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Perspectives on the adoption of disruptive innovations in the construction industry

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Master of Science Thesis

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Perspectives on adoption of disruptive innovations in the Dutch construction industry

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This report has been written as master thesis for Management of Technology MSc taught at the faculty Technology Policy and Management of the Delft University of Technology. Before starting this master, I completed my bachelors in Civil Engineering. During my bachelors I developed an interest in management and innovation and especially within the construction industry. Internships and study related jobs stimulated this interest even more. During one of my jobs, I was asked to implement "augmented reality" in work processes of Royal Dutch BAM Group. In a period of about a year I realised two things. One, people were very enthusiastic about the technology but, on the other hand, they would not spend €1000 in their million euro's project to give this innovation a chance. Second, the technology that is crucial to the execution of "augmented reality" is 3D CAD models, which is not a standard working procedure within the construction industry. In other words, most construction projects in 2012 were engineered in 2D.

These two observations, together with the knowledge gained during my masters, triggered me to look further into the innovation processes of the construction industry. Questions that rose were, why is the construction industry reluctant to spend a tiny percentage of their enormous budget for a construction project on innovation. In addition, what causes the long duration of implementing a disruptive innovation, like 3D CAD software, in the work process?

This research has been executed in a cooperation between the TU Delft and KPMG, where from section Policy, Organisation, Law, and Gaming, Dr. W.W. (Wijnand) Veeneman has been first supervisor in this research.

Executive summary

A problem in the construction industry is the limited and slow implementation of disruptive innovations in the construction industry in the last hundred years. Another observation is that most disruptive innovations where implemented only after they had proven their success in another industry.

The objective of this research is to find out which factors influence the implementation of disruptive innovations in the Dutch construction industry and if people in the industry are aware of these factors. The expectation is that this information could support the more effective and faster implementing of disruptive innovations in the industry.

The results in this report are based on a comparison between the influencing factors derived from a literature study with the perspectives from people in the Dutch industry of office buildings found by using the Q-method.

On the other hand, organisational factors originate from human interactions. When people work according to an informal process and there is a structural repetition of this process, at a certain moment this process will be formalised and standardised.

The financial factor controls the organisational processes. Therefore it has an important influence on the implementation of disruptive innovations. An implementation of a fundamentally different business model in an existing business is an example of a disruptive innovation. Besides the purchase of new equipment, an adjustment of current work processes is required. This adjustment requires for example the retraining of employees, which demands a fundamental investment.

The factor rules and regulations influences the freedom that a disruptive innovation needs to develop. First, the construction of an office building involves many risks for both the client and the coalition. These risks and responsibility are laid down in contracts. Secondly, a logical result of adjusting current work processes is the creation of new rules.

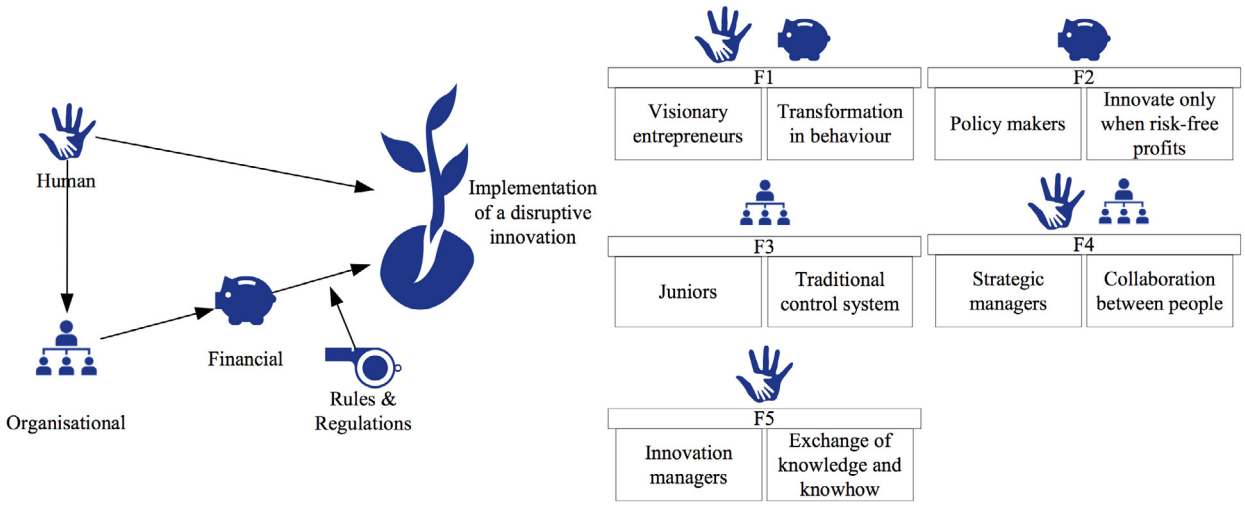

Figure 1: Relations between factors found in literature and perspectives found via the Q-method

From the literature on innovation, five factors are found. The relations between them can be found in the above figure (see Figure 1).

The human factor has a direct influence on the implementation and represents the skills, the knowledge, and the culture of the industry. It includes informal rules made by groups of users in society. These rules give guidelines for an innovation and it helps the innovation to be accepted by the users. In the construction industry, the rules can for instance be found in the informal control system. Due to the strict rules in the system, people are forced to stick to their disciplines and do not deviate from that.

The human factor also influences the organisational factor. On the one hand, there are organisational processes that steer and control human interactions. These can be found in formal communication and documentation processes, whereby people are forced to process information in a predefined method. These contracts and rules form a limitation in implementing a disruptive innovation and therefor one should be aware that things should be simplified and not be complicated.

By using Figure 1, it can be seen that the financial factor influences the implementation process by reinforcing the organisational factor. The human factor has a direct influence on the implementation process. At the same time, the human factor has an influence on the organisational factor. This means that the financial and human factors play an important role in the implementation of disruptive innovations in the construction industry.

The results from the Q-method are based on thirty respondents from the Dutch construction industry of office buildings. Their shared perspective on the topic is that innovations are profitable and that the Dutch govern-

ment does not need to make extra investments to stimulate the implementation of disruptive innovations.

Furthermore, the Q-method results in five different perspective on the topic. Each perspective comes with their own group of respondents. In each group a correlation between the respondents can be found in the years of work experience and job description. The perspectives are, in random order:

The first perspective is that a transformation in behaviour is needed. The respondents in this group are called visionary entrepreneurs and they give priority to the statement that the construction industry has to deal with old behaviour in a new world, where soft skills have become a condition for executing projects.

The second perspective is that financial restrictions limit the implementation, because it is only interesting to innovate when one generates risk-free profits. The respondents in this group are characterised as policy makers, they have the longest work experience, and they have a large influence in the innovation process due to their jobs.

The third perspective is that the traditional informal control system needs to change. The juniors corresponding to this perspective give priority to statements about organisational factors that follow out of this system.

The fourth perspective is that an increasing collaboration between people both inter- intra-industrial can positively influence the implementation. The strategical managers corresponding to this perspective see innovation as a business opportunity.

The fifth perspective is that the exchange of knowledge and knowhow must increase to stimulate the implementation positively. The respondents in this factor, the innovation managers, find it very important to increase this exchange inside the construction industry.

The conclusion of this research is that the people included in this research have a limited awareness of the factors that influence the implementation of disruptive innovations. This is primarily caused by the culture in the industry that is based on strict rules, like the informal control system. People in the Dutch construction industry do not look beyond their speciality and tasks. Therefore, it is a logical consequence that there is little inter-industrial knowledge exchange. What also belongs to the culture in the industry is the project-based manner of doing business and the collaborative and inter-organisational nature of project execution. A result is a complex multi-actor environment in the project coalition. The implementation of the disruptive innovations must be agreed by the whole coalition, which is difficult considering this multi-actor environment.

Secondarily, people have a limited awareness due to the unhealthy financial situation of the Dutch construction industry at the moment. Because of a current overcapacity in the industry profit margins are low and firms tender construction projects sometimes even below cost price. Furthermore, before the economic crisis of 2008 the construction industry invested very little in R&D and thus people in the construction industry were not used to invest in a disruptive innovation. Therefore, the current policy makers do not dare to invest in such innovations, because they are not used to this kind of investments and have little financial capacities to make these investments. When they do invest in a disruptive innovation, the return on investment must come out of the project where it is implemented, which results only in short term investments connected to projects.

The main recommendation is to aim for a transition towards a culture where people in the industry feel comfortable to exchange knowledge and knowhow intra and inter-industrial. The managers in the industry should encourage this knowledge exchange and they should be aware of the positive results of this long-term strategy. The result of this will be a quicker acceptance of a change of rules in the user groups in the construction industry.

Furthermore, the implementation of a disruptive innovation needs encouraging and consistent investments. For this reason, the current short-term investments must change to long-term investments.

The construction sectors works in a competitive environment in which price is a major factor. Additionally, the sector works in projects that temporarily bring people together under strict boundaries of scope, budget and time. That environment is not conducive to disruptive innovations, as the risks are considered too high. It allows for sustained innovations that drive efficiency of the design and construction processes, but more radical changes of the business models that would drastically improve performance are hampered by financial risks and how they manifest themselves to those who would be the key drivers of that change.

Change will be hard. As the sector has split itself along the lines of a large number of different roles, the effort needed of coming together over specific disruptive innovations is immense. New entries that would introduce these innovations find a sector relying on specialised knowledge, regulated and inflexible processes of market functioning, internally focused, and leverage to sustain the current situation and the existing interests.

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1. INTRODUCTION

This chapter will introduce this thesis in three paragraphs. In the first paragraph (§1.1 Problem introduction) the problem is introduced that is going to be researched in this thesis. The second paragraph (§1.2 Problem statement) will start with the problem to be researched, followed by the research objective, research question and sub-research questions. This paragraph will end with the scientific and social relevance of doing this research. The final paragraph of this chapter (§1.3 Report structure) will give insight in how the report is structured.

