestion in the city center'. Parking operators also expect a increasing 'parking demand in the city center' which could have a positive effects on their business: if parking capacity remains equal, occupation rates will increase. The control aspects, related to business planning are considered not to change.

Weaknesses

High investment costs are expected by both stakeholders. The costs related to the introduction of an application which is able to deliver the proposed value are considered high. Decision makers at municipalities are not expecting a positive impact regarding return on investment, in contrast to experts of parking operators that expect no change.

Advise

Given the mutual insights on sustainability of parking, positive effects on the mobility in the inner city, stakeholder groups agree on the positive effects of this development. The criteria related to financial aspects suggest that both stakeholder groups have to find funds to invest in the development while no direct return on investment is expected. Therefore, It appears both stakeholder groups are not expected to develop such an application independently.

Some of the services related to the electronic application are already exploited by navigation service providers (e.g. TomTom) or mobile payment providers (e.g. Yellow Brick). Information, for example the availability of parking spaces in a city, is collected and presented to car drivers by municipalities (e.g. PRIS). Parking operators provide booking services for parking spaces individually (e.g. www.20voor020.nl). These initiatives seem to follow parking users' requirements.

In order to integrate all these developments, information has to be transferred from, for example, parking operators to a different entity and vice versa to let this development succeed. Municipalities and parking operators could cooperate to make arrangements with service providers to integrate information by an independent new entity. All participating parties should be obliged to provide trustworthy information and be able to derive this

information. As a result. investment costs and the potential value of the information are shared by multiple parties. A more challenging task is the development of an single application that integrates all services and information. Some stakeholders may reject such a development because of their current business case. A potential solution could be found in the development of a basic application platform that controls and regulates all information and services. It enables parties to develop an individual application based on the platform while an individual identity remains.

Parking operators are expecting positive effects resulting from this development but are not able to develop an integral application individually. Municipalities, on the other hand, require parking operators to participate. Given the legislative power, policy and sustainability targets of municipalities, governmental decision makers should stimulate this development and propose fair sharing of investments costs, information and potential benefits.

5.4 Recommendations for scientific research
The research framework that is proposed in this research consists of a literature review and Multi Criteria Decision Analysis (MCDA) which combines the Analytic Hierarchy Process (AHP), Qualitative evaluation and Qualitative Dominance scores. Given these different approaches, the research framework has to be considered in general and by element.

Research framework
The research framework has proven itself successful to find the most promising development regarding sustainable parking according to decision makers. It enables one to find criteria weights and investigate a high number of developments. The high number of developments could be scored because, in contrast to AHP, the evaluation task was not integrated with the establishment of criteria weights. The mix of methods, could have increased the difficulty of the analysis. The data collection resulted in complex tasks for the expert respondents. Interpreting the comments of experts on the questionnaire, one could conclude that a high number of experts experienced difficulties caused by a lack of knowledge or inexperience with the decision criteria. Other qualitative techniques, for example interviewing, could deliver information directly from specialists in the field of sustainable parking solutions. Dividing the research in multiple research topics, for example criteria prioritization without development evaluation, could reduce complexity and provide more detailed information.

Literature review
Relevant stakeholders, criteria and sustainable developments emerged from the literature review. The lack of 'standardized' criteria forced to develop selection rules and methods during the research in order to select from the high number of criteria found in literature. Qualitative research, for example interviewing experts from practice and researcher could deliver a set of criteria in a more efficient manner. Additional interviews could be used to check if the right criteria or developments are selected.

Analytic Hierarchy Process (AHP)
AHP was used to find criteria weights. The method suggested by Saaty (1980) was not completely used. The evaluation of a fixed number of developments could be implemented

using the same type of pairwise comparisons. Given the unknown number of development at the start of this research, it was more efficient to adopt the current research framework. Also other alterations are used in this research: a lower number of scale levels for the pairwise comparisons is used to reduce the difficulty of the task and maximum consistency that was accepted is higher compared to standard use. Following the suggestions by Saaty in detail could improve the sensitivity of the analysis. An automated consistency check in the software used for the questionnaire could correct respondents during their task performance. The minimal differences between the criteria could be caused by an incomplete set of criteria, vagueness of the criteria description or lack of knowledge. As mentioned in this paragraph qualitative research could provide more insight in criteria.

Qualitative evaluation of developments
Developments have been evaluated in a qualitative manner. The criteria are scored by a three point ordinal scale. A ratio scale is not applicable because of the character of the criteria but eases calculations and transforms the quantitative/qualitative research into entirely quantitative. Qualitative Dominance (QD) scores are implemented in the research framework without any difficulties. An increase of the three ordinal levels is supported by QD and increases the variance in criteria values that differentiate evaluated development.

Further research
Initially, the questionnaire was developed to capture evaluation scores of development from self-perspective and the perceived expectation of the contrasting stakeholder. For example, respondents from the market stakeholder group are asked to score own expectations and the perceive expectation of the governmental stakeholder. Because of time constraints in this graduation report, analysis of these data is not possible. Students and researchers could use the entire dataset to find similarities and differences in actual expectation and perceived expectations regarding respondent' background variables.

References

Ahmed, H., Bwisa, H. & Otieno, R., 2012. Business Selection using Multi-Criteria Decision Analysis. *International Journal of Business and Commerce,* 1(5), pp. 64-81.

Ajzen, I., 1988. *Attitudes, Personality, and Behavior.* Chicago, USA: Dorsey Press.

Ajzen, I., 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Process,* Volume 50, pp. 179-211.

Ajzen, I., 2006. Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior. *Journal of Applied Social Psychology,* 32(4).

Arnott, R., Rave, T. & Schob, R., 2005. *Alleviating Urban Traffic Congestion.* Cambridge, USA: MIT Press..

Bakker, J., 2011. *Contesting range anxiety; The role of electric vehicle charging infrastructure in the transportation transition (Thesis),* Eindhoven, The Netherlands: Eindhoven University of Technology.

Bouwfonds REIM, 2012. *Parking money in parking garages; Summary,* Hoevelaken, the Netherlands: Bouwfonds REIM.

Buyukyazici, M. & Sucu, M., 2003. The Analytic Hierarchy and Network Processes. *Hacettepe Journal of Mathematics and Statistics, Volume 32,* pp. 65-73.

Coyle, G., 2004. The Analytic Hierarchy Process (AHP). *Practical strategy,* pp. 1-11.

CROW / KpVV, 2005. *Implementation of P+R policy [NL: Aan de slag met P+R beleid; van strategie tot exploitatie,* Deventer, the Netherlands: CROW.

CROW, 2002. *From parking enforcement towards mobility management [NL: Van parkeerbeheer naar mobiliteitsmanagement],* Ede, the Netherlands: CROW.

CROW, 2012. *Guidelines for parking [NL: Handboek parkeren].* Ede, the Netherlands: CROW.

Department of Communities and Local Government, 2009. *Multi-criteria analysis: a manual,* London, United Kingdom: Department for Communities and Local Government.

Dijk, M. & Montalvo, C., 2011. Policy frames of Park-and-Ride in Europe. Volume 19, pp. 1106-1119.

European Union, 2007. *Commission plans legislative framework to ensure the EU meets its target for cutting CO2 emissions from cars,* Brussels, Belgium: European Union.

Farla, J., Alkemade, F. & Suurs, R., 2010. Analysis of barriers in the transition toward sustainable mobility in the Netherlands. *Technological Forecasting and Social Change 77*, pp. 1260-1269.

Geng, Y. & Cassandras, C., 2012. A new "Smart-Parking" System Infrastructure and Implementation. *Procedia- Social and Behavioral Sciences,* Volume 54, pp. 1278-1287.

Giuffrè, T., Siniscalchi, S. & Tesoriere, G., 2012. A Novel Architecture of Parking Management for Smart Cities. *Procedia- Social and Behavioral Sciences,* Volume 53, pp. 16-28.

Han, Q., Kadarpeta, S. & Vries, B. d., 2011. Governance instruments for energy neutral housing developments. *ERES 2011.*

IPI (International Parking Institute), 2012. *Emerging trends in Parking 2012,* Fredericksburg, USA: IPI.

Karlström, D., Puneson, P. & Wohlin, C., 2002. Aggregating Viewpoints for Strategic Software Process Improvement - A Method and a Case Study. *IEE Proceedings - Software engineering,* 149(5), pp. 143-152.

Kennisplatform Verkeer en Vervoer (KpVV), 2005. *Getting started with Park and Ride policy [NL: Aan de slag met P+R beleid],* Utrech, the Netherlands: KpVV.

Kennisplatform Verkeer en Vervoer (KpVV), 2010. *Focus on Social and Safe Parking, Guide for the realization of social, safe and comfortable P+R areas [NL: Sociaal veilig parkeren in beeld; Handreiking voor het realiseren van sociaal veilige en prettige P+R terreinen,* Utrecht, the Netherlands: KpVV.

Kennisplatform Verkeer en Vervoer (KpVV), 2012. *SUMP What's in it for me?,* Utrecht, the Netherlands: KpVV.

Kennisplatform Verkeer en Vervoer (KpVV), 2013. *Parking policy in the medium term [NL: Parkeerbeleid op de middellange termijn: maatschappelijke trends en de toekomst van parkeren],* Ede, the Netherlands: Kennisplatform Verkeer en Vervoer.

Litman, T., 2006. What's It Worth; Economic Evaluation For Transportation Decision-Making. *Victoria Transport Policy Institute.*

Litman, T., 2013. Parking management, comprehensive implementation guide. *Victoria Transport Policy Institute.*

Longo, G. et al., 2009. *Considerations on the application of AHP/ANP methodologies to decisions concerning a reilway infrastructure.* s.l., s.n., pp. 1-14.

May, A., 2003. *Developing Sustainable Urban Land Use and Transport Strategies: A Decision Makers' Guidebook,* Brussels, Belgium: Procedures for Recommending Optimal Sustainable planning of European City Transport Systems (PROSPECTS).

Ministry of Infrastructure and Environment (VROM), 2010. *Information for sustainable procurement of Parking,* Den Haag,the Netherlands: Ministry of Infrastructure and Environment (VROM).

Montalvo, C., 2002. *Environmental Policy and Technological Innovation: why do firms adopt or reject new technologies?.* Cheltenham, United Kingdom: Edward Elgar.

P1 Parkings, 2005. *Dossier 1: Parking and Public Private Partnerships [NL: Dossier 1: Parkeren en Publiek Private Samenwerking],* Den Haag, the Netherlands: Parkeer Management Nederland.

P1 Parkings, 2008. *Dossier 5: Future of parking [NL: De toekomst van parkeren],* Den Haag, the Netherlands: P1 Parkings.

PIANOo, Expert center for Tendering, 2012. *How to apply EMAT? [NL: Hoe pas je EMVI toe?],* Den Haag, the Netherlands: PIANOo, Expertise centrum Aanbesteden..

Q-Park NV, 2012b. *Annual Report 2011,* Maastricht, the Netherlands: Q-Park NV.

Q-Park NV, 2012a. *Responsible Parking 2011,* Maastricht, the Netherlands: Q-Park NV.

Q-Park NV, 2013b. *Annual Report 2012,* Maastricht, the Netherlands: Q-Park NV.

Q-Park NV, 2013a. *Responsible Parking 2012,* Maastricht, the Netherlands: Q-Park NV.

Richardson, D., 2013. Electric vehicles and the electric grid: A review of modeling approaches, impacts and renewable energy integration. Volume 19, pp. 247-254.

Rupprecht Consult, 2007. *Adapted from SUMP Manual, Guidance for Stakeholders,* Cologne, Germany: Rupprecht Consult – Forschung und Beratung GmbH.

Saaty, T., 1980. *The Analytic Hierarchy Process.* New York, USA: McGraw-Hill.

Saaty, T*.,* 1990. How to make a decision: The Analytic Hierarchy Process. *European Journal of Operational Research,* Volume 48, pp. 9-26.

Stewart, T., 1992. A critical survey on the status of multiple criteria decision making theory and practice. *Omega,* 20(5-6), pp. 569-586.

Technical Committee on Transport, 2006. *Parking Policies and the Effect on Economy and Mobility - Report on COST,* Brussels, Belgium: Technical Committee on Transport, European Union.

Vaidya, O. & Kumar, S., 2004. Analytic hierarchy process: An overview of applications. *European Journal of Operational Research,* Volume 169, pp. 1-29.

Vargas, L., 1990. An overview of the Analytic Hierarchy Process and its applications. *European Journal of Operational Research,* Volume 48, pp. 2-8.

Vergragt, P. & Brown, H., 2007. Sustainable mobility from technological innovation to societal learning. *Journal of Cleaner Production,* 15(11-12), pp. 1104-1115.

Vigar, G., 2001. Reappraising UK transport policy 1950-1999: the myth of 'mono-modality' and the nature of 'paradigm shifts'. *Planning Perspectives,* Volume 16, pp. 269-291.

Waerden, P. v. d., 2012. *Pamela, a parking analysis model for predicting effects in local areas,* Eindhoven: Technische Universiteit Eindhoven.

Waerden, P. v. d., Timmermans, H. & Barzeele, P., 2011. Car Drivers' Preferences Regarding Location and Contents of Parking Guidance Systems: Stated Choice Approach. Volume 2245, pp. 63-69.

Appendix A: Stakeholders in parking

Goup	Stakeholder	Incentives
Investors	Shareholders Banks Real Estate Investors / Developers	Financial health Insensitivity to risks Innovation / R&D Reputation Transparency and communication Privacy and data security sustainable reporting
Customers	Private customers Business customers	Fair prices Accessible parking facilities Security practices Quality of parking services Privacy and data security Quality of customer service
Business partners	Suppliers Commercial parties	Ethical business operations Partnerships Quality Chain responsibility Transparency and communication Innovation / R&D
Municipalities Regions	Local authorities Communities	Viable, accessible and economically flourishing cities Integration of transport modes Partnerships Employment Ethical business operations
Goverments Politics Society	National governments EU International institutes	Viable, accessible and economically flourishing cities Safe, healthy pleasant and social living environment Countering climate change Economical use of raw materials, energy and water Ethical business operations
Other	Scientist Media Industry	Innovation / R&D Fair competition Ethical business operations Accessibility to customers Cooperation and support for social projects Countering climate change Transparency and communication Responsibility for fair prices

Detailed stakeholder analysis by Q-Park NV (2013)

Appendix B: Analysis on developments in parking

Category Sustainability	Type /development	Description of development	E.g.
Construction of sustainable facilities	Product development	Demand for cashless or electronic payment	IPI (2012)
Construction of sustainable facilities	Product development	LED lightning systems	www.parkeer24.nl
Construction of sustainable facilities	Product development	Licence plate parking	www.parkeer24.nl
Construction of sustainable facilities	Product development	Move toward innocative technologies to improve access control and payment automation	IPI (2012)
Construction of sustainable facilities	Product development	Need for improved visual appeal / aesthetics of parking	IPI (2012)
Construction of sustainable facilities	Product development	Suistainable construction using BREEAM-NL	Q-Park (2013)
External	Demografic	Population growth, population composition by age, education, gender and employment (work participation	KpVV (2013)
External	Market development	Internet shopping, shopping behavior	www.parkeer24.nl
External	Socio-economic	Changing preferences and needs that influence the way in which people organise their daily lives, such as family development, household composition, changing lifestyle, individualisation and emancipation	KpVV (2013); NL Institute for social research (2003)
External	Socio-economic	Environmental certification of organizations (ISO/CO2neutral)	KpVV (2013)
External	Socio-economic	EU procurement and tendering	Lenferink et al. (2012)
External	Socio-economic	Increase in prosperity (income from employment) and car ownership	KpVV (2013)
External	Socio-economic	Increase of shopping activities on sundays [NL]	KpVV (2013)
External	Socio-economic	Demand for green / sustainable solutions	IPI (2012)
Improving the efficiency of trafic and way finding	Market development	Digital parking information, booking and guidance	P1(2008)
Improving the efficiency of trafic and way finding	Policy development	Improve infrastructure (Reduce vehicle-mile traveled)	Chu et al. (2010)
Improving the efficiency of trafic and way finding	Policy development	PRIS guidance city	
Improving the efficiency of trafic and way finding	Product development	Real-time communication of pricing and availability to mobile phone or PDA components	IPI (2012)
Improving the efficiency of trafic and way finding	Product development	Use of wireless sensing devices for traffic management	IPI (2012)

Analysis of developments in parking (Part 1)

Mobility and parking policy	Market development	More public private partnerships	IPI (2012)
mobility and parking policy	Market development	Pricing per minute (smaller time units)	
Mobility and parking policy	Mobility	Road network expansion and the separation of housing from the place of work, urbanisation and increases in spatial scales	KpVV (2013)
Mobility and parking policy	Policy development	Car sharing is increasing	IPI (2012)
Mobility and parking policy	Policy development	Collaboration between parking, transportation and planning of decision makers	IPI (2012)
Mobility and parking policy	Policy development	Dynamic norms and standards	
Mobility and parking policy	Policy development	Increase of P&R locations	P1(2008)
Mobility and parking policy	Policy development	Multiple use of parking spaces	
Mobility and parking policy	Policy development	New way to work (Het nieuwe werken)	KpVV (2003), Q-Park (2013)
Mobility and parking policy	Policy development	Park and Bike (P+B)	KpVV (2003)
Mobility and parking policy	Policy development	Parking as key element of the mobility chain	P1(2008)
Technological improvement of personal vehicles	Market development	Bio fuels	Farla et al. (2010)
Technological improvement of personal vehicles	Market development	Electric Driven Vehicles (EDV)	Pasaoglu et al. (2011), Roman et al
Technological improvement of personal vehicles	Market development	Need to accommodate electric car charging stations	IPI (2012)
Technological improvement of personal vehicles	Product development	Hybrid Vehicles	Farla et al. (2010)
Technological improvement of personal vehicles	Product development	Hydrogen vehicles	Huetink et al. (2010)
Technological improvement of personal vehicles	Product development	Vehicle to grid systems (V2G)	Turton et al. (2008)

Analysis of developments in parking (Part 2)

Focus on current topics in the parking business (KpVV, 2013)	2008	2013
Future oriented parking policy	Small	Very strong
More understanding of consumer choice behavior	Average	Very strong
Parking as integral part of transport policy	Limited	Strong
Municipal parking exploitation versus mobility policy	Average	Limited
Relationship market and government in the field of parking	Moderate	Very strong
Demographics (increase / decrease)	Moderate	Moderate
Upscaling of social and economic services	Moderate	Moderate
Changes in spatial structure of cities (polycentric)	Average	Average
Urbanization	Average	Average
Area based approach for parking demand	Limited	Strong
Location specific parking standards	Small	Average
Functional change of the built environment (e.g. office locations	Small	Strong
New ways to work	Limited	Average
Increasing parking demand in residential areas	Limited	Average
Shared Space and parking	Limited	Limited
Increasing car ownership	Strong	Moderate
Intensification pattern of life	Limited	Average
Mobility for the elderly	Limited	Average
Decreasing car usage of young people	Limited	Moderate
Car-sharing	Moderate	Strong
Influence of IT on mobility	Small	Very strong
Shifting attitude toward car mobility	Limited	Moderate
Alternative energy resources for cars	Limited	Strong
Sustainability	Small	Very strong

Levels
Very strong
Strong
Moderate
Average
Limited
Small

Focus on current topics in the parking business (adapted from KpVV, 2013)

Appendix C: AHP Hierarchy structure
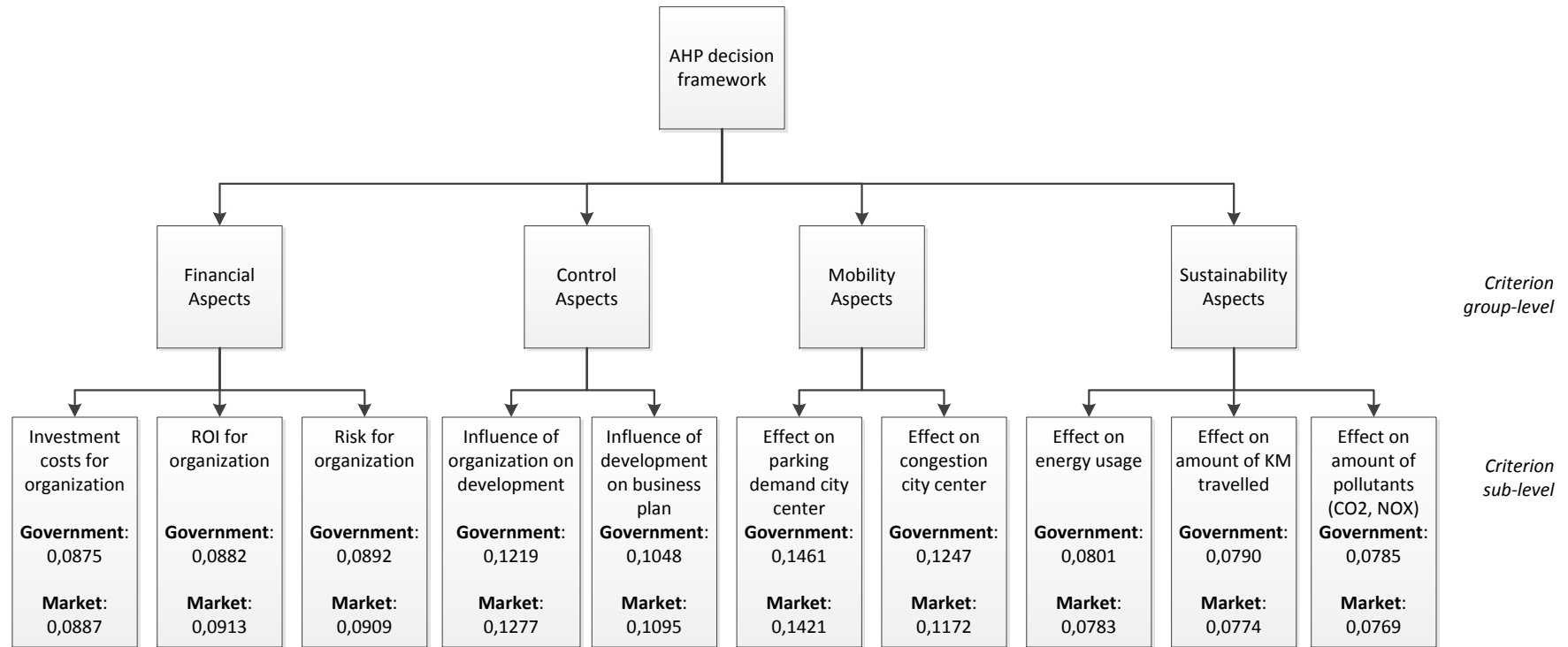
AHP Hierarchy structure with weighted sub-criteria.