1.1. Problem introduction

One of the main characteristics of the construction industry is its project-based manner of doing business. The collaborative and inter-organisational nature of project execution is one of the elements that make the industry unique (Harty, 2005). Due to the complexity of a project, a coalition of different specialised contractors is formed to gather all specific knowledge and know-how to fulfil the need of the client, who has a strong interest in the project (Winch, 2003). The execution is not only done by the project coalition themselves, but generally there is also a large number of sub-contractors involved. This large and hierarchical group of different companies is constantly changing between projects, because of different project locations and different specialities required per project (Sante, 2016).

Due to the low profit margins, which is also characterising the industry, there is a strong urge to win tenders and there is a constant need for new projects. This results in little time between projects for reflection and analysis (Blanco, Janauskas, & Ribeirinho, 2016; Drejer & Vinding, 2006).

Having limited time for reflection and analysis has clearly its effect on the implementation of an innovation. This is especially true when considering an innovation that is new to the industry and has a totally different set of attributes than what users normally value. Such an innovation is called a disruptive innovation and is able to change the business case in an industry completely (Bower & Christensen, 1995). In order to implement such an innovation, time for reflection and analysis is needed in order to optimise the implementation. More specific, a disruptive innovation only succeeds with support from multiple organisations throughout the construction industry, because it needs to be adopted far beyond the department where it is implemented (Harty, 2005). On top of that, every element in the process is affected by this disruptive innovation (Bower & Christensen, 1995; Harty, 2005). In Harty's (2005) case study on the transition of 2D to 3D CAD software, the software needed to be implemented far beyond the drafting department, because in each phase of a construction project drawings are needed. Currently, more than a decade later then Harty (2005) did his case study, the construction industry still struggles with the implementation of the same innovation (Sante, 2016).

In the past hundred years few disruptive innovations can be observed in the construction industry, where 2D to 3D CAD software is the most recent example. Besides reinforced concrete, which had its introduction late 19th beginning 20th century, the construction industry only copied disruptive innovations from other industries (Sergeeva & Radosavljevic, 2010). Moreover, the construction industry thus only implements a disruptive innovation when it has proven its success in another industry (Winch, 2003).

When looking back at 3D CAD software, serious research into 3D modelling CAD software began in 1965. 'The migration out of research and into commercial use started in the 70's. Throughout this decade automotive and aerospace manufactures all had large internal CAD software development groups." In the early 80's the first wave of real commercial CAD software vendors had formed and a large-scale diffusion of the software can be observed (CADAZZ, 2014). However, one of the pioneering case examples of this technology in the construction industry was during the construction of Terminal 5 at Heathrow Airport in 2002 (Eastman, Eastman, Teicholz, Sacks, & Liston, 2011; Harty, 2005). This means that it took twenty years for the construction industry to start using 3D CAD software. Currently in the Dutch construction industry, the implementation of this technology is still very poor and the speed of development is low (Nijssen, 2016). The question that rises is, what factors influence this long implementation phase of a disruptive innovation in the construction industry?

Involving promising technologies, like Google Genie could be leading in a construction project, when Google Genie turns out to be a success. Through analysing a large dataset of different building projects, Genie is able to automate calculations in the design and engineering process and therefore costs are reduced (Globes, 2013).

Another technology capable of changing the business case is cognitive computing. Self-learning computers analyse unstructured data to support human decisions. It is reasonable to assume that such computers are able to define and validate risks in a construction project better than humans. When taking IBM's Watson computer as an example, IBM could take the lead in construction projects, harnessing the computer power to exclude failure costs by a better risk validation.

That the business case of construction projects can change

has been seen with the construction of SMART office buildings. Due to creating higher efficiency on workspace and sustainability, soft- and hardware is playing a more prominent role in an office building (Randall, 2015). This results in technical service providers receiving more leading roles in construction projects. The Dutch technical service provider Breijer saw this shift and took the lead in the construction project of the new court house in Breda (Verbeek, 2016). Another example is the new courthouse in Amsterdam. Australian bank Macquarie together with small engineering companies are going to construct this project and thus show to be able to change the business case where large construction companies hold on to (Battes, 2016; Oldenhof, 2016b; Oldenhof & De Rooy, 2016).

Compared to other industries, it is not a unique situation that a new entrant is overtaking a current market segment and changes a business. For example, in the mobile telecom industry a major disruptive change in the design and usage of the mobile phone can be observed, when IT firm Apple in 2007 introduced their first mobile phone (FierceWireless, 2006). In a couple of years their design became the standard and a radical change in the market took place (Elgan, 2011). Secondly, a radical change took place in the travel industry, where the digital revolution and online sales caused a major disruption (Bearne, 2016; Oldenhof, 2016b).

Coming back to the characteristics of the construction industry, there are factors in the construction industry that cause a long period of implementing a disruptive innovation. Together with the changing business case of the construction of office buildings and the possibility that new entrants are able to change a business completely, another question rises. Namely, are people in the construction industry aware of this possible change? Moreover, are people in the construction industry aware of the factors that influence the implementation of disruptive innovations?

1.2. Problem statement

As stated in the previous paragraph, the described problem in the construction industry is the long duration of implementing disruptive innovations. What has been argued is that there are factors in the construction industry that cause this delay. The first question here is: what are these factors?

When having a look at the development of disruptive innovations and promising technologies in other industries, the question arises if people in the construction industry are similarly aware of the possibility of a completely changing business case. More in depth, are people in the construction industry aware of the factors that influence the implementation of disruptive innovations?

In what way do the factors that influence the implementation of disruptive innovations derived from the literature study differ from the factors derived from the Q-method, and can these factors be used to influence the duration of the implementation process?

1.2.1. Research objective and question

The objective of this research is to find out which factors influence the implementation of disruptive innovations in the construction industry. This is done via literature study and via the Q-method in the Dutch construction industry of office buildings. Knowing the factors could help influence the duration of implementing disruptive innovation.

The research question that logically is concluded from this objective is:

In what way do the factors that influence the implementation of disruptive innovations derived from the literature study differ from the factors derived from the Q-method, and can these factors be used to influence the duration of the implementation process?

The research will try to answer the above question. In order to answer the research question, it needs to be divided into different sub-questions. Namely:

- What characterises the innovation process of disruptive innovations, specified to the construction industry.
- What are the factors that influence disruptive innovations to be implemented in an industry, and particularly in the construction industry?
- What are the perspectives of people in the Dutch construction industry of office buildings on the implementation of disruptive innovations in their industry (via the Q-method)?
- Reflecting the perspectives on the factors from literature, can these factors be used to influence the duration of the implementation process?

1.2.2. Scientific and societal relevance

From a scientific perspective, this master thesis will be an academic contribution by making the connection between theory on implementation of disruptive innovations and perspectives found in the construction industry. More specific, factors that influence the implementation of a disruptive innovation in the construction industry can be found in existing literature. These factors will be reflected on the perspectives of people on this topic that are participating in the construction of office buildings in The Netherlands. By doing this research, it will contributes to a better understanding of the current situation concerning innovating disruptively in the Dutch construction industry of office buildings.

From a societal perspective, Dutch governmental organisations would value a more quality oriented construction industry, but finds it hard to drive that change (BouwendNederland et al., 2016). Furthermore, their goal is to create a more collective ambition where the government and the construction industry are working together. The leading governmental organisations in the Dutch construction industry have published their ambitions in the Marktvisie. In this document, they try to stimulate the Dutch construction industry to come up with new and innovative ideas. The Dutch Building counsel (Bouwend Nederland) has published at the start of 2016 their agenda with guidelines for tendering (BouwendNederland, 2016). This document also emphasises the will of the government to improve the creativity of contractors in the tender process.

From these two documents it can be concluded that the Dutch government observes that the construction industry needs change. The information that the government is obviously not giving, is how the industry should implement these changes. Besides, more in-depth information is lacking why the government wants these changes.

1.3. Report structure

The next chapter in this report is the literature research (ch. 2 Literature research), which has the goal to find factors that influence implementation of disruptive innovations in the construction industry. The first paragraph of chapter two (§2.1) describes the definition of innovation, how innovation develops, and which factors derived from literature influence the implementation of disruptive innovations. The second paragraph (§2.2) describes the innovation process in the construction industry and will function as an addition to the already found factors. The third paragraph (§2.3) is a quick scan of the factors in the literature done by professionals from the industry. Finally, a conclusion of this chapter will be written in the fourth and last paragraph (§2.4) of this chapter.

The third chapter in this report (see ch. 3 Methodology) will describe which method is applied to execute this research. In the first paragraph (§3.1) the main research structure is given. Furthermore, research boundaries are stated and the outcomes of the feasibility study are presented here. The second paragraph (§3.2) will describe the method of the literature research. In the third paragraph (§3.3) the preparation of Q-methodology is explained that is used to collect the perspectives of people in the construction industry.

The fourth chapter in this report (ch. 4 Results from the Q-methodology) will describe the results of the Q-methodology. The purpose of this chapter is to find out what perspectives people have in the Dutch construction industry of office buildings on the implementation of disruptive innovations. The first paragraph (§4.1) of this chapter describes which respondents took part and which statements are used in the Q-methodology. The second paragraph (§4.2) describes the results obtained from the questionnaire. In the third paragraph (§4.3) is described how many factors are extracted and they are analysed in the fourth and fifth paragraph (§4.4 and §4.5). In the concluding paragraph (§4.6) the perspectives of people in the Dutch construction industry are given. The conclusion of the results in this report will be described in the fifth chapter (ch. 5 Conclusion). In the sixth chapter (ch 6 Recommendations, discussion) the recommendation, discussion, and reflection of the research on this thesis will be given

2. LITERATURE RESEARCH

The goal of the literature research is to find out what factors can be derived from literature that are relevant for the implementation of disruptive innovations in the construction industry. By finding these factors, a theoretical perspective is created that is compared with the perspectives of people in the construction industry. This theoretical perspective is based on the industry as a whole and not on specific company strategies.

The purpose of the first paragraph of this chapter (§2.1) is to find factors that influence the implementation of disruptive innovations in general. In order to get a better understanding of the research problem and to obtain knowledge of what factors influence the implementation of an innovation, two descriptions are given:

- A description of different types of innovation, and
- A description of how innovation develops.

The second paragraph (§2.2) describes the innovation process in the construction industry and will be an addition to the factors found in the literature. This addition is to specify those factors to the construction industry. This paragraph gives a better understanding of the industry and the complexity of the implementation process. The third paragraph (§2.3) is a quick scan of the factors in the literature done by professionals from the industry. The result is a validation of the found literature. Finally, a conclusion of this chapter will be written in the fourth and last paragraph (§2.4) of this chapter.

2.1. Innovation

What is innovation? The definition of innovation according to Webster's dictionary is:

- The introduction of something new
- A new idea, method, or device.

This paragraph gives an exploration of the definition of "innovation", which is done by differentiating types of innovations that have a different impact on the business of an industry. The differentiation will specify the different characteristics of the innovations. Indicating the differences creates a clearer view on the of the long duration of implementation and the low number of implemented disruptive innovations. Furthermore, the differentiation creates a better image of what is important in implementing an innovation.

2.1.1. Sustained and disruptive innovation

In 1995, Bower and Christensen defined the term disruptive innovation, since then this term has been used often to make a differentiation between types of innovation. The authors look at the impact a new technology has on a certain market. They use the concept of performance trajectories, describing "the rate at which the performance of a product has improved, and is expected to improve, over time" (Bower & Christensen, 1995). By looking at how a technological innovation affects this performance trajectory, a differentiation can be made between the effectiveness of technologies. Because, there are technologies that tend to maintain the rate of improvement, which they called sustained technologies also known as sustained innovations. These "give customers something more or better in the attributes they already value" (Bower & Christensen, 1995).

An example of such a sustained innovation in the construction industry is the usage of formwork components,

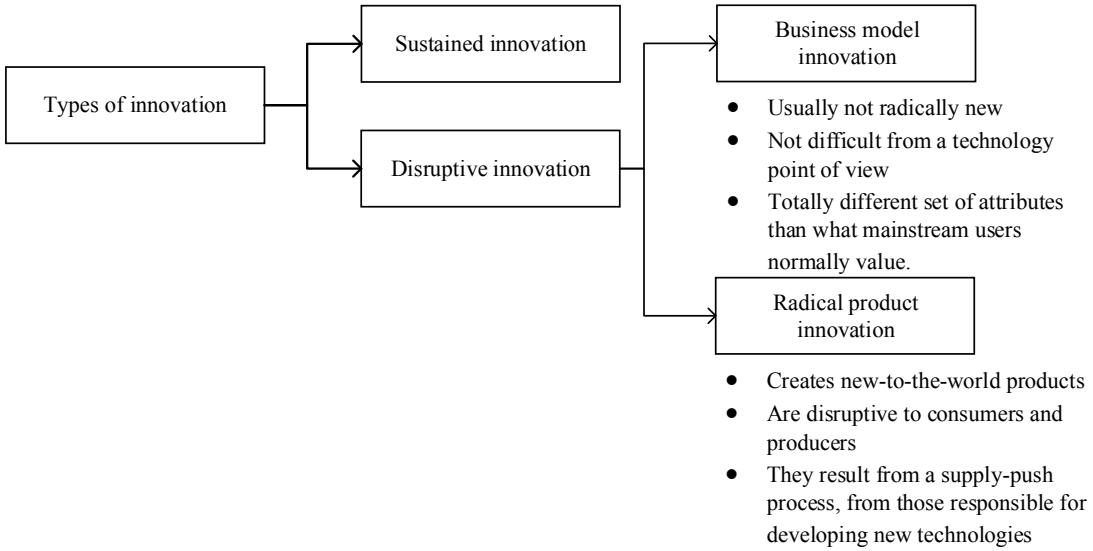

Figure 2: Types of innovation

which are used to make temporary concrete moulds. Before the industry used components, a carpenter had to make formwork out of wood. Because every concrete object is unique, formworks need to be highly adjustable. On the other hand, there is also a large repetition. Thus, by using formwork components the carpenter needs less time than if he has to make the mould out of wood himself. Therefore, by using formwork components in concrete constructions, a sustained innovation is found where the carpenter is given something better in the attributes he already valued.

Besides sustained innovations, the authors define disruptive technologies, also known as disruptive innovations. These type of innovations have a disruptive effect on the performance trajectory and come with a totally different set of attributes than what mainstream users normally value. On top of that, disruptive innovations also contain attributes already valued by the users, these attributes improve in such a rapid way that the innovation can invade in the established market and takes over the old technology. This invasion only happens when the innovation goes through a starting period where mainstream users are unwilling to use a disruptive product in an application they know and understand. From a technological point of view, disruptive innovations are usually not difficult and are not always radically new. Meaning, that a disruptive innovation can be copied from one industry to another (Bower & Christensen, 1995).

Disruptive innovations in further detail

Markides (2006) published an article in which he adds a differentiation to what Bower and Christensen (1995) defined as a disruptive innovation. Where Bower and Christensen (1995) focussed on technological innovations, Markides (2006) defines disruptive innovation as radical-product and business-model innovations (Markides, 2006). Figure 2 shows a visualisation of the different types of innovation.

The business-model innovation is an innovation "that enlarges the existing economic pie, either by attracting new customers in to the market or by encouraging existing customers to consume more." "A business-model innovation is the discovery of a fundamentally different business model in an existing business" (Markides, 2006).

The radical product innovation is a new-to-the-world product and is disruptive to consumers and producers. Such an innovation results from a supply push, mostly from the one that is responsible for developing the new product (Markides, 2006).

Other authors differentiate innovations similarly as done above. An example is the differentiation of Nagij and Tuff (2012), where they named them as follows:

- Sustained innovations → "Core innovations – Optimising existing products for existing customers";
- Business-model innovations → Adjacent innovations – Expanding from existing business in to 'new to the company' business";
- Radical product innovation → "Transformational innovations – Developing breakthroughs and inventing things for markets that don't yet exist" (Nagji & Tuff, 2012)

The conclusion is that Bower & Christensen, Markides, and Nagji & Tuff gave the same meaning to the three types of innovation, but named them differently. In this research, the types of innovation described in §2.1.1 will be used (sustained and disruptive innovations).

The differentiation in types of innovations is showing the different characteristics per innovation. It is likely that a disruptive innovation requires a more complex implementation process than a sustained innovation. For this reason, it is interesting to look into the development of disruptive innovations.

2.1.2. Development of innovation

The topic of this sub-paragraph is the development of a disruptive innovation over time, with a closer look on how an invention can cause a technological transition in an industry. In other words, how can an innovation cause a disruptive effect in the market? A theory that integrates several theories from literature to describe this transition is the multi-level perspective of Geels (2002).

Geels' theory describes three different levels in society that have an influence on the implementation process of disruptive innovations and therefore gives a clear understanding of the process. Each level consists of factors that influence the process and thus helps us to understand it. Geels describes first the socio-technical regimes, secondly, the landscape developments, and thirdly the technological niches. (See Figure 3)

The first theory that Geels introduces is the existence of technical regimes. Geels uses the term 'socio-technical regimes' to refer to the set of rules made by the different groups in society. The rule-set made by the different groups in society gives guidelines for innovations and it helps the innovations to be accepted by the users. Since society is an unstable organism, the rules in the regimes are constantly changing.

Deep structural trends are set in the 'landscape developments'. The landscape developments can be seen as a reflection of slowly changing external factors, such as oil prices, economic growth, and political coalitions. "The

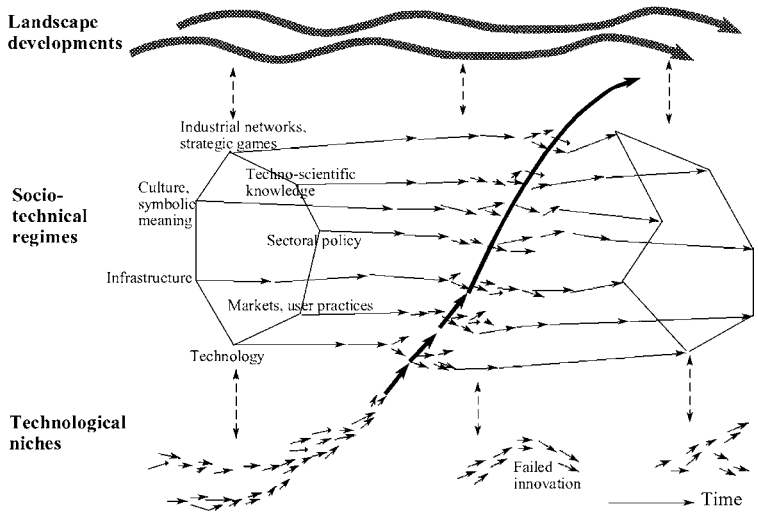

Figure 3: Multi-level perspective (Geels, 2002)

metaphor 'landscape' is chosen because of the literal connotation of relative 'hardness' and the material context of society". Geels asserts that the socio-technical regimes and the landscape are connected to each other, meaning that a change in the landscape development can influence the rules in the socio-technical regime and the other way around.

Radical product innovations, according to Geels, are generated only in the 'technological niches'. These niches are places where an innovation is excluded from the rules in the regimes. So, technological niches can be seen as incubation rooms where an innovation can be developed before it is exposed to the rule-set.

In Figure 3 the previously defined levels are visualized. In the lower part of the figure, the technology niches, in the middle part the socio-technical regimes and in the upper part the landscape developments.