Appendix D: Final criteria weights

Criteria (Financial aspects)	All respondents	Government	Market
Investment costs for organization	0,0863	0,0875	0,0887
Risk for organization	0,0870	0,0882	0,0913
ROI for organization	0,0873	0,0892	0,0909

Criteria (Control aspects)	All respondents	Government	Market
Influence of organization on development	0,1250	0,1219	0,1277
Influence of development on businessplan	0,1140	0,1048	0,1095

Criteria (Mobility aspects)	All respondents	Government	Market
Effect on parking demand city center	0,1362	0,1461	0,1421
Effect on congestion city center	0,1230	0,1247	0,1172

Criteria (Sustainability aspects)	All respondents	Government	Market
Effect on energy usage	0,0808	0,0801	0,0783
Effect on amount of KM travelled	0,0803	0,0790	0,0774
Effect on amount of pollutants (CO2, NOX)	0,0800	0,0785	0,0769

Overview of final criteria weights specified per stakeholder group

Appendix E: overview of the evaluation of developments

Improving the sustainability of the existing parking stock (Theme: Sustainability)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	Medium	0	-6	High	-1	-10
ROI for organisation	Low	-1	-5	High	1	10
Risk for organization	Low	1	7	Medium	0	0
Influence of organization on development	Medium	0	-6	Medium	0	3
Influence of development on business plan	Medium	0	4	Medium	0	-8
Parking demand city center	Neutral	0	-1	Neutral	0	4
Congestion city center	Neutral	0	9	Neutral	0	4
Energy usage	Decrease	1	14	Decrease	1	16
Amount of KM travelled	Neutral	0	7	Decrease	1	8
Amount of pollutants	Decrease	1	10	Decrease	1	14

Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-11	High	-1	-5
ROI for organisation	Low	-1	-13	Low	-1	-6
Risk for organization	Medium	0	2	Medium	0	1
Influence of organization on development	Medium	0	-3	Medium	0	-3
Influence of development on business plan	Low	1	8	Medium	0	4
Parking demand city center	Neutral	0	2	Neutral	0	5
Congestion city center	Neutral	0	2	Neutral	0	1
Energy usage	Decrease	1	8	Neutral	0	6
Amount of KM travelled	Neutral	0	-1	Neutral	0	-1
Amount of pollutants	Decrease	1	14	Decrease	1	13

Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organisation	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Overview of the evaluation of developments (part 1)

Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-8	Low	1	2
ROI for organisation	Low	-1	-9	Low	-1	-5
Risk for organization	Low	1	2	Medium	0	-2
Influence of organization on development	Medium	0	4	Medium	0	-4
Influence of development on business plan	Medium	0	3	Medium	0	0
Parking demand city center	Decrease	-1	-13	Decrease	-1	-11
Congestion city center	Decrease	1	13	Decrease	1	6
Energy usage	Decrease	1	9	Decrease	1	9
Amount of KM travelled	Decrease	1	12	Decrease	1	10
Amount of pollutants	Decrease	1	13	Decrease	1	10

Introducing policy in order to enable flexible parking standards (Theme: location specific parking standards)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	Low	1	12	Low	1	8
ROI for organisation	Medium	0	1	High	1	3
Risk for organization	Medium	0	2	Medium	0	4
Influence of organization on development	High	1	11	Low	-1	-5
Influence of development on business plan	Medium	0	0	Medium	0	1
Parking demand city center	Neutral	0	6	Neutral	0	-1
Congestion city center	Neutral	0	2	Neutral	0	2
Energy usage	Neutral	0	-3	Neutral	0	4
Amount of KM travelled	Neutral	0	-3	Neutral	0	2
Amount of pollutants	Neutral	0	-3	Neutral	0	4

Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment)

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	Low	1	4	Low	1	3
ROI for organisation	Low	-1	-7	Low	-1	-8
Risk for organization	High	-1	-6	High	-1	-5
Influence of organization on development	Medium	0	0	Medium	0	1
Influence of development on business plan	High	-1	-6	High	-1	-5
Parking demand city center	Decrease	-1	-13	Decrease	-1	-11
Congestion city center	Decrease	1	12	Decrease	1	9
Energy usage	Decrease	1	8	Decrease	1	10
Amount of KM travelled	Decrease	1	13	Decrease	1	11
Amount of pollutants	Decrease	1	13	Decrease	1	12

Overview of the evaluation of developments (part 1)

Appendix F: Qualitative Dominance scores (government)

Qualitative standardization		C1	C2	C3	C4	C5	C6	C7*	C8	C9	C10
	St1D1	0	-1	1	0	0	0	0	1	0	1
	St1D2	-1	-1	0	0	1	0	0	1	0	1
	St1D3	-1	-1	0	0	1	0	1	1	1	1
	St1D4	-1	-1	1	0	0	-1	1	1	1	1
	St1D5	1	0	0	1	0	0	0	0	0	0
	St1D6	1	-1	-1	0	-1	-1	1	1	1	1
Qualitative ranking Criteria											
	St1D1	3	4	1,5	4	4	2,5	5	3	5	3
	St1D2	5	4	4	4	1,5	2,5	5	3	5	3
	St1D3	5	4	4	4	1,5	2,5	2	3	2	3
	St1D4	5	4	1,5	4	4	5,5	2	3	2	3
	St1D5	1,5	1	4	1	4	2,5	5	6	5	6
	St1D6	1,5	4	6	4	6	5,5	2	3	2	3
	Total	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**
Comparison ranking Criteria											
	D1-D2	1	0	1	0	-1	0	0	0	0	0
	D1-D3	1	0	1	0	-1	0	-1	0	-1	0
	D1-D4	1	0	0	0	0	1	-1	0	-1	0
	D1-D5	-1	-1	1	-1	0	0	0	1	0	1
	D1-D6	-1	0	1	0	1	1	-1	0	-1	0
	D2-D3	0	0	0	0	0	0	-1	0	-1	0
	D2-D4	0	0	-1	0	1	1	-1	0	-1	0
	D2-D5	-1	-1	0	-1	1	0	0	1	0	1
	D2-D6	-1	0	1	0	1	1	-1	0	-1	0
	D3-D4	0	0	-1	0	1	1	0	0	0	0
	D3-D5	-1	-1	0	-1	1	0	1	1	1	1
	D3-D6	-1	0	1	0	1	1	0	0	0	0
	D4-D5	-1	-1	1	-1	0	-1	1	1	1	1
	D4-D6	-1	0	1	0	1	0	0	0	0	0
	D5-D6	0	1	1	1	1	1	-1	-1	-1	-1

Calculation of QD scores for the governmental stakeholder group (part 1).

Qualitative Dominance scores	aij	D1	D2	D3	D4	D5	D6		
Developments (D)	D1	0,0000	0,0709	-0,1328	0,0298	-0,0518	0,0479		
	D2	-0,0709	0,0000	-0,2037	-0,0411	-0,0353	0,0479		
	D3	0,1328	0,2037	0,0000	0,1626	0,1685	0,2516		
	D4	-0,0298	0,0411	-0,1626	0,0000	0,0058	0,1055		
	D5	0,0518	0,0353	-0,1685	-0,0058	0,0000	0,1879		
	D6	-0,0479	-0,0479	-0,2516	-0,1055	-0,1879	0,0000		

Criteria Weights	C1	0,0875		C6	0,1461
	C2	0,0892		C7	0,1247
	C3	0,0882		C8	0,0801
	C4	0,1219		C9	0,0790
	C5	0,1048		C10	0,0785

Weights * Scores		D1	D2	D3	D4	D5	D6		
Developments (D)	D1	0,0000	0,0709	0,1328	0,0298	0,0518	0,0479		
	D2	0,0709	0,0000	0,2037	0,0411	0,0353	0,0479		
	D3	0,1328	0,2037	0,0000	0,1626	0,1685	0,2516		
	D4	0,0298	0,0411	0,1626	0,0000	0,0058	0,1055		
	D5	0,0518	0,0353	0,1685	0,0058	0,0000	0,1879		
	D6	0,0479	0,0479	0,2516	0,1055	0,1879	0,0000		**Total**
	Total	0,3332	0,3988	0,9192	0,3449	0,4493	0,6408		3,0863

Overall dominance scores	Dij	D1	D2	D3	D4	D5	D6		
Developments (D)	D1	0,0000	0,0230	-0,0430	0,0097	-0,0168	0,0155		
	D2	-0,0230	0,0000	-0,0660	-0,0133	-0,0114	0,0155		
	D3	0,0430	0,0660	0,0000	0,0527	0,0546	0,0815		
	D4	-0,0097	0,0133	-0,0527	0,0000	0,0019	0,0342		
	D5	0,0168	0,0114	-0,0546	-0,0019	0,0000	0,0609		
	D6	-0,0155	-0,0155	-0,0815	-0,0342	-0,0609	0,0000		

Standardised scores		D1	D2	D3	D4	D5	D6		
Developments	D1	0,0000	0,0230	0,0430	0,0097	0,0168	0,0155		
	D2	0,0230	0,0000	0,0660	0,0133	0,0114	0,0155		
	D3	0,0430	0,0660	0,0000	0,0527	0,0546	0,0815		
	D4	0,0097	0,0133	0,0527	0,0000	0,0019	0,0342		
	D5	0,0168	0,0114	0,0546	0,0019	0,0000	0,0609		
	D6	0,0155	0,0155	0,0815	0,0342	0,0609	0,0000		**Total**
	Total	0,1080	0,1292	0,2978	0,1118	0,1456	0,2076		1

	Mij	Si		Rank
Government	D1	-0,0019		3
Government	D2	-0,0164		5
Government	D3	0,0496		1
Government	D4	-0,0022		4
Government	D5	0,0054		2
Government	D6	-0,0346		6

Calculation of QD scores for the governmental stakeholder group (part 2).

Appendix G: Qualitative Dominance scores (Market)

Qualitative standardization		C1	C2	C3	C4	C5	C6	C7*	C8	C9	C10
	St2D1	-1	1	0	0	0	0	0	1	1	1
	St2D2	-1	-1	0	0	0	0	0	0	0	1
	St2D3	-1	0	0	0	0	1	1	1	1	1
	St2D4	1	-1	0	0	0	-1	1	1	1	1
	St2D5	1	1	0	-1	0	0	0	0	0	0
	St2D6	1	-1	-1	0	-1	-1	1	1	1	1
Qualitative ranking Criteria	St2D1	5	1,5	3	3	3	3	5	2,5	2,5	3
	St2D2	5	5	3	3	3	3	5	5,5	5,5	3
	St2D3	5	3	3	3	3	1	2	2,5	2,5	3
	St2D4	2	5	3	3	3	5,5	2	2,5	2,5	3
	St2D5	2	1,5	3	6	3	3	5	5,5	5,5	6
	St2D6	2	5	6	3	6	5,5	2	2,5	2,5	3
	Total	21	21	21	21	21	21	21	21	21	21
Comparison ranking Criteria	D1-D2	0	1	0	0	0	0	0	1	1	0
	D1-D3	0	1	0	0	0	-1	-1	0	0	0
	D1-D4	-1	1	0	0	0	1	-1	0	0	0
	D1-D5	-1	0	0	1	0	0	0	1	1	1
	D1-D6	-1	1	1	0	1	1	-1	0	0	0
	D2-D3	0	-1	0	0	0	-1	-1	-1	-1	0
	D2-D4	-1	0	0	0	0	1	-1	-1	-1	0
	D2-D5	-1	-1	0	1	0	0	0	0	0	1
	D2-D6	-1	0	1	0	1	1	-1	-1	-1	0
	D3-D4	-1	1	0	0	0	1	0	0	0	0
	D3-D5	-1	-1	0	1	0	1	1	1	1	1
	D3-D6	-1	1	1	0	1	1	0	0	0	0
	D4-D5	0	-1	0	1	0	-1	1	1	1	1
	D4-D6	0	0	1	0	1	0	0	0	0	0
	D5-D6	0	1	1	-1	1	1	-1	-1	-1	-1

Calculation of QD scores for the market stakeholder group (part 1).