As mentioned before, society is an unstable organism and has constant changes in the rule-set. These changed rules have an effect on the success and acceptance of radical product innovations that are created in the technological niches. The dotted lines in the picture have visualized this. When a radical innovation does not meet the rules, it will not be accepted within society and so the innovation will fail.

The same dotted line can be seen between the landscape developments and the socio-technical regimes. This line indicates the connection between these two levels and how they influence each other. Changes in the landscape developments might change the rules-set in the regime, which can influence the success of a radical innovation in the technological niche. That means the landscape developments also have an influence on the technological niches. Geels has not included this in Figure 3, but it nevertheless belongs to the theory.

Geels combines in the multi-level perspective two views on the evolution of an innovation. His first view on evolution is 'variation and selection', where disruptive innovations are found in the technological niches and the regime functions as a selection and retention mechanism.

- "In stable situations, innovation is mainly incremental and 'down the design hierarchy'.
- Radical innovations, which are pioneered in niches, have a hard time to break out of the niche-level. If the regime is confronted with problems and tensions emerge, the linkages in the configuration 'loosen up'. The configuration becomes 'warm' (Callon, 1998). This creates opportunities for radical innovations to escape the niche-level and be incorporated in the ST-configuration."

In his second view, Geels describes the evolution of an innovation as 'unfolding'.

- "If new elements are introduced in the regime, they may trigger further changes if changes at the landscape level create pressure and new opportunities.
- Another driver for further changes is the emergence of specialised actors directing their activities towards improving and expanding the new element.
- Reconfigurations thus occur when developments at multiple levels link up and reinforce each other."

The conclusion that Geels draws in his article is that the breakthrough of disruptive innovations depends on processes in the socio-technical regimes and landscape developments. This can also be understood as a process of niche-cumulation. "A technology transition thus does not occur due to a sudden change in the regime, but occurs through a stepwise process of reconfiguration, "a process of shifting assemblies and reconfiguration of socio-technical elements."

He explains this in a case study, describing the transition of sailing ships to steamships. In this case the step from the technological niches to the socio-technical regimes

does not occur at once. It happens gradually in a step-by-step procedure, with the use of disruptive innovations in market niches or from other domains. (Side note: Geels does not include the differentiation between radical product and business model innovations as defined previously.)

2.1.3. Factors found in literature on innovation

The purpose of this paragraph is to find factors that influence the implementation of disruptive innovations in general. In order to get a better understanding of the research problem and to obtain knowledge of which factors influence the implementation of an innovation, two descriptions are given:

- A description of different types of innovation, and
- A description of how innovation develops.

According to Webster's dictionary, the definition of innovation is the introduction of something new, or a new idea, method or device. To make a differentiation between types of innovation, Bower and Christensen (1995) defined the terms sustained and disruptive innovations. A sustained innovation "gives customers something more or better in the attributes they already value", and a disruptive innovation comes with a totally different set of attributes than what customers normally value.

Markides (2006) adds a differentiation to what Bower and Christensen (1995) defined as a disruptive innovation, namely a radical product innovation and business model innovation. A radical product innovation is a new-to-the-world product and is disruptive to consumers and producers. A business model innovation is the discovery of a fundamentally different business model in an existing business.

A theory that integrates several theories from literature to describe the development of a disruptive innovation over time is the multi-level perspective of Geels (2002). Geels describes in his theory (see Figure 3) the socio-technical regimes as the rule-set or grammar made by groups of users in society. The rule-set gives guidelines for innovations and it helps the innovations to be accepted by the user groups in society. "A set of deep structural trends" is set in the landscape developments. "The metaphor 'landscape' is chosen because of the literal connotation of relative 'hardness' and the material context of society." According to Geels, radical product innovations are generated only in the technological niches. Technological niches can be seen as incubation rooms where an innovation can be developed before it is exposed to the rules-set in the socio-technical regime.

By making use of a case study, Geels explains that the implementation of a disruptive innovation occurs through a stepwise process of reconfiguration, "a process of shifting assemblies and reconfiguration of socio-technical elements".

The authors named in this paragraph all describe factors that influence the implementation of a disruptive innovation. Because of the large number of factors, the result is a very long list. Therefore a division is made in three categories.

The large involvement of users in the implementation of a disruptive innovation results into the human factors (1). Geels (2002) describes this large involvement most clearly in his defined socio-technical regime. In this regime, Geels defines single human factors as personal skills and knowledge. Collective human factors he defines as culture in society. Other collective human factors are communication between people, the manner of coordination, and how people make decisions (Christensen & Overdorf, 2000; Nagji & Tuff, 2012). These collective human factors have a direct influence on the transformation of resources into products (Christensen & Overdorf, 2000)

Organisational factors (2) cover organisational processes and formal work methods. Examples of these factors are structured documentation of data or formal communication methods. A well-structured documentation can inform managers and decision-makers how the innovation develops (Christensen & Overdorf, 2000). A well-structured documentation also results in clarity of formal work methods for employees that work with the innovation.

Finally, financial factors (3) have a major influence on the implementation of a disruptive innovation (Christensen & Overdorf, 2000; Geels, 2002; Nagji & Tuff, 2012). In order to implement a disruptive innovation, encouraging and consistent investments are needed (Nagji & Tuff, 2012). According Geels', economic growth is influencing buying power and thus influences buying behaviour in an industry.

2.2. The construction industry

As mentioned in the introduction of this report there are not many disruptive innovations in the construction industry. The function of this paragraph is to find out why there is little use of disruptive innovations in the construction industry. This paragraph describes the innovation process in the construction industry and it will be an addition to the factors found in the literature. This addition is to apply these factors to the construction industry. Furthermore, this paragraph gives a better understanding of the industry and the complexity of the implementation process.

The first subparagraph (§2.2.1) describes general characteristics of the construction industry, to create a clearer image of the industry. In the second subparagraph (§2.2.2) an analysis is given of what type of innovations are mostly observed in the industry and how these relate to the general characteristics of the construction industry. The third subparagraph (§2.2.3) gives a description of the influence of the organisational structures in the construction industry on the implementation of a disruptive innovation. The fourth subparagraph (§2.2.4) describes how culture in the construction industry influences innovation, and to find out what human influences are. The second last subparagraph (§2.2.5) describes the financial situation in the construction industry and how this influences the process. Finally, a conclusion of this paragraph is given in the last subparagraph (§2.2.6)

2.2.1. General characteristics

One of the main characteristics of the construction industry is the project-based manner of working. Obviously, this can also be observed in other industries, like the IT industry, but the construction industry differs from others because of the manufacturing of complex product systems (Winch, 2003). Complex product systems means that the industry manufactures a total package including design, production, logistics and maintenance of the construction. The complex product system can be characterised by:

- "Its project orientation,
- the contribution of temporary coalitions of firms to production,
- the heavy involvement of the client in the process, and
- most notably, the adamant refusal of the industry to move down the product life cycle" (Winch, 2003). The industry is characterised by many firms with many unique designs, but according to product life cycle management the industry logically should transform to few firms with similar products.

What does this characterisation mean in comparison with other industries with respect to the implementation of disruptive innovations? In each project, a diverse range of firms form a project coalition. Each firm is participating in the coalition because of their single specialism (Brewer & Gajendran, 2011; Harty, 2005). In the construction industry these coalitions are temporary, which is unique in comparison with other industries. When the project ends, firms in the coalition will be dissolved and form with other firms a new coalition in another project. The implementation of the disruptive innovations must be agreed by the whole coalition, which is difficult considering the multi-actor environment.

The heavy involvement of the client in the process, due to the complex product systems, causes many restrictions in the innovations process as well. The construction of an office building involves many risks for both the client and the coalition. These risks and responsibility are laid down in contracts (De Bruijn & Maas, 2005). These contracts form a restriction for the innovation process in the construction project.

2.2.2. Types of innovations in the construction industry

In the construction industry since the nineteenth century, four disruptive innovations are found:

- Invention of the high-speed electric elevator in the ninetieth century (radical-product innovations);
- Invention of structural steel and reinforced concrete in the late ninetieth century and early twentieth century (radical-product innovations);
- Introduction of the computer in the late twentieth century (business-model innovation);
- Introduction of CAD software in the early twenty-first century (business-model innovation) (Sergeeva & Radosavljevic, 2010).

The constant need for projects leads to sustained innovations in order to help reducing production costs.

This number compared is much lower than the number of sustained innovations in the construction industry. This is mostly due to the project-based character of the industry, where there is a constant need for projects. In order to win a tender process, a firm needs to build cheaper than the competitor does. This leads to incremental improvements or sustained innovations to help reducing production costs (Oldenhof, 2016a). Furthermore, in order to reduce production costs, innovations are primarily process oriented (De Bruijn & Maas, 2005; Harty, 2005).

This observation is in line with Winch's (1998) theory of the "bottom-up and top-down approach" on the innovation

process in the construction industry (see Figure 4). The bottom-up approach means, small improvements discovered during projects will be implemented in new projects. This is called a sustained innovation (Winch, 1998). With the top-down approach, an innovation originates in the firm and is implemented in the work process of the firm (Winch, 1998). In contrast to a sustained innovation, a disruptive innovation is seldom project related. It is invented in the firm itself as a radical-product innovation, or it derives from another industry as a business-model innovation. In both cases, the firm individually decides to implement this disruptive innovation.

The difficulty of implementing a disruptive innovation exists when the firm has to cooperate with other firms in a project coalition. At this point, the firm has to convince other firms to adopt the disruptive innovation as well. Because of this problem, a number of authors argue that the construction industry has failed to implement very promising innovations from other industries (Dubois & Gadde, 2002). Examples of those are: quality management, partnering with suppliers, supply chain management or industrialisation of manufacturing processes (Dubois & Gadde, 2002).