Qualitative Dominance scores	aij	D1	D2	D3	D4	D5	D6
Developments (D)	D1	0,0000	0,2466	-0,1684	0,0270	0,2716	0,2279
	D2	-0,2466	0,0000	-0,5059	-0,2196	0,0250	-0,0188
	D3	0,1684	0,5059	0,0000	0,1443	0,4400	0,3451
	D4	-0,0270	0,2196	-0,1443	0,0000	0,2446	0,2008
	D5	-0,2716	-0,0250	-0,4400	-0,2446	0,0000	-0,0437
	D6	-0,2279	0,0188	-0,3451	-0,2008	0,0437	0,0000

Criteria Weights	C1	0,0887	C6	0,1421
	C2	0,0909	C7	0,1172
	C3	0,0913	C8	0,0783
	C4	0,1277	C9	0,0774
	C5	0,1095	C10	0,0769

Weights * Scores		D1	D2	D3	D4	D5	D6		
Developments (D)	D1	0,0000	0,2466	0,1684	0,0270	0,2716	0,2279		
	D2	0,2466	0,0000	0,5059	0,2196	0,0250	0,0188		
	D3	0,1684	0,5059	0,0000	0,1443	0,4400	0,3451		
	D4	0,0270	0,2196	0,1443	0,0000	0,2446	0,2008		
	D5	0,2716	0,0250	0,4400	0,2446	0,0000	0,0437		
	D6	0,2279	0,0188	0,3451	0,2008	0,0437	0,0000		
	Total	0,9415	1,0158	1,6037	0,8362	1,0249	0,8362		6,2585

Overall dominance scores	Dij	D1	D2	D3	D4	D5	D6
Developments (D)	D1	0,0000	0,0394	-0,0269	0,0043	0,0434	0,0364
	D2	-0,0394	0,0000	-0,0808	-0,0351	0,0040	-0,0030
	D3	0,0269	0,0808	0,0000	0,0230	0,0703	0,0551
	D4	-0,0043	0,0351	-0,0230	0,0000	0,0391	0,0321
	D5	-0,0434	-0,0040	-0,0703	-0,0391	0,0000	-0,0070
	D6	-0,0364	0,0030	-0,0551	-0,0321	0,0070	0,0000

Standardised scores		D1	D2	D3	D4	D5	D6		
Developments	D1	0,0000	0,0394	0,0269	0,0043	0,0434	0,0364		
	D2	0,0394	0,0000	0,0808	0,0351	0,0040	0,0030		
	D3	0,0269	0,0808	0,0000	0,0230	0,0703	0,0551		
	D4	0,0043	0,0351	0,0230	0,0000	0,0391	0,0321		
	D5	0,0434	0,0040	0,0703	0,0391	0,0000	0,0070		
	D6	0,0364	0,0030	0,0551	0,0321	0,0070	0,0000		Total
	Total	0,1504	0,1623	0,2562	0,1336	0,1638	0,1336		1

	Mij	Si	Rank
Government	D1	0,0161	2
Government	D2	-0,0257	5
Government	D3	0,0427	1
Government	D4	0,0131	3
Government	D5	-0,0273	6
Government	D6	-0,0189	4

Calculation of QD scores for the market stakeholder group (part 2).

The pages of the questionnaire are presented as slides

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Kenmerken respondent

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Op de volgende twee pagina's wordt u gevraagd naar persoonlijke kenmerken en kenmerken van de organisatie waarvoor u werkzaam bent. Voor de analyse van de onderzoeksresultaten is het van belang het perspectief mee te wegen waar vanuit uw bedrijf of uzelf opereert.

Voor welk type stakeholder bent u voornamelijk werkzaam?

○ Overheid
● Marktpartij

Op welk schaalniveau bent u vooral actief?

○ Internationaal
● Nationaal
○ Provinciaal
○ Lokaal

**Op welk van onderstaande werkterreinen bent u voornamelijk werkzaam? (meerdere antwoorden mogelijk)**

☑ Aanbesteding en Acquisitie
☐ Consultancy
☐ Financieel management
☐ Operationeel management
☐ Product ontwikkeling (diensten en services)
☐ Product ontwikkeling (apparatuur en faciliteiten)
☐ Project ontwikkeling
☐ Technisch management

| Vorige | **Volgende** |

2

Onderzoek: Ontwikkelingen in duurzaam parkeren

Kenmerken organisatie
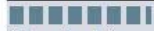
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Stelling: De organisatie waartoe ik behoor hanteert een actief duurzaamheidsbeleid.

Zeer mee oneens	Oneens	Neutraal	Eens	Zeer mee eens
○	●	○	○	○

Het duurzaamheidsbeleid van de organisatie waartoe ik behoor richt zich met name op: (meerdere antwoorden mogelijk)

- ☐ Grondstoffen (materiaal) gebruik
- ☐ Energie gebruik
- ☐ Afvalstromen
- ☐ Water gebruik
- ☐ Uitstoot van schadelijke stoffen
- ☑ Sociale verantwoordelijkheid

Stelling: Innovatie speelt een belangrijke rol binnen de organisatie waartoe ik behoor.

Zeer mee oneens	Oneens	Neutraal	Eens	Zeer mee eens
○	○	○	○	●

De innovatie binnen de organisatie waartoe ik behoor uit zich met name in: (meerdere antwoorden mogelijk)

- ☐ Interne processen
- ☑ Samenwerking met andere stakeholders
- ☑ Producten en diensten voor consumenten of burgers
- ☐ Producten en diensten voor commerciele organisaties

[Vorige]   [**Volgende**]

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Criteria

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In deze enquête worden u vragen gesteld over een aantal criteria. In onderstaande tabel vindt u omschrijvingen van de gebruikte criteria.

Criteria-groepen	Sub-criteria	Beschrijving sub-criteria
Impact op businessplan: financiële aspecten	Investeringskosten voor organisatie	Investeringskosten die gepaard gaan met adoptie van de ontwikkeling. (Ingeschat ten opzichte van normaal investeringspatroon).
	ROI: Return on Investment	De financiële toegevoegde waarde van een activiteit ten opzichte van de hiermee gepaard gaande kosten. Een hoge ROI geeft een hogere toegevoegde "winst" weer.
	Risico	De waarschijnlijkheid dat een negatief financieel effect zich binnen een bepaalde periode of onder bepaalde omstandigheden voordoet.
Impact op businessplan: controle	Invloed van de organisatie op de ontwikkeling	De mate van invloed die door een organisatie uitgeoefend kan worden op het proces en verschijningsvorm van een ontwikkeling.
	Invloed van ontwikkeling op het businessplan van organisatie	De mate van invloed die een ontwikkeling heeft op de manier waarop de organisatie opereert of omzet genereert.
Effect op mobiliteit	Verwacht effect op parkeervraag in binnenstad	De mate waarin een ontwikkeling de on- en offstreet parkeervraag van autoverkeer in de binnen stad beïnvloedt.
	Verwacht effect op doorstroming in binnenstad	De mate waarin een ontwikkeling de doorstroming van autoverkeer in de binnenstad beïnvloedt.
Effect op duurzaam parkeren en mobiliteit	Effect op energieverbruik	De mate waarin de ontwikkeling het energieverbruik van autoverkeer en faciliteiten gerelateerd aan de ontwikkeling beïnvloedt.
	Effect op aantal gereisde kilometers	De mate waarin de ontwikkeling het aantal gereisde kilometers van autoverkeer in de binnenstad beïnvloedt.
	Effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	De mate waarin de ontwikkeling de hoeveelheid vervuilende gassen en stoffen van autoverkeer beïnvloedt.

Vorige	Volgende

4

Onderzoek: Ontwikkelingen in duurzaam parkeren

Weging van criteria-groepen

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In onderstaande tabel wordt het gewicht van de criteria-groepen bepaald.Geef in de tabel aan welk van de criteria-groepen u belangrijker vindt of kies neutraal.

Situatie: Uw organisatie overweegt te investeren in een nieuwe ontwikkeling op het gebied van parkeren.

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Impact op businessplan: financiële aspecten	○	○	○	○	○	●	○	Effect op duurzaam parkeren en mobiliteit
Impact op businessplan: controle	○	○	○	○	○	●	○	Effect op mobiliteit
Effect op mobiliteit	○	●	○	○	○	○	○	Impact op businessplan: financiële aspecten
Impact op businessplan: financiële aspecten	○	○	○	○	●	○	○	Impact op businessplan: controle
Effect op mobiliteit	○	●	○	○	○	○	○	Effect op duurzaam parkeren en mobiliteit
Effect op duurzaam parkeren en mobiliteit	○	●	○	○	○	○	○	Impact op businessplan: controle

Betekenis symbolen:
0 Neutraal + Belangrijker ++ Veel belangrijker +++ Extreem belangrijk

| Vorige | | Volgende |

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Weging van afzonderlijke criteria

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In onderstaande tabel wordt het gewicht van de criteria bepaald. Geef in de tabel aan welk van de criteria u belangrijker vindt of kies neutraal.

Situatie: Uw organisatie overweegt te investeren in een nieuwe ontwikkeling op het gebied van parkeren.

Impact op businessplan: financiële aspecten

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Investeringskosten	○	○	○	○	○	●	○	ROI (Return on Investment)
Risico	○	○	○	○	○	●	○	Investeringskosten
ROI (Return on Investment)	○	●	○	○	○	○	○	Risico

Impact op businessplan: controle

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Invloed op ontwikkeling	○	○	○	○	●	○	○	Invloed van ontwikkeling op businessplan

Effect op mobiliteit

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Effect op parkeervraag binnenstad	○	○	●	○	○	○	○	Effect op doorstroming binnenstad

Effect op duurzaam parkeren en mobiliteit

<<<<<	+++	++	+	0	+	++	+++	>>>>>
Effect op aantal gereisde kilometers	○	○	○	○	○	●	○	Effect op hoeveelheid vervuiling
Effect op hoeveelheid vervuiling	○	●	○	○	○	○	○	Effect op energieverbruik
Effect op energieverbruik	○	●	○	○	○	○	○	Effect op aantal gereisde kilometers

Betekenis symbolen:
0 Neutraal + Belangrijker ++ Veel belangrijker +++ Extreem belangrijker

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Verduurzamen van bestaand parkeerareaal (thema: duurzaamheid)
Het vervangen van installaties en apparatuur door nieuwe duurzame oplossingen (b.v. LED, efficiëntere technologie) op on- en off-street parkeerlocaties.

Geef in onderstaande tabel uw verwachting aan. In de kolom <u>Overheid</u> uw inschatting van de stakeholder "overheid" en in de kolom <u>Marktpartij</u> uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Gemiddeld ▼	Hoog ▼
Verwacht Return on Investment voor organisatie	Laag ▼	Gemiddeld ▼
Verwacht risico voor organisatie	Laag ▼	Laag ▼

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Klein ▼	Gemiddeld ▼
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Klein ▼	Gemiddeld ▼

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Neutraal ▼	Neutraal ▼
Verwacht effect op doorstroming in binnenstad	Verhoging ▼	Verhoging ▼

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Verlaging ▼	Verlaging ▼
Verwacht effect op aantal gereisde kilometers	Verlaging ▼	Verlaging ▼
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Verlaging ▼	Verlaging ▼

[Vorige]   [**Volgende**]

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Onderzoek: Ontwikkelingen in duurzaam parkeren

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Realiseren van een laadnetwerk voor elektrisch aangedreven auto's (thema: alternatieve energiebronnen)
De plaatsing van laadstations op on- en off-street parkeerlocaties voor hybride en elektrisch aangedreven auto's zoals oplaadpunten en snel-laadstations.