2.2.3. Organisation structures

In the construction industry, a diverse group of firms form a coalition to realise a project. A disruptive innovation has to be implemented and adopted by the project coalition (Winch, 1998). This is a complex negotiation process. According to Dubois and Gadde (2002), this multi-actor negotiation process is why several authors state that the implementation of disruptive innovations is the most complex undertaking in comparison with other industries. The main cause is the diversity of specialisms in the project coalition. Further, each firm has its own expectations, work methods in order to fulfil their role in the project (Harty, 2005).

A factor that positively influences the implementation of a disruptive innovation is an efficient intra- and inter-organisational collaboration. Thereby, effective communication and diffusion of information is a method to increase this efficiency of the collaboration. “In construction work, communication must hold together complex sequences of activity extending across organisational boundaries” (Harty, 2005). However, communication has been a problematic area in the construction industry for some time. Because of the complicated organisational structures in the construction industry people find it hard to communicate the right information to the right persons (Blanco et al., 2016; Winch, 2003). Without a clear structure, people do not know who is responsible for what and therefore people do not take responsibility for the innovations that need extra attention (Blanco et al., 2016).

A reason for this lack of clarity is the continuous changing projects and simultaneously changing coalitions. With each project, a new organisational structure is created, and every time new project teams are put together. The teams in the coalition consists of people from different organisations. During a project, inter-organisational collaboration causes formal and informal processes to be standardised among the team members and within the coalition. The lack of clarity comes from the point where each coalition creates its own standards and work methods (Brewer & Gajendran, 2011). In addition, there are many subcontractors, which complicate the communication even more. Also, these subcontractors do not always have the financial capability to adopt the innovation (Blanco et al., 2016).

Thus, the largest difficulty in the organisation structure of the construction industry considering implementation of disruptive innovation is the complex multi-actor environment and the decision making that comes along during the process.

2.2.4. Culture of the industry

The issue with organisational structures is the inter-organisational collaboration within the coalition. Human interaction and culture within the construction industry is for this reason a factor to look into. Despite the complex organisational structures, Dubois and Gadde (2002) argue that the disciplines in the process of design, planning, and construction are informally standardised. This gives each party a clear expectation of each other’s finished work. This clear expectation is caused by the specific skills and knowledge that each process demands and where each firm is specialised in. This informal control system forces firms to stick to their disciplines (Dubois & Gadde, 2002).

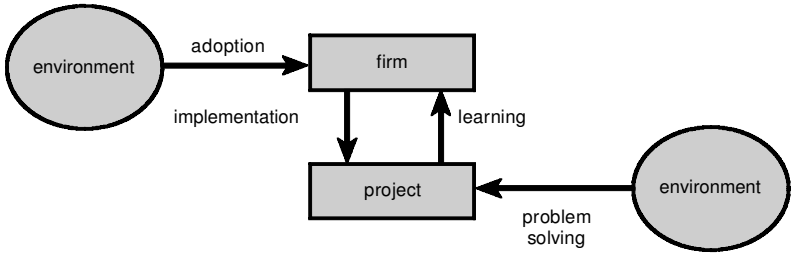

Figure 4: A model of construction innovation processes (Winch, 1998)

On the one hand, these standards simplify the complexity in the coalition so that people know what to expect from one another. On the other hand, when a firm decides to innovate disruptively (in)formal standards will change, which results in unclear expectations towards others in the coalition (Brewer & Gajendran, 2011). Another side effect of this informal control system is that firms are pointing at each other when something goes wrong, which leaves no room for bonding and building up a trustworthy relationships. The result is that firms do not dare to exchange knowledge about disruptive innovations, because they believe it will only work against them. In this way it could happen that multiple firms invent the same innovations more or less at the same time (reinvention of the wheel) (De Bruijn & Maas, 2005).

The reluctance to accept input from other industries limits the industry's ability to reinvent itself and learn from other sectors

The informal control system thus forces firms to stay in their role and keep their experiences as they are (Dubois & Gadde, 2002). A subsequent result is that firms do not see it as their responsibility to improve the skills of or train their employees. Especially the small sub-contractors are lacking effective governance and talent management (Blanco et al., 2016). Surprisingly, engineering and construction companies complain that they cannot find people with the right skills (Blanco et al., 2016). On top of that, these companies are also lacking in leading-edge sales capabilities, such as strategic account management and cross-selling (Blanco et al., 2016).

Another observation is that there exists a belief in the industry that only engineers with long records in the field can succeed. Hiring people from outside the industry happens rarely and is mostly resisted by the industry itself. The reluctance to accept input from other industries limits the industry's ability to reinvent itself and learn from other sectors (Blanco et al., 2016). "It seems to be a common view among most authors that the construction industry would be better off changing its behaviour in accordance with the norms of other industries" (Dubois & Gadde, 2002).

It therefore can be said that there is a strong need to change culture and behaviour in the construction industry where human resource management, or talent-management, could play a substantial role in changing the industry.

2.2.5. Financial activities

The 2008 economic crisis caused a large amount of bankruptcies globally, including the Netherlands. Companies where forced to rethink their investment plans and cut cost in daily activities. This also had its effect on the Dutch construction industry of office buildings, where the vacancy of offices increased and construction of new buildings decreased. The effect of the economic crisis is notable much later in the construction industry. This can be seen in the number of bankruptcies in the Dutch construction industry, which was at its peak in 2013 (Koenen, 2015).

Moreover, the effects of the economic crisis led to a surplus of construction firms. In order to keep employees at work, firms sometimes tendered for construction projects below cost price. The Dutch media called the situation where coalitions underbid others to get a project, 'price fighting' (Koenen, 2015). According to several sources, the number of bankruptcies has recently decreased significantly and the number of available projects increased. However, only a small increase in revenue in the industry can be observed (De Waal, 2016; Visser, 2015; Wijnans & Roest, 2015).

Before the economic crisis, the construction industry was not investing much money in innovation, especially not in disruptive innovation. According to TNO (Dutch research organisation), the Dutch construction industry invested only 0,22% from their revenue on R&D. This is very low in comparison with other capital and labour intensive industries, where they invest respectively 3,6% and 1,7% of their revenue in R&D-investments (De Bruijn & Maas, 2005). On top of that, the belief of the industry is mostly that innovation, especially disruptive innovation, has a very low even negative return on investment (Koenen, 2015).

It therefore can be said that the construction industry was not reinventing itself by investing in innovation. Despite the economic crisis, the Dutch construction industry is currently having a surplus of construction firms, which means they are still in an unhealthy economic situation. In this situation, it can be assumed that no extra money will be invested in R&D.

2.2.6. The application of the factors to the construction industry

This paragraph describes the innovation process in the construction industry and it will be an addition to the factors found in the literature. This addition is to apply these factors to the construction industry.

According to Winch (2003), the construction industry differs from others because of the complex product systems. Complex product systems means that the industry manufactures a total package including design, production, logistics and maintenance of the construction (Winch, 2003).

Due to the project-based manner of doing business and the urge to win tender processes, a firm needs to build cheaper than the competitor does. This leads to incremental improvements or sustained innovations to help reducing production costs and optimise the process (De Bruijn & Maas, 2005; Oldenhof, 2016a).

There are more sustained than disruptive innovations in the construction industry. The difficulty of implementing a disruptive innovation arises when the firm has to cooperate with firms in a project coalition (Dubois & Gadde, 2002). At this point, the firm has to convince other firms to adopt the disruptive innovation as well.

Organisational factors, such as formal communication and spreading of information, influence the implementation of disruptive innovation. However, communication has been a problematic area for some time in the construction industry. Because of the complicated organisational structures in the construction industry, people find it hard to communicate the right information to the right persons (Blanco et al., 2016; Winch, 2003). The largest difficulty in the implementation of a disruptive innovation in the construction industry is the complex multi-actor environment and the decision making that comes along during the process.

Human factors that influence implementation of disruptive innovations can be found in the informal control system in the construction industry. The informal control system forces people, both single and collective, to stick to their role and keep their experiences as they are. A side effect is that firms are pointing at each other when something goes wrong, which leaves no room for bonding and building up trustworthy relationships (De Bruijn & Maas, 2005). Another effect is that firms do not see it as their responsibility to improve the skills of or train their employees (Dubois & Gadde, 2002).

Furthermore, in the construction industry exists a belief that only engineers with long records in the field can succeed. Hiring people from outside the industry happens rarely and is mostly resisted by the industry itself, which limits the industry's ability to reinvent itself and learn from other sectors (Blanco et al., 2016).

According to the previous paragraph (§2.1) the influence of financial factors in the implementation of disruptive innovations in the construction industry is large. In comparison with other capital and labour intensive industries, the Dutch construction industry invests a very low percentage from their revenue on R&D projects (De Bruijn & Maas, 2005). These percentages were measured before the economic crisis of 2008, the Dutch construction industry is currently having a surplus of construction firms, which means they are still in an unhealthy economic situation. In this situation, it can be assumed that no extra money will be invested in R&D. In order to keep employees at work, project coalitions underbid others and even below cost price to get a project (Koenen, 2015).

On top of that, the belief of the construction industry is mostly that innovation, especially disruptive innovation, has a very low or even negative return on investment (Koenen, 2015).

In addition to the factors found in §2.1 another factor is derived from this paragraph, namely: rules and regulating factors. The construction of an office building involves many risks for both the client and the coalition. These risks are documented in contracts (De Bruijn & Maas, 2005). These contracts form a restriction for the innovation process in the construction project.

2.3. A quick scan by professionals

The purpose of this paragraph is a quick scan of the factors in the literature done by professionals from the industry. The result is either a validation of the found literature and/or the factors will be extended with another factor that has not been named yet in literature. The structure in the interviews is based on the four factors found in literature. The professionals were asked to explain their experiences with disruptive innovations in the construction industry. The validation was done on the basis of their experiences and the issues they raised.

This paragraph will start with a short summary (See Appendix: Qualitative interviews for an extensive summary). A conclusion will compare the literature factors with the ones from the interviews.