Geef in onderstaande tabel uw verwachting aan. In de kolom Overheid uw inschatting van de stakeholder "overheid" en in de kolom Marktpartij uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Gemiddeld	Gemiddeld
Verwacht Return on Investment voor organisatie	Laag	Laag
Verwacht risico voor organisatie	Laag	Laag

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Klein	Klein
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Klein	Klein

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Neutraal	Neutraal
Verwacht effect op doorstroming in binnenstad	Neutraal	Neutraal

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Verlaging	Verlaging
Verwacht effect op aantal gereisde kilometers	Neutraal	Neutraal
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Verlaging	Verlaging

| Vorige | Volgende |

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Introductie van elektronische navigatie gecombineerd met betaalapplicatie (thema: invloed van ICT)

Een elektronische navigatie en betaalapplicatie van gemeenschappelijke betalingsproviders biedt parkeerders de mogelijkheid om te navigeren naar een beschikbare on- of off-street parkeer locatie, te reserveren en contactloos het parkeertarief te betalen.

Geef in onderstaande tabel uw verwachting aan. In de kolom Overheid uw inschatting van de stakeholder "overheid" en in de kolom Marktpartij uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Gemiddeld	Gemiddeld
Verwacht Return on Investment voor organisatie	Gemiddeld	Hoog
Verwacht risico voor organisatie	Laag	Laag

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Gemiddeld	Gemiddeld
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Gemiddeld	Groot

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Verhoging	Verhoging
Verwacht effect op doorstroming in binnenstad	Verhoging	Verhoging

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Neutraal	Neutraal
Verwacht effect op aantal gereisde kilometers	Verlaging	Verlaging
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Verlaging	Verlaging

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Toename van het aantal P+R en K+R gebieden ten behoeve van Car-Sharing (thema: Car-Sharing)

Ten behoeve van Car-Sharing initiatieven neemt het aantal Park and Ride (P+R) en Kiss and Ride (K+R) gebieden met gunstige tarieven en voorzieningen toe.

Geef in onderstaande tabel uw verwachting aan. In de kolom <u>Overheid</u> uw inschatting van de stakeholder "overheid" en in de kolom <u>Marktpartij</u> uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Hoog	Laag
Verwacht Return on Investment voor organisatie	Laag	Laag
Verwacht risico voor organisatie	Gemiddeld	Laag

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Gemiddeld	Klein
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Gemiddeld	Klein

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Verlaging	Verlaging
Verwacht effect op doorstroming in binnenstad	Verhoging	Verhoging

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Verlaging	Verlaging
Verwacht effect op aantal gereisde kilometers	Verlaging	Verlaging
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Verlaging	Verlaging

Vorige   **Volgende**

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Invoeren van flexibele parkeernormen (thema: parkeernormen locatie specifiek)
Het invoeren van flexibele parkeernormen die sterk gerelateerd zijn aan de functie, het gebruik en de configuratie van de stedelijke bebouwing in de directe omgeving.

Geef in onderstaande tabel uw verwachting aan. In de kolom <u>Overheid</u> uw inschatting van de stakeholder "overheid" en in de kolom <u>Marktpartij</u> uw inschatting van de commerciële stakeholder: parkeerexploitant die onder "markt" geschaard wordt

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Laag	Laag
Verwacht Return on Investment voor organisatie	Laag	Laag
Verwacht risico voor organisatie	Laag	Laag

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Groot	Klein
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Groot	Groot

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Neutraal	Neutraal
Verwacht effect op doorstroming in binnenstad	Verhoging	Verhoging

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Verlaging	Verlaging
Verwacht effect op aantal gereisde kilometers	Verlaging	Verlaging
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO_2, NOX)	Verlaging	Verlaging

Vorige   Volgende

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Wijziging van functies in binnenstedelijke gebieden ten gevolge van krimp en internetwinkels (thema: functiewijziging van gebieden)
Het aantal panden in binnenstedelijke gebieden met een winkelfunctie neemt af ten gevolge van krimp en internetshopping.

Geef in onderstaande tabel uw verwachting aan. In de kolom <u>Overheid</u> uw inschatting van de stakeholder "overheid" en in de kolom <u>Marktpartij</u> uw inschatting van de commerciële stakeholders die onder "markt" geschaard worden

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	Laag	Laag
Verwacht Return on Investment voor organisatie	Laag	Laag
Verwacht risico voor organisatie	Hoog	Hoog

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	Klein	Klein
Verwachte invloed van ontwikkeling op het businessplan van organisatie	Groot	Groot

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	Verlaging	Verlaging
Verwacht effect op doorstroming in binnenstad	Verhoging	Verhoging

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	Verlaging	Verlaging
Verwacht effect op aantal gereisde kilometers	Verlaging	Verlaging
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO2, NOX)	Verlaging	Verlaging

Vorige   Volgende

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Onderzoek: Ontwikkelingen in duurzaam parkeren

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Ontwikkeling naar keuze

Welke belangrijke ontwikkeling onbreekt in uw ogen op voorgaande pagina's en zou u graag willen beoordelen? Omschrijf deze ontwikkeling in onderstaand tekstveld.

| |

Geef in onderstaande tabel uw verwachting aan. In de kolom Overheid uw inschatting van de stakeholder "overheid" en in de kolom Marktpartij uw inschatting van de commerciële stakeholders die onder "markt" geschaard worden

Impact op businessplan: financiële aspecten	Overheid	Marktpartij
Verwachte investeringskosten voor organisatie	▾	▾
Verwacht Return on Investment voor organisatie	▾	▾
Verwacht risico voor organisatie	▾	▾

Impact op businessplan: controle	Overheid	Marktpartij
Verwachte invloed van de organisatie op de ontwikkeling	▾	▾
Verwachte invloed van ontwikkeling op het businessplan van organisatie	▾	▾

Effect op mobiliteit	Overheid	Marktpartij
Verwacht effect op parkeervraag in binnenstad	▾	▾
Verwacht effect op doorstroming in binnenstad	▾	▾

Effect op duurzaam parkeren en mobiliteit	Overheid	Marktpartij
Verwacht effect op energieverbruik	▾	▾
Verwacht effect op aantal gereisde kilometers	▾	▾
Verwacht effect op hoeveelheid vervuilende gassen en stoffen (CO_2, NOX)	▾	▾

| Vorige | **Volgende** |

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Onderzoek: Ontwikkelingen in duurzaam parkeren

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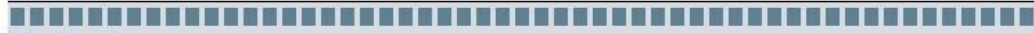
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Dank voor uw deelname aan deze enquête.

Heeft u nog opmerkingen met betrekking tot deze enquete of het onderwerp "duurzaam parkeren"?

Indien u wenst, kunt u de resultaten van het onderzoek toegestuurd krijgen. Om op de hoogte te blijven kunt u uw e-mail adres in het tekst vak achter laten.

Met vriendelijke groet,
Niels Weterings

Verzend

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Dank voor uw deelname aan de enquête.

Deze enquête is onderdeel van het afstudeeronderzoek "**Decision making of governmental and commercial stakeholders in the context of sustainable parking**" aan de Technische Universiteit Eindhoven (TU/e), master opleiding 'Construction Management and Engineering'. Daarnaast maakt het onderzoeksproject deel uit van Kenwib (**K**enniscluster **E**nergie-**N**eutraal **W**onen en **W**erken in **B**rabant).

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Drs. V. (Vladan) Jankovic RA   (CEO Pink and Nelson b.v.)
Prof. Dr. Ir. W.F. (Wim) Schaefer   (Chairman CME and graduation committee TU/e)

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KENWIB
Website: http://www.kenwib.nl/
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16

TOWARDS SUSTAINABLE PARKING:
decision making of governmental and commercial stakeholders
Author: N.P.A. Weterings

ABSTRACT
Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility. Recently, attention is growing on sustainability in relation with parking. As a result, the parking industry and government are embracing a large number of developments. In order to successfully cooperate in projects, municipalities and parking operators should focus on the most promising developments. MDCA and AHP provide decision criteria which are used to evaluate six important sustainable developments in parking. The final ranking of developments results in a first priority for 'introduction of electronical navigation, way finding and payment systems' by both stakeholder groups.

Keywords: Parking, Decision making, Sustainability, MCDA, Analytic Hierarchy Process.

INTRODUCTION
Mobility in general, and car usage in particular have a negative impact on the environment due to the use of (fossil) fuels, and the emissions of particulate matter [fijnstof] and exhaust gasses including CO_2 (Q-Park NV, 2012a). The energy consumption in urban districts, related to traffic and mobility, accounts for almost 20% of the total of energy use in the urban environment (Energiebureau.nl).

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility: in 27 European countries the transport sector is responsible for 19% of the greenhouse gas emission. The situation in the Netherlands is even more extreme: the transport sector is responsible for 35% of the total emission. Overall, the transportation sector is responsible for 30% of all fossil fuel emissions in the European Union (European Union, 2007).

Parking is an important aspect of mobility in the context of the urban environment. Parking facilities, as elements of the built environment, provide users with spaces for their cars nearby their destinations. As a result, it affects urban planning, spatial use, the convenience of transportation and sustainability of the city is growing. Recently, attention on sustainability in relation with parking. For example way finding to a parking space: "On a daily basis, it is estimated that 30% of vehicles on the road in the downtown area of major cities are cruising for a parking spot and it takes an average of 7.8 minutes to find one" (Arnott, et al., 2005). As a result, the parking industry and government is embracing a large number of developments ranging from sustainable innovations to environmental policy in the context of parking.

In general, four types of sustainable developments exist (van der Waerden, 2012; Farla, et al., 2010; Q-Park NV, 2012a):

1. Sustainability by technological improvement of personal vehicles;
2. Sustainability by construction of sustainable buildings;
3. Sustainability by improving the efficiency of traffic and way finding;
4. Sustainability by mobility and parking policy.

Decision making
The increase of traffic congestion combined with a societal focus on environment and sustainability, lead to challenges in how mobility and parking have to be managed. For example, municipalities are eager to reduce traffic congestion for the improvement of the quality of life by solving problems related to pollution and noise (Giuffrè, et al., 2012). Governmental bodies like municipalities, national governments and the European Union have "an important role to play in building a system of sustainable mobility, through regulatory policies, and strategic incentives and disincentives" (Vergragt & Brown, 2007).

A market party's willingness to embrace developments and innovation towards a more sustainable society is a function of the following aspects: its attitude towards cleaner technology (based on the party perception of environmental and economic risks); the pressure that the party perceives itself to be under; and the control the firm believes it actually has over the innovation of cleaner technologies (Montalvo, 2002).

Problem statement
Given the indicated developments; differences of interests; and governmental policies in the field of mobility and parking, it is difficult for cooperating stakeholders to choose, invest in, or predict the effects of (long term) sustainable developments. In order to successfully cooperate in a project, individual actors should be able to predict preferences and decision making of partners and competitors. Therefore, an analysis of attributes, characteristics, and decision criteria is required in order to enable stakeholders to anticipate in future developments. The problem statement is divided in two parts which are presented below.

1.   The aspects, characteristics, and attributes of developments in the context of sustainable mobility are not clear. Most effects on mobility and sustainability are assumed but not quantified in detail.

2.   Actors in mobility and parking embrace specific developments in the context of sustainable parking, but also need the cooperation of other stakeholders. Therefore, the most promising developments according to decision makers are required. A ranking of sustainable developments in parking is currently not available.

Relevance
As far as the author knows, limited scientific research is available regarding the decision making in and evaluation of multiple sustainable developments in the field of parking. Limited literature is available on decision making in parking (e.g. Litman, 2013; May, 2003) and decision making regarding sustainable innovations (e.g. Montalvo, 2002). On the other hand, sustainable developments are individually assessed by researchers (e.g. Bakker, 2011; Dijk & Montalvo, 2011; Giuffrè, et al., 2012). A certain combination of both approaches could not be found during the preparation of this research.

This research aims to find criteria to compare and evaluate sustainable developments in parking with respect to the decision making process. Besides insight in criteria, developments could be evaluated using these criteria and help to select the most promising developments.

The parking industry continuously adopts new innovations and developments in parking (KpVV, 2013). Generally, these developments are initiated by financial benefits (efficiency), technological innovation, societal change or policy by legislators (e.g. Farla, et al., 2010; VROM, 2010; Montalvo, 2002).

In order to decide which developments should be implemented in business planning, developments have to be prioritized according to the stakeholders' interest. As stated in this introduction, governmental and market parties influence decision making in parking. Therefore, it is necessary to find the influential criteria, current developments in parking and priorities of both stakeholder groups. Comparing these priorities, should provide the parking industry insight in the most interesting developments that are supported by both stakeholders. Consensus on priority could ease the decision making process and improve the financial benefits en outcome of adopted developments.

METHODS

The main question in this research is: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"

In order to answering the central question four sub-questions have been defined: Which stakeholders are involved in the decision making process regarding to sustainable parking?; Which criteria can be used to evaluate developments regarding sustainable parking?; What are important developments in the context of sustainable parking?; What is the importance of selected criteria regarding developments in sustainable parking? T

Research Framework

An extensive review of literature is considered the start of this research (Phase 1). It provides background information on the subjects parking, sustainability in parking, and decision making. Besides a description of the subjects and relevant mechanisms, the literature review is conducted to identify a number of current sustainable developments in parking; important stakeholders and their incentives, and decision criteria. These three elements will be used as key ingredients for the used research method in the next phase and answer the first three sub-questions.

Decision making in parking by governmental and commercial stakeholders is a complicated process. Together, parking operators and municipalities, led by specific incentives, decide over new developments in sustainable parking. An Analytic Hierarchy Process decision framework is built to capture decision criteria with respect to both stakeholders (Phase 2). The framework is used as a base for the next steps in the research. The second phase consists of Multi Criteria Decision Analysis (MCDA) based on the methods included in Analytic Hierarchy Process (AHP). Qualitative Dominance scores (QD) are used to synthesize the results.

By using MCDA, multiple criteria of alternatives can be considered comprehensively. The method combines criteria weights and evaluation scores of alternatives, resulting in a general value for each alternative. In order to find the criteria weights AHP is adapted to a specific quantitative form of multi criteria analysis. QD is used to evaluate the developments, on a qualitative base.

An on-line questionnaire is used to gather data from governmental and commercial stakeholders in parking. Experts, working for both stakeholder groups, are asked to complete the questionnaire in which criteria weights are determined and developments are evaluated. After the synthesis and analysis of data results are available and developments are prioritized.

In the finalization phase (Phase 3) results from the literature review and Multi Criteria Decision Analysis are used to answer the research questions. Recommendations for practice and science will show the relevance of the research findings for both fields.
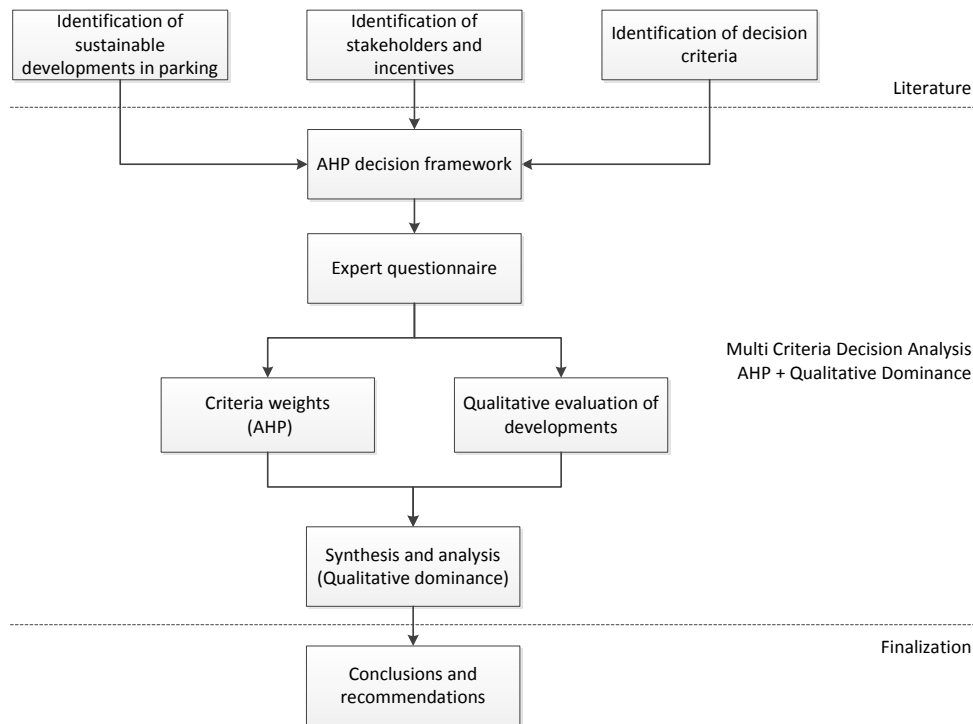
Figure 1: Research framework

FINDINGS

The results of the application of the research framework (figure 1) are presented in this section. First, the results from the review of literature, the selection of stakeholders, developments and criteria, are presented. Next, the criteria weights are established using the analytic hierarchy process and an example of a development evaluation is provided. Finally, Qualitative dominance scores provide a ranking of developments for governmental and commercial stakeholders.

Review of literature

Extensive review of literature took place to find the most important decision makers in parking that influence sustainable developments. Next, criteria are elaborated which enable one to evaluate developments. Finally, six development are presented which are evaluated in by the experts using a questionnaire.

Selection of stakeholders

Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking. Municipalities (Government) enforce parking policy and Parking operators (market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved. Generally speaking, decision making in parking is controlled by the government who develops policy and market parties that perform activities with facilities, services or products related to parking. Two parties decide directly on the implementation of new developments in sustainable parking: Municipalities (government) and parking operators (market). Other stakeholders, for example investors, are indirectly involved in this process. The direct and indirect relationships to the subject are presented in figure 2. As a result of this analysis, this research focuses on municipalities and parking operators.
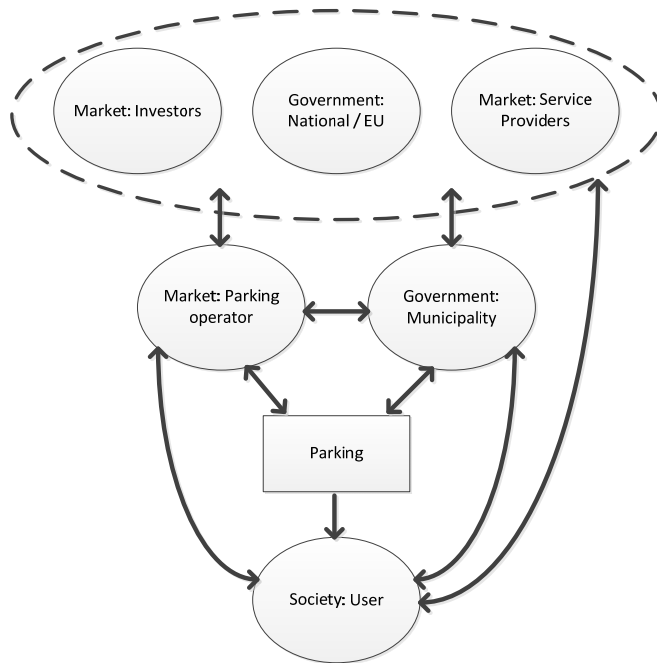
Figure 2: Relationships between stakeholders

Selection of developments

The developments are categorized by type of sustainable development as suggested in the introduction. A recent publication (KpVV, 2013) about noteworthy developments in parking provided six important developments. These developments are described below and reflect on a theme of suggested by the KpVV publication (2013).

1.   Improving the sustainability of the existing parking stock (Theme: Sustainability): Replacement of facilities and equipment by new and more sustainable solutions, e.g. LED, innovations and efficient technology, at on-street and off-street parking locations;

2.   Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources): A charging network at on-and off-street parking locations is introduced for hybrid and electric cars such as low and high voltage charging stations;

3.   Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT): An electronic navigation and payment processing application introduced by payment providers offers customers the ability to navigate to an available on-or off-street parking location, to make a reservation and pay wireless;

4.   Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing): The number of Park and Ride (P + R) and Kiss and Ride (K + R) areas with favorable rates and services increases for the purpose of Car-Sharing initiatives;

5.   Introducing policy in order to enable flexible parking standards (Theme: location specific parking standards): The introduction of flexible parking standards which are strongly related to the function, the use and configuration of urban buildings in the immediate vicinity;

6.   Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment): The number of properties in inner city areas with a store function decreases due to shrinkage and internet shopping.

Selection of criteria
Review of literature showed that multiple decision criteria are available that represent stakeholders' incentives, sustainable goals in society, en presumed effects of developments. In this research, potential sustainable developments are evaluated to find differences and similarities in opinion between stakeholders.

Selection rules are used to find the most important criteria involved in the assessment of the developments in parking: criteria should be applicable to evaluate all types of developments; criteria represent incentives of both stakeholder groups; and vagueness of criteria has to be prevented. Payoff and outcomes of developments related to the decision criteria can be divided as impacts and effects. An 'impact' is described as the influence that something has on a situation or person. While 'effect' describes a more direct and intended result of a development.

The two definitions described above help to define the final decision criteria for this research. Impact criteria are used to describe the impact on the stakeholders' business plan: the 'financial aspects' and 'control aspects' that may be affected by the developments. On the other hand, effect criteria, are used to describe the outcome of a development regarding mobility and sustainability. The criteria, presented and described below, are selected from business planning and control criteria, policy criteria and EMAT criteria for parking (3).

Financial Aspects			Control Aspects	
Investment costs for organization	ROI for organization	Risk for organization	Influence of organization on development	Influence of development on business plan
Government: 0,0875	**Government:** 0,0882	**Government:** 0,0892	**Government:** 0,1219	**Government:** 0,1048
Market: 0,0887	**Market:** 0,0913	**Market:** 0,0909	**Market:** 0,1277	**Market:** 0,1095

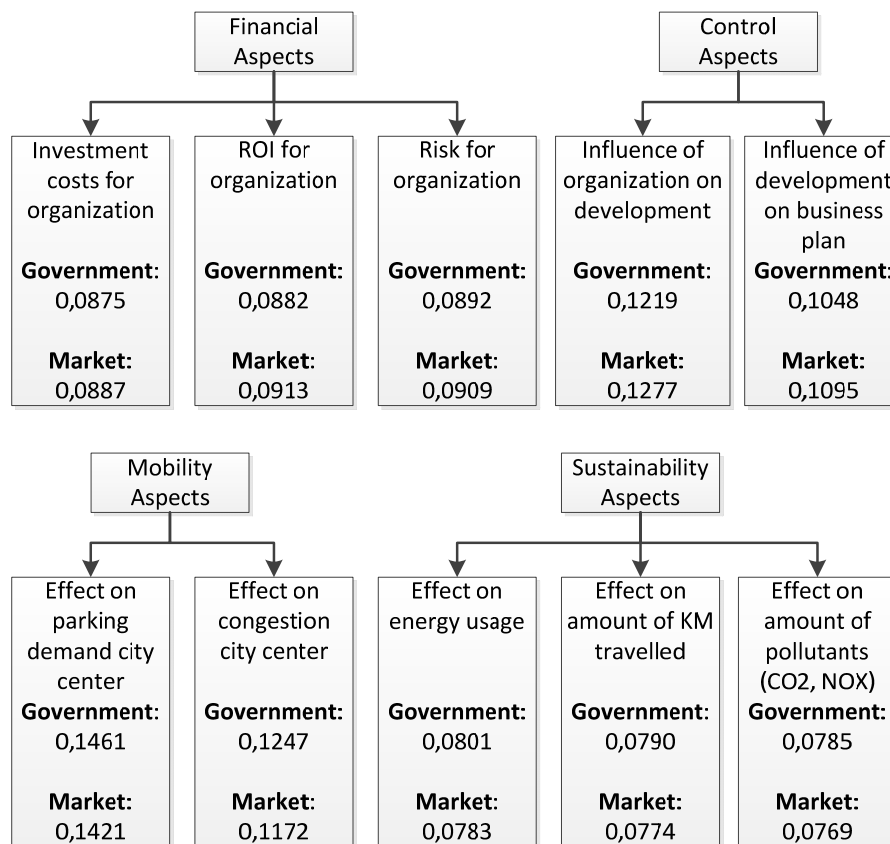| Mobility Aspects		Sustainability Aspects		
Effect on parking demand city center	Effect on congestion city center	Effect on energy usage	Effect on amount of KM travelled	Effect on amount of pollutants (CO2, NOX)
Government: 0,1461	**Government:** 0,1247	**Government:** 0,0801	**Government:** 0,0790	**Government:** 0,0785
Market: 0,1421	**Market:** 0,1172	**Market:** 0,0783	**Market:** 0,0774	**Market:** 0,0769

Figure 3: Hierarchy containing criteria and weights by government and market

Analysis

The approached expert respondents are selected from a group of decision makers from municipalities and parking operators. A third group, 'Consultants', was targeted which experts provide services to both key decision makers. A total of 109 respondents was approached. Approximately, 30% of the respondents finished the questionnaire. 45% of the respondents provided results that are usable for the prioritization of criteria. Background variables confirm that the majority of the experts are considered decision makers given their working field and professional activities.