2.3.1. Professional's story

The first interview was with Mr. Nijssen, a former managing director of an engineering company. Mr. Nijssen characterises himself as very innovative and always adjusts to future perspectives. In his career, Mr. Nijssen emphasises the human interactions in the development of disruptive innovations, with a strong focus on the individual. He claims that stimulating impulses, originating in their own environment, create innovative thoughts with people. When referring to the literature on innovation, Geels (2002) also describes Mr. Nijssens claim, but in other words. Namely, when the socio-technical regime is confronted with problems and when tensions emerge, the rules in the regime will loosen up.

However, large organisations can have a paralysing impact on people's impulses. Mr. Nijssen thinks that the innovations are held back from implementation, because most processes in the construction industry are unorganised. Nowadays, this is due to the decentralised structure of the construction industry. In particular when looking at information management and the gathering of knowledge, says Mr. Nijssen. This observation has been found in literature as well. According to the literature the decentralised structures resulted in complicated organisational structures in the industry. Therefore, people find it hard to communicate the right information to the right persons (Blanco et al., 2016; Winch, 2003). Without a clear structure, people do not know who is responsible for what and therefore people do not take responsibility for the innovations that need extra attention (Blanco et al., 2016).

Mr. Nijssen experience is that knowledge is not being shared inter- and intra-organisationally, which could be the result of the complex organisational structures. The solution Mr. Nijssen comes up with is a knowledge centre that collects and shares knowledge from public, private and educational institutes in order to find innovative solutions.

The second interview was with Mr. Oldenhof, who is currently director at KPMG, and he gained his experience as managing director at several leading contractors in the Dutch construction industry. Mr. Oldenhof looks at his work from a financial point of view. He starts the interview with the claim that the construction industry is cost driven with a short-term vision. This is due to low profit margins and to a project-oriented market. Hereby he names the characteristics also found in the literature (Koenen, 2015). On top of that, due to the strong hierarchical structure in the industry, only the board of directors decide on long-term investments. However, they ignore discussions on long-term strategies in their board meetings and focus only on topics as current performances of projects. Disruptive innovations are long-term strategies, which are thus usually ignored in these meetings.

The ignorance of discussing long-term strategies can be seen as a supporting argument to the informal control system, found in literature. Hereby it can be seen that the informal control system even functions on board level, where board members are forced to stay in their role. Mr. Oldenhof adds that the creation of the informal control system lies in the former ways of contracting, where the requesting party had a plan that the delivering party had to execute. The delivering party, led by the main contractor, divided the total work among different sub-contractors. Each only doing their specialised jobs.

Mr. Oldenhof makes a practical addition to what literature writes about the project-orientated market by saying that all financial investments are project related. When the board decides to invest in a disruptive innovation, the return on investment must come out of the project where it is implemented. The consequence of this implementation is that it gives large risks in relation to the profit margin and these risks need to be covered in the contracts. This confines the innovation process.

Another observation of Mr. Oldenhof that is in line with literature is the limited cooperation with other firms in the industry, especially concerning innovation processes. Companies see an innovation as an asset in the tender process.

With respect to talent management, there is a high rate of low educated labour in the industry, which he thinks is negatively correlating with the innovation rate. In addition, for management functions it is highly exceptional that people make a career switch to the construction industry. The low salary for management functions, compared to other industries, is the main reason.

The third interview took place at the "Rijksvastgoedbedrijf", which is a government organisation that manages all governmental real estate in The Netherlands. They are an initiator in many construction projects. Mr. Kerpel and Mrs. De Lint-Zorge are both member of the Durability and

Comfort department and are often dealing with innovations in the construction industry. Mr. Mol is head of Procurement and Contract Management in the organisation, and looks at innovations from a financial point of view.

According to the interviewees, human factors are of great importance in the process of disruptive innovations. One should dare to invest in innovation. A spokesperson with convincing power needs to persuade people of the importance of implementing a disruptive innovation and find an area of support herefor.

They also experienced that sharing knowledge with other firms in the industry is tough. In order to cope with this difficulty, there is a need for better communication methods. This can also be found in the literature, where collective human factors are communication between people, the manner of coordination, and how people make decisions (Christensen & Overdorf, 2000; Nagji & Tuff, 2012).

Most strategies in the industry are short-term strategies. This is the result of an unhealthy financial situation in the market where profit margins are too low.

2.3.2. Conclusion

The purpose of the quick scan is to validate the factors from the literature by professionals from the industry. The conclusion from these three interviews is that all of them find the human factors important in the innovation process. Where, Mr. Nijssen lays the focus on single human factors, and Mr. Kerpel, Mrs. De Lint-Zorge, and Mr. Mol focus on collective human factors. Mr. Oldenhof and Mr. Nijssen both address the inter- and intra-organisational processes to be of importance in the success of a disruptive innovation. Only Mr. Oldenhof thinks financial factors are most important. In addition, Mr. Oldenhof addresses the complicated contracts as a restriction to the innovation process.

Only Mr. Oldenhof mentions, indirectly, that better talent management is of importance for the industry. This is an interesting observation, while Mr. Nijssen together with Mr. Kerpel, Mrs. De Lint-Zorge and Mr. Mol are finding human factors most important in the process, but do not address this explicitly.

Finally, it can be concluded that the factors found in literature are in line with the perspectives of professionals from the industry. The human factors, inter- and intra-organisational processes and financial effects are of great importance according to professionals. No new factors were mentioned by the professionals.

2.4. Conclusion from literature research

This paragraph answers the first two sub-research questions:

- What characterises the innovation process of disruptive innovations, specified to the construction industry?
- What are the factors that influence the implementation of disruptive innovations in an industry, and in particular in the construction industry?

§2.1 defines innovations and describes the factors that influence those innovations. §2.2 describes the innovation process in the construction industry and functions as an addition to the already found factors. §2.3 is a quick scan of the theory by professionals from the industry to give their view on the factors from the first and second paragraph.

2.4.1. Conclusion from literature on innovation

The purpose of the research of literature on innovation is to find factors that influence the implementation of disruptive innovations in general. In order to get a better understanding of the research problem and to obtain knowledge of what factors influence the implementation of an innovation, two descriptions are given:

- A description of different types of innovation, and
- A description of how innovation develops.

According to Webster's dictionary, the definition of innovation is the introduction of something new, or a new idea, method or device. To make a differentiation between types of innovation the definition of Bower & Christensen (1995) together with Markides' (2006) definition is used:

- Sustained innovation: "Gives customers something more or better in the attributes they already value." (Bower & Christensen, 1995)
- Disruptive innovation: "Comes with a totally different set of attributes than what customers normally value." (Bower & Christensen, 1995)
  * Business model innovation: The discovery of a fundamentally different business model in an existing business (Markides, 2006).
  * Radical product innovation: A new-to-the-world product and is disruptive to consumers and producers (Markides, 2006).

The process of a disruptive innovation characterises itself as a stepwise process of reconfiguration, "a process of shifting assemblies and reconfiguration of socio-technical elements" (Geels, 2002).

From the literature on innovation, three factors can be derived.

- Human factors:

Human factors are divided in single and collective human factors. Single human factors are personal skills and knowl-

edge. Where collective human factors are seen as culture in the industry, communication between people, the manner of coordination, and how people make decisions with each other.

- Organisational factors:

These factors cover formal work methods and organisational processes, where structured documentation or formal communication methods can be used as example.

- Financial factors:

Financial factors have a major influence on the implementation of disruptive innovations. In order to implement such an innovation, sustained and consistent investments are needed.

2.4.2. Conclusion from literature on innovation in the construction industry

This section describes the innovation process in the construction industry and it will be an addition to the factors found in the literature on innovations in general. This addition is to apply these factors to the construction industry. Furthermore, this paragraph gives a better understanding of the industry and the complexity of the implementation process of disruptive innovations.

The construction industry differs from others because of the complex product systems. Complex product systems means that the industry manufactures a total package including design, production, logistics and maintenance of the construction.

Firms in the Dutch construction industry implement sustained innovations in order to reduce production costs and optimise the construction process, to help win a tender process. The largest difficulty at the implementation of a disruptive innovation in the construction industry is the complex multi-actor environment and the decision making that comes along during the process.

In addition to the factors from §2.1:

- Human factors:

The informal control system in the construction industry forces people, both single and collective, to stick to their role and their experiences. A side effect is that there is no room left for bonding and building up trustworthy relationships. Another effect is that firms do not see it as their responsibility to improve the skills of and train employees. Furthermore, in the construction industry exists a belief that only engineers with long records in the field can succeed. Hiring people from outside the industry happens rarely and is mostly resisted by the industry itself, which limits the industry's ability to reinvent itself and learn from other sectors.

- Organisational factors:

Because of the complicated organisation structures in the construction industry, people find it hard to communicate the right information to the right persons. Therefore communication has been a problematic area for some time in the construction industry.

- Financial factors:

In comparison with other capital and labour intensive industries, the Dutch construction industry invests a very low percentage from their revenue on R&D projects. Due to a current surplus of construction firms, project coalitions underbid others and even below cost price to get a project, in order to keep their employees at work. In this unhealthy financial situation, there is no room for R&D investments. Furthermore, the Dutch construction industry beliefs that disruptive innovations have a very low or even negative return on investment.

- Rules and regulation factors:

The multiple rules and restrictions to control risks that come along with implementing disruptive innovations in the construction industry. These decrease the freedom that an innovation needs to develop.

2.4.3. Factors from professionals in the industry

The purpose of this section is a quick scan of the factors in the literature done by professionals from the industry. The result is a validation of the found literature.

It can be concluded that the factors found in literature are in line with the perspectives of professionals from the industry. The human factors, inter- and intra-organisational processes and financial effects are of great importance according to professionals. In retrospect, the interviews were a confirmation of the factors. Concluding, no new factors were mentioned by the professionals.