AHP analysis is performed to find the weights of the decision criteria. First, a consistency check is carried out on the individual datasets of the questionnaire. It appeared, a consistency index of 0,15 is necessary to incorporate at least 10 respondents per stakeholder group. The AHP analysis on the stakeholder groups results in criteria weights (figure 3) that slightly differ from each other. Small differences in priority are presented for the 'criteria-groups', 'control aspects' and 'mobility aspects'. On criteria-group level, municipalities prefer the 'effect on mobility' above others while parking operators consider 'financial aspects' of more importance. Consensus is reached for 'control aspects'. The 'influence of the organization on the development is considered more important compared to the 'influence of the development on the business plan'. It emerged from the results for 'mobility aspects' that both stakeholder groups consider 'effect on parking demand in city center' more significant compared to 'effect on congestion in city center'.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organization	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Figure 4: Example of evaluation scores: introduction for electronic navigation, way finding and payment systems.

By combining the criteria weights (figure 3) and modes of the evaluation scores (figure 4) for these criteria. The Qualitative Dominance scores (QD scores) are calculated. The QD scores (figure 5) for the governmental and market stakeholder result in a first priority for 'introduction of electronical navigation, way finding and payment systems'. 'Introducing policy in order to enable flexible parking standards' is prioritized second for the governmental stakeholder followed by 'improving the sustainability of the existing parking stock. The latter is prioritized second by the market stakeholder. A third position is given to 'increasing number of P+R and K+R areas in order to support car-sharing'.

Development (prioritized by government)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0496	1
Introducing policy in order to enable flexible parking standards	0,0054	2
Improving the sustainability of the existing parking stock	-0,0019	3
Increasing number of P+R and K+R areas in order to support Car-Sharing	-0,0022	4

Developments (prioritized by market)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0427	1
Improving the sustainability of the existing parking stock	0,0161	2
Increasing number of P+R and K+R areas in order to support Car-Sharing	0,0131	3
Increasing number of functional changes in inner city built environ-ment as a result of demographic change and internet shopping	-0,0189	4

Figure 5: Ranking of developments by QD scores for stakeholder groups

DISCUSSION

The selection of decision criteria and sustainable developments in parking are important results from this research. The selected criteria can be used to evaluate and characterize sustainable developments. The results, summarized in the previous paragraph, answer the sub-questions in this research. These sub-questions provide the basic elements that are required to conclude on the main question in this research: *"What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"*

The results of this research (figure 5) showed which developments regarding sustainable parking are preferred most by the governmental stakeholder group (represented by decision makers of municipalities) and the market stakeholder group (represented by decision makers of parking operators). The rankings of developments by both stakeholder groups show the 'introduction of elektronical navigation, way finding and payment systems' as highly preferred. The prioritizations confirms the high number of related developments the parking industry such as the integration of parking information, mobile payment services and reservation services of parking operators.

On one hand, this research showed which developments are most promising regarding both stakeholder groups. On the other, the evaluation of the developments provide underlying criteria scores that affected the final prioritization. These underlying expectations of decision makers could be considered as strengths and weaknesses for the implementation of sustainable developments in parking.

REFERENCES

Arnott, R., Rave, T. & Schob, R., 2005. *Alleviating Urban Traffic Congestion.* Cambridge, USA: MIT Press..

Dijk, M. & Montalvo, C., 2011. Policy frames of Park-and-Ride in Europe. Volume 19, pp. 1106-1119.

European Union, 2007. *Commission plans legislative framework to ensure the EU meets its target for cutting CO2 emissions from cars,* Brussels, Belgium: European Union.

Farla, J., Alkemade, F. & Suurs, R., 2010. Analysis of barriers in the transition toward sustainable mobility in the Netherlands. *Technological Forecasting and Social Change 77*, pp. 1260-1269.

Giuffrè, T., Siniscalchi, S. & Tesoriere, G., 2012. A Novel Architecture of Parking Management for Smart Cities. *Procedia- Social and Behavioral Sciences,* Volume 53, pp. 16-28.

Kennisplatform Verkeer en Vervoer (KpVV), 2013. *Parking policy in the medium term [NL: Parkeerbeleid op de middellange termijn: maatschappelijke trends en de toekomst van parkeren],* Ede, the Netherlands: Kennisplatform Verkeer en Vervoer.

Litman, T., 2013. Parking management, comprehensive implementation guide. *Victoria Transport Policy Institute.*

May, A., 2003. *Developing Sustainable Urban Land Use and Transport Strategies: A Decision Makers' Guidebook,* Brussels, Belgium: Procedures for Recommending Optimal Sustainable planning of European City Transport Systems (PROSPECTS).

Ministry of Infrastructure and Environment (VROM), 2010. *Information for sustainable procurement of Parking,* Den Haag,the Netherlands: Ministry of Infrastructure and Environment (VROM).

Montalvo, C., 2002. *Environmental Policy and Technological Innovation: why do firms adopt or reject new technologies?.* Cheltenham, United Kingdom: Edward Elgar.

Q-Park NV, 2012a. *Responsible Parking 2011,* Maastricht, the Netherlands: Q-Park NV.

Saaty, T., 1980. *The Analytic Hierarchy Process.* New York, USA: McGraw-Hill.

Vergragt, P. & Brown, H., 2007. Sustainable mobility from technological innovation to societal learning. *Journal of Cleaner Production,* 15(11-12), pp. 1104-1115.

Waerden, P. v. d., Timmermans, H. & Barzeele, P., 2011. Car Drivers' Preferences Regarding Location and Contents of Parking Guidance Systems: Stated Choice Approach. Volume 2245, pp. 63-69.

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"Parking involves elements of real estate management, urban development, process management and technology. The topic is very interesting regarding the scope of CME."

2004 – 2012   Bachelor Architecture Building and Planning
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OP WEG NAAR DUURZAAM PARKEREN:
beslissingsgedrag van overheids- en markt partijen
Auteur: N.P.A. Weterings

Afstudeer richting:
Construction Management and Engineering 2013

Afstudeercommissie:
Prof. Dr. Ir. W.F. Schaefer
Dr. Ing. P.J.H.J. van der Waerden
Drs. V. Jankovic RA

Afstudeerdatum:
31-08-2013

Samenvatting
Duurzaamheid van de stedelijke omgeving is zeer afhankelijk van vervuiling en emissies die veroorzaakt worden door mobiliteit. De laatste jaren groeit de aandacht voor duurzaamheid in relatie tot parkeren. Als gevolg, implementeren en ondersteunen de overheid en parkeer industrie een groot scala aan duurzame ontwikkeling. Om succesvol samen te kunnen werken in projecten die als doel hebben parkeren duurzamer te maken, moeten gemeenten en parkeerexploitanten samen inzetten op de meest kansrijke ontwikkeling. Binnen dit onderzoek wordt MCDA en AHP gebruikt om zes belangrijke duurzame parkeerontwikkelingen aan de hand van criteria te beoordelen. Dit resulteert in een prioritering waarbij 'introductie van navigatie gecombineerd met betaalapplicatie' als belangrijkste duurzame ontwikkeling wordt gezien door de stakeholder groepen overheid en markt partijen.

Steekwoorden: Parkeren, Beslissingsgedrag, Duurzaameheid, MCDA, Analytic Hierarchy Process.

INTRODUCTIE

De duurzaamheid van de stedelijke omgeving is zeer afhankelijk van vervuiling en uitstoot die wordt veroorzaakt door mobiliteit. De transport sector is verantwoordelijk voor 19% van de uitstoot van broeikasgassen in de 27 landen van de Europese Unie. Parkeren is een belangrijk aspect van mobiliteit in de bebouwde omgeving. Parkeer faciliteiten bieden binnen de deze omgeving gebruikers parkeerruimte voor auto's dichtbij de bestemming en bieden daarnaast overheids- en marktpartijen een bron van inkomsten. Parkeer activiteiten bevinden zich in het publieke domein (on-street) en private domein (off-street) in garages, parkeerterreinen of op straat.

De laatste tijd groeit de belangstelling met betrekking tot duurzaamheid in relatie met parkeren. Als gevolg omarmt de parkeer industrie en overheid een groot aantal ontwikkelingen. Deze ontwikkelingen variëren van de implementatie van duurzame innovaties tot duurzaamheidsbeleid in relatie tot parkeren. De focus in dit onderzoek ligt bij recente ontwikkelingen in de context van duurzaam parkeren.

Algemeen beschouwd bestaan er vier typen duurzame ontwikkelingen m.b.t. parkeren:

1. Duurzaamheid door technische ontwikkelingen met betrekking tot elektrische auto's;
2. Duurzaamheid door het ontwikkelen van energie neutral gebouwen;
3. Duurzaamheid door de efficiency van vervoer en het zoekverkeer te verbeteren;
4. Duurzaamheid door transport en mobiliteitsbeleid.

Beslissingsgedrag

De toename van verkeerscongestie gecombineerd met maatschappelijke focus op het milieu, leidt tot uitdagingen met betrekking tot de manier hoe mobiliteit en parkeren zijn georganiseerd. Gemeenten richten zich bijvoorbeeld op het verminderen van problemen als verkeerscongestie om de kwaliteit van de leefomgeving te verbeteren. Overheidsinstituten zoals gemeenten, nationale overheid en de Europese Unie spelen een belangrijke rol in het verduurzamen van het mobiliteitssysteem door gebruik te maken van regulerend beleid, stimulerings- en beperkende maatregelen.

De bereidheid van een marktpartij om ontwikkelingen en innovatie te omarmen die een duurzamere samenleving als doel hebben is afhankelijk van verschillende factoren namelijk: De houding ten opzichte van een schonere technologie (gebaseerd op de perceptie van milieu en economische risico's) en de controle die het bedrijf over een innovatie denkt te hebben.

Onderzoeksprobleem

Vanwege het hoog aantal ontwikkelingen, verschillen in belang en overheidsbeleid is het zeer lastig voor samenwerkende stakeholders om een keuze te maken voor, te investeren in en om (lange termijn) effecten in te schatten van duurzame ontwikkelingen die zich richten op parkeren. Om die reden is het belangrijk vast te stellen welke ontwikkeling volgens beide stakeholders het meest veelbelovend zijn. Op dit moment is er namelijk geen prioriteitenlijst met betrekking tot duurzame ontwikkelingen in het parkeren beschikbaar.