2.4.4. Answer to the sub-research question 1 and 2

As a result of the literature research, the first two sub-research questions can be answered. The first questions is: What characterises the innovation process of disruptive innovations, specified to the construction industry?

The process of a disruptive innovation characterises itself as a stepwise process of reconfiguration, "a process of shifting assemblies and reconfiguration of socio-technical elements" (Geels, 2002). The largest difficulty at the implementation of a disruptive innovation in the construction industry is the complex multi-actor environment and the decision making that comes along during the process.

This multi-actor environment is a result of the manufacturing of complex product systems, that makes the industry unique compared to others. In each project, a diverse range of firms form a project coalition. Each firm is participating in the coalition because of their single specialism (Brewer & Gajendran, 2011; Harty, 2005). In the construction industry these coalitions are temporary, which is unique in comparison with other industries.

Furthermore in this multi-actor environment an informal control system forces people, both single and collective, to stick to their role and keep their experiences as they are. A side effect is that firms are pointing at each other when something goes wrong, which leaves no room for bonding and building up trustworthy relationships (De Bruijn & Maas, 2005).

Putting the informal control system in the context of Geels' multi-level perspective, it can be said that the rules in the socio-technical regime of the construction industry are strict. Because of these strict rules, the regime must be confronted with a problem that has a large impact in order to change the rules. Another way to change the rules is to introduce new elements in the regime. Specialised actors must direct their activities towards improving and expanding new elements. New elements can be seen as promising technologies, like cognitive computing, as discussed in the introduction of this report.

When one abstracts Geels' multi-level perspective, it can be said that the speed by which rules in the regime are adopted is related to the duration of implementing a disruptive innovation. In other words, when the regime quickly adopts new rules, the duration of implementing a disruptive innovation is short.

The second sub-research question is: What are the factors that influence disruptive innovations to be implemented in an industry, and particularly in the construction industry?

The four factors that influence the implementation of disruptive innovations can be found in the figure below (see Figure 5). In each vertical lane, the factors are described together with the issue that illustrates the factor, the reason for this issue and a possible solution. What can be concluded from the figure below is that the research objective depends on the four factors. When looking for a relation between the factors and the implementation of disruptive innovations in the construction industry, the figure below is made (see Figure 6).

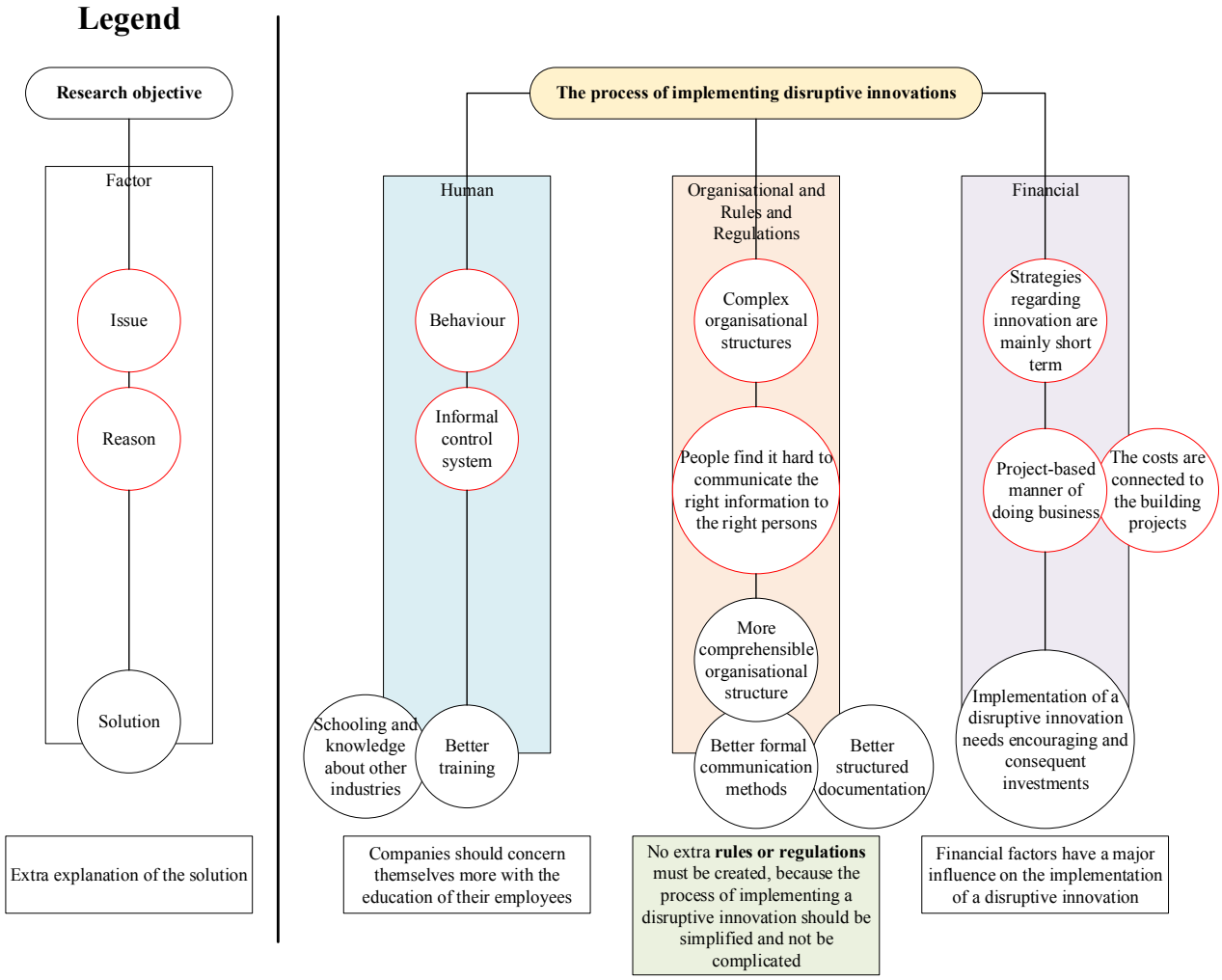

Figure 5: Factors that influence disruptive innovations to be implemented in the construction industry

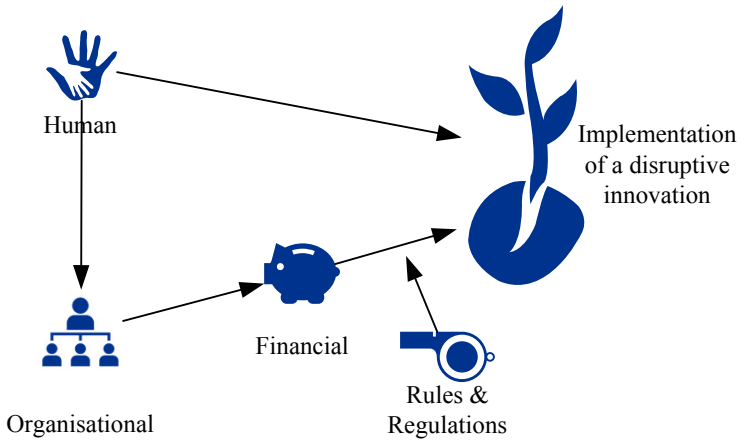

Figure 6: The relationships between the factors

Starting with the human factor, the elements in this factor can be connected to the rules in the socio-technical regime The rules in the regime give guidelines for an innovation and it helps the innovation to be accepted by the users. In the construction industry, the rules can for instance be found in the informal control system. Due to the informal control system, people are forced to stick to their disciplines and do not deviate from that. The informal control system forms very strict rules and therefore deviation from them is hard.

The human factor is also connected with the organisational factor. On the one hand, there are organisational processes that steer and control human interactions. These can be found in formal communication and documentation processes, whereby people are forced to process information in a predefined method. On the other hand, organisational factors originate from human interactions. When people work according to an informal process and there is a structural repetition of this process, at a certain moment this process will be formalised and standardised.

The factor that mediates between organisational processes and the implementation of a disruptive innovation is the financial factor. An implementation of a fundamentally different business model in an existing business is an example of a disruptive innovation. Besides the purchase of new equipment, an adjustment to current work processes is required. This adjustment requires for example the retraining of employees, which demands a fundamental investment.

The factor rules and regulations influences the freedom that a disruptive innovation needs to develop. First, the construction of an office building involves many risks for both the client and the coalition. These risks and responsibility are laid down in contracts. Secondly, a logical result of adjusting current work processes is the creation of new rules. These contracts and rules form a limitation in implementing a disruptive innovation and therefor one should be aware that things should be simplified and not be complicated.

3. METHODOLOGY

This chapter will give a step-by-step description on how in this research is executed. The purpose of this research is to find out which factors influence the implementation of disruptive innovations in the construction industry. The first paragraph (§3.1) gives a general overview of the research structure, which is done via literature study and via the Q-method in the Dutch construction industry of office buildings. Furthermore, in this paragraph research boundaries and a feasibility study are described. Research boundaries have been set on the researched industry and types of innovations, in order to limit the field of research. A feasibility study has been done to find out if this research or similar researches have been executed previously. The second paragraph (§3.2) explains why which literature has been used in the research. The goal of the literature research was to find out which factors could be derived from literature that are relevant for the implementation of disruptive innovations in the construction industry. The third paragraph (§3.3) explains the preparation of the Q-methodology that is used to collect the perspectives of people in the Dutch construction industry of office buildings.

3.1. Research structure

This paragraph gives a general overview on the structure of this research (see Figure 7). In this research, a comparison has been made between findings from literature research and perspectives of people in the construction industry. This has been done via literature study and via the Q-method in the Dutch construction industry of office buildings.

3.1.1. Research boundaries

In order to limit the field of research, research boundaries have been set on the researched industry and types of innovations. First, the construction industry is a very broad industry with several different sectors that contain different work processes and specialisms. This resulted from the literature research, where it is stated that different specialised firms form a project coalition to start a project. In order to have consistency in the data a choice has been made to select a particular sector within the construction industry and therefore find consistency.

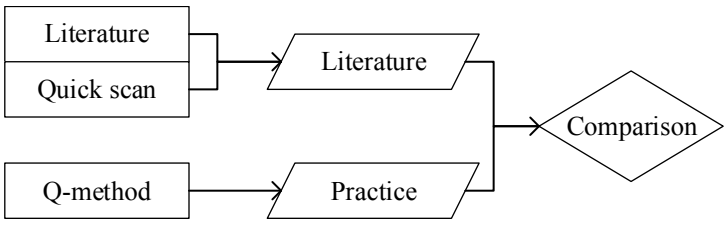

Figure 7: Research structure

The speciality that has been chosen is the construction of utility buildings and in particular the construction of offices. The choice for researching the sub-industry utility buildings was made because of its many different aspects of implementing innovations and because of the large group of different stakeholders. In this sub-industry different types of buildings can be observed, e.g. office buildings, schools, hospitals, etc. Each type of building has its own requirements and therefore its own specialities. To prevent mixing up different specialities and to find a consistent response of the respondents, one type of utility building, the office building, was randomly chosen to focus on.

Moreover, the Dutch construction industry is divided into three sub-industries, which are “ground, road and water constructions”, “utility buildings”, and “housebuilding” industries. The reason for excluding the ground, road and water constructions is because this sub-industry is involved with many risks concerning environmental issues. The environmental impact of the construction of new highways that cross villages, waterways or natural parks is much higher than with utility buildings or housebuilding, and therefore more complex. According to KPMG’s supervisor Mr. Oldenhof this can reflect the innovation process, and therefore sub-industry ground, road, water constructions was excluded from this research.

Housebuilding has been excluded, because the construction process of office buildings is more extensive. In a housebuilding project, where multiple houses are built at once, the design and construction process consists of many repetitions per house. This is a less extensive than for office buildings, and therefore less interesting.

The choice was further enhanced because of the stakeholders involved in building offices, namely: project initiators, architects, engineers, contractors, and technical service provider. There are public as well as private project initiators in the construction of office buildings. This gives a large variety in the group of respondents for the Q-method interviews. Each stakeholder group used for the interviews will be described hereafter:

- Project initiators

These are people initiating to build something new or renovate old building. This group can consist of e.g.: government organisations, financial organisations, project developers, etc.. Shortly, everyone that is initiating an office building project.

• Architects

Architects are the people that create and design the buildings. Architects are commonly seen as creative people that come up with innovative ideas and find new solutions to existing problems or complex situations.

• Engineers

Engineers are the group of stakeholders which make a constructive feasibility study of the ideas from the architectural drawings. This group needs to take into account all rules set by local and international government, such as the NEN-norms or ISO-standards.

• Contractors

The contractors construct and build the project.

• Technical service providers

This group is responsible for installing all products that come from the manufacturing industry, like lightning systems, fire indication systems, etc. According to Drejer and Vinding (2006), the rate of innovation is much higher in the manufacturing industry than in the construction industry. Technical service providers, in comparison with other stakeholders, are forced by the manufacturing industry to implement new products. Hypothetically, this group should be more innovation driven or at least have another perspective on innovation.

"The frequency of innovation in the industry is generally considered rather low." A Danish survey found that:

- **58% of firms in the manufacturing industry,**
- **44% of firms in trade and services, and**
- **22% of firms in the construction industry**

had introduced new products or services during the period from 1998 to 2000 (Drejer and Vinding, 2006)

Another research boundary is the focus on disruptive innovations (see §2.1.1) in construction industry of office buildings. The diversification in types of innovations is showing the different characteristics per innovation. It is likely that a disruptive innovation requests a more complex implementation process in comparison with the implementation of a sustained innovation.

3.1.2. Similar researches

Before starting the research, a study has been done to find out if this research or similar research is executed previously. Scopus.com has been used to find all relevant articles about innovation in the construction industry. Scopus.com is an online database with scientific articles and by using a combination of keywords one finds research connected to the keywords. The following combination of keywords was found most successful:

• TITLE-ABS-KEY ((innovation) AND ("construction industry" OR "building industry" OR "building and construction" OR "project based industry" OR "project-based"))

With this search phrase, the keywords "innovation" and different definitions of "construction industry" were searched in the titles, abstracts and keywords of articles. Without any further restrictions, Scopus found 2414 hits. A restriction on basis of relevance with a minimum of 50 citations per article, resulted in 81 hits. This list of 81 articles was evaluated on similarity of articles with the same topic as this research. The conclusion of this study is: there is no similar research done previously.

3.2. Literature research

The goal of the literature research was to find out which factors could be derived from literature that are relevant for the implementation of disruptive innovations in the construction industry. This paragraph explains which decisions have been made in the literature research.

3.2.1. Factors found in literature research

From the literature research four factors can be derived:

- Human factors
- Organisational factors
- Financial factors
- Rules and regulating factors

These factors have also been used as guidance in the execution of the Q-method.

These factors were found by making use of the theory found in literature, which is based on the number of times an article is cited in other scientific work. The most prominently used articles in §2.1 are from Bower and Christensen (1995) and Geels (2002).

According to Google Scholar, the article published by Bower and Christensen (1995) has been cited 2200 times. In Chistensen's later book "The Innovator's Dilemma" (1997), he describes his earlier work and elaborates on the definition of disruptive innovations. According to Google Scholar, this book has been cited almost 14000 times in other scientific work. The article and especially the book are having a high amount of citations. It may be concluded that the definition of Bower and Christensen is the most general theory on innovations.

Geels' (2002) article, describing the development of disruptive innovations, has been cited 2500 times in scientific work.

3.2.2. A quick scan by professionals

This paragraph describes (see §2.3) a quick scan of the factor in the literature done by professionals from the industry. This quick scan consists of three qualitative interviews, by making use of a semi-structured interview method. The structure in the interviews is based on the four factors found in literature. The professionals were asked to explain their experiences with disruptive innovation in the construction industry. The reason for using the semi-structured method is to create openness in the interview, in order to give room for the interviewee to give his or her input.

Retrospect, the predefined structure was not always needed, because the professionals came up with the factors themselves. The outcome of the quick scan is that no new factors were mentioned by the professionals.

The people that have been interviewed are:

- Mr. Nijssen – Former CEO Ingenieursbureau Rotterdam (Advisory organisation for municipality Rotterdam)

The added value to interview Mr. Nijssen is because of his broad experience in the construction industry and his personal interests in innovation. As engineer, Mr. Nijssen had a leading role in innovative projects in the building environment of Rotterdam, and in particular in the field of urban areas. Mr. Nijssen was mostly active in the early stages of construction projects.

- Mr. Oldenhof – Former CEO Strukton Worksphere

The benefit of interviewing Mr. Oldenhof is because of his managerial and financial perspective on innovation in the construction industry. As contractor, Mr. Oldenhof was mainly involved in concrete construction work. During his career, he had to cope with many established rules and contracts, and thus has another view on innovation than Mr. Nijssen.

- Rijksvastgoedbedrijf

The "Rijksvastgoedbedrijf" (RVB) is a government organisation that manages all governmental real estate in The Netherlands. They are an initiator in many construction projects.

  * Mr. Mol – Head of Procurement and Contract Management

As Head of Procurement and Contract Management, Mr. Mol has a financial view on innovations in the construction industry.

  * Mr. Kerpel – Head of Durability and Comfort

Mr. Kerpel is head of section Durability and Comfort. His section gives advice on improvements of building processes and on climate and durable aspects. Innovation is in his section an important topic since complex cases need to be solved, where current technologies cannot always function as a solution.

  * Mrs. De Lint – Zorge – Manager Green Technologies Programme

Mrs. De Lint – Zorge is programme manager at the Green Technologies programme (PGT). The programme is an initiative out of the RVB. The main goal of this programme is to find ways to establish energy neutral buildings. The focus in this programme is on technological innovations that will lead to the energy neutrality.

Mr. Kerpel and Mrs. De Lint – Zorge have both managerial functions in durable programmes. Both are thus decision-makers concerning innovations in terms of durable technologies.

3.3. The Q-methodology

The Q-method is a research method to study people's subjectivity that is their viewpoint. It has been used to examine how people think about a certain topic. The purpose of the Q-method is to find out what perspectives people have in the Dutch construction industry of office buildings on the implementation of disruptive innovations. In this paragraph, the preparation of Q-methodology is explained.

In order to find out what perspectives people have on a certain topic several methods can be applied. The Q-methodology is able to collect these perspectives in a quantitative and qualitative manner. Since the perspective of the respondent is captured via a quantitative manner, each respondent is equally treated and the involvement of the researcher's subjectivity is limited. As opposed to the most commonly used method, face-to-face interviews, which brings a certain subjectivity along. The subjectivity in face-to-face interviews is mostly due to the questions, the manner of questioning of the researcher, and how he interprets the answers. Because more objective results are appreciated, limiting the researcher's subjectivity in the research method is important.

Another effect of limiting the researcher's subjectivity can be found in the treatment of the respondent. During the execution of the research, the researcher's opinion on the research topic can alter. By using the Q-method, the research keeps treating his respondents equally during the whole execution of the research (Watts & Stenner, 2012). In order to understand and execute this method, the book Doing Q-methodological Research of Watts and Stenner (2012) has been used.

With the Q-method a strategically chosen group of 30 to 40 respondents (the P-set) have been asked to rank a set of statements that reflect a certain topic. The Q-method is a type of factor analysis. A normal factor analysis has the aim to find correlation between different variables, such as age, weight, density of population, etc. Mostly they are executed through a questionnaire and a large population of respondents is needed to get significant outcome. The possible outcome of a normal factor analysis is a validation of a theory.

The Q-method, on the other hand