ONDERZOEKSMETHODE

Tijdens het onderzoek is een onderzoeksmodel ontwikkeld om de hoofd onderzoeksvraag te beantwoorden: *'Wat zijn de meest belangrijke ontwikkelingen met het oog op duurzaam parkeren volgens beslissingsnemers bij overheden en marktpartijen?'.* Dit model is zichtbaar als figuur 1.
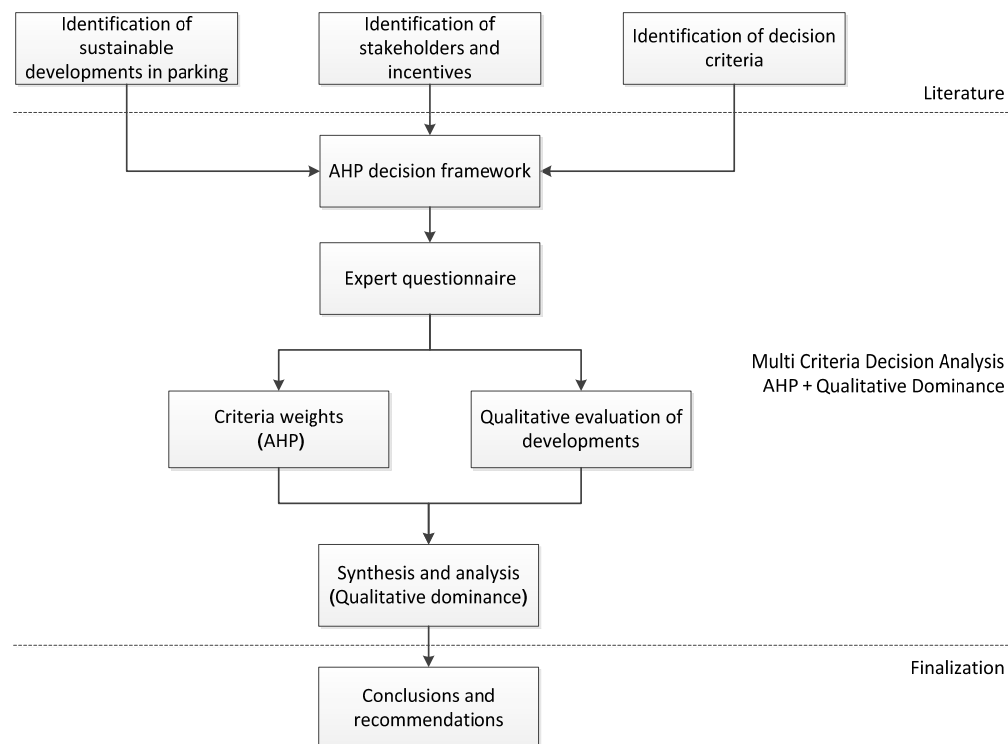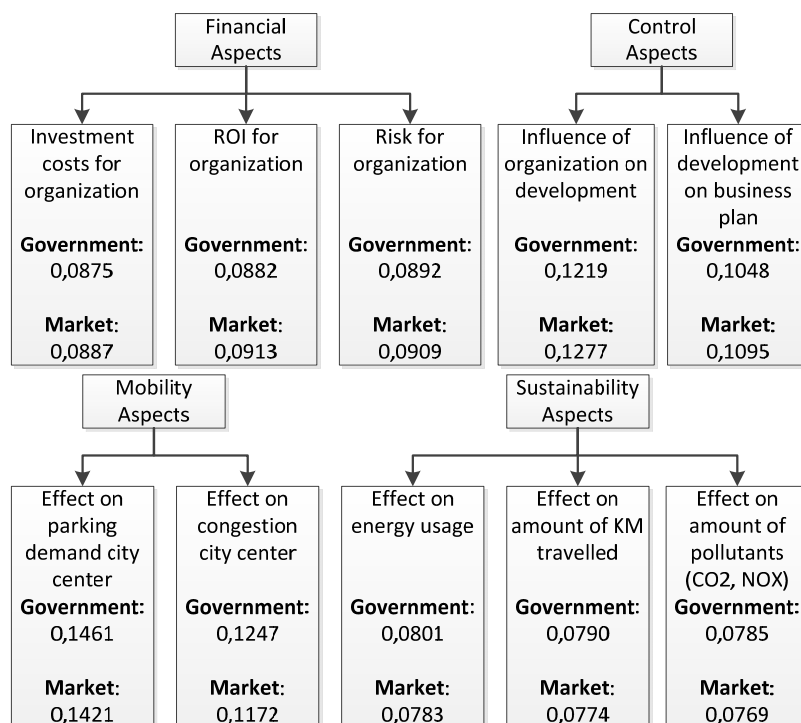

Figuur 1: Onderzoeksmodel

Een literatuur onderzoek levert informatie op over de meest belangrijke actoren in het beslissingsproces, beslissingscriteria en recente ontwikkelingen ten aanzien van de vier categorieën duurzame ontwikkelingen die in de introductie zijn genoemd. De belangrijkste methode binnen dit onderzoek is Multi Criteria Decision Analysis (MCDA). Deze evaluatie methode combineert criteria gewichten met evaluatie scores. Om de gewichten te vinden wordt gebruik gemaakt van Analytical Hierarchy Process (AHP). Met deze methode wordt van beslissingsnemers in het parkeren gevraagd om beslissingscriteria met paarsgewijze vergelijkingen te prioriteren. Daarnaast wordt in de online enquête experts, die werken voor de belangrijkste actoren in het beslissingsproces, gevraagd om de geselecteerde ontwikkelingen kwalitatief te scoren. Tenslotte worden gewichten en evaluatiescores gecombineerd door gebruik te maken van Qualitative Dominance (QD) scores opdat een prioritering van ontwikkelingen volgens de twee stakeholdergroepen mogelijk is.

RESULTATEN

Stakeholders in parkeren kunnen verdeeld worden in de groepen 'overheid', 'markt', en 'samenleving'. De eerste twee stakeholdergroepen zijn met name verantwoordelijk in het beslissingsproces. Gemeenten (overheid) maken gebruik van parkeerbeleid terwijl parkeerexploitanten parkeerfaciliteiten exploiteren en facilitaire diensten leveren. De samenleving (met name gebruikers) is juist indirect bij het beslissingsproces betrokken.

Gemeenten en parkeerexploitanten worden gezien als de meest belangrijke actoren in het beslissingsproces. Binnen het proces rond de ontwikkeling van parkeren beleid of het voeren van een onderneming, gebruiken deze twee actoren financiële en controle aspecten bij het beoordelen van ontwikkelingen.

Beslissingscriteria, die met behulp van de literatuurstudie zijn gevonden, kunnen worden verdeeld in vier groepen. De criteria groep 'financiële aspecten' bestaat uit drie sub-criteria: 'investeringskosten'; 'Return on Investment' en 'Risico'. De groep 'controle aspecten' bestaat uit twee sub criteria: 'invloed van de organisatie op de ontwikkeling' en 'invloed van de ontwikkeling op het business plan van de organisatie'. De derde criteria-groep 'mobiliteitsaspecten' bestaat uit sub-criteria 'effect op parkeervraag in binnenstad' en 'effect op de doorstroming van de binnenstad'. Tot slot de criteria groep 'duurzaamheidsaspecten'. Deze groep bestaat uit het 'effect op energie gebruik', het 'effect op het aantal gereisde kilometers' en 'effect op de hoeveelheid vervuilende stoffen. De criteria zijn ingedeeld in een AHP hiërarchie. Uit de AHP analyse blijkt dat in het algemeen slechts kleine verschillen zichtbaar zijn tussen de twee stakeholder groepen 'overheid' en 'markt'. De indeling en gewichten die volgen uit de analyse van de onderzoeksresultaten is zichtbaar in figuur 2.

Financial Aspects

Investment costs for organization	ROI for organization	Risk for organization
Government: 0,0875	Government: 0,0882	Government: 0,0892
Market: 0,0887	Market: 0,0913	Market: 0,0909

Control Aspects

Influence of organization on development	Influence of development on business plan
Government: 0,1219	Government: 0,1048
Market: 0,1277	Market: 0,1095

Mobility Aspects

Effect on parking demand city center	Effect on congestion city center
Government: 0,1461	Government: 0,1247
Market: 0,1421	Market: 0,1172

Sustainability Aspects

Effect on energy usage	Effect on amount of KM travelled	Effect on amount of pollutants (CO2, NOX)
Government: 0,0801	Government: 0,0790	Government: 0,0785
Market: 0,0783	Market: 0,0774	Market: 0,0769

Figuur 2: Hiërarchie van criteria en bijbehorende gewichten voor 'overheid' en 'markt'.

Tijdens het onderzoek zijn zes ontwikkelingen geselecteerd aan de hand van recente en interessante thema's die op dit moment actueel zijn in de parkeer industrie. Deze ontwikkelingen zijn: 'het verbeteren van de duurzaamheid van het bestaande parkeer areaal'; 'Het ontwikkelen van laadnetwerken voor elektrisch aangedreven auto's; 'de introductie van navigatie gecombineerd met betaalapplicatie'; 'toename van het aantal P+R en K+R gebieden ten behoeve van Car-Sharing'; 'Invoeren van flexibele parkeernormen'; en 'wijziging van functies in binnenstedelijke gebieden ten gevolge van krimp en internetwinkels'. Al deze ontwikkelingen zijn in de enquête door de respondenten

geëvalueerd. De modus geeft informatie over het groepsoordeel zoals zichtbaar is in figuur 3. De gewichten en evaluatie scores per ontwikkeling worden gecombineerd in Qualitative Dominance scores (figuur 4).

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organization	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Figuur 3: Voorbeeld: evaluatie scores van 'introductie van navigatie gecombineerd met betaalapplicatie'.

DISCUSSIE

Het onderzoek maakt duidelijk welke stakeholders een belangrijke rol spelen in het beslissingsproces, de criteria die gebruikt kunnen worden voor de evaluatie van ontwikkelingen en evalueert zes belangrijke ontwikkelingen. Uit de resultaten (figuur 4) blijkt dat beide stakeholdergroepen de 'introductie van navigatie gecombineerd met betaalapplicatie' als meest belangrijke ontwikkeling zien. Daarnaast blijkt dat beide stakeholder groepen 'het verbeteren van de duurzaamheid van het bestaande parkeer areaal' hoog prioriteren al is het verschil in score ten opzichte van nummer 1 groot.

De evaluatie scores van ontwikkelingenbieden daarnaast de meer informatie over de invloed van de criteria volgens de stakeholder groepen 'overheid' en 'markt'. Deze onderliggende verwachtingen bieden inzicht in de sterke en zwakke punten een ontwikkeling. Deze informatie kan gebruikt worden in het beslissingsproces met betrekking tot het implementeren van duurzame ontwikkelingen in parkeren.

Development (prioritized by government)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0496	1
Introducing policy in order to enable flexible parking standards	0,0054	2
Improving the sustainability of the existing parking stock	-0,0019	3
Increasing number of P+R and K+R areas in order to support Car-Sharing	-0,0022	4

Developments (prioritized by market)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0427	1
Improving the sustainability of the existing parking stock	0,0161	2
Increasing number of P+R and K+R areas in order to support Car-Sharing	0,0131	3
Increasing number of functional changes in inner city built environ-ment as a result of demographic change and internet shopping	-0,0189	4

Figuur 4: Prioritering van ontwikkelingen volgens QD scores van beide stakeholder groepen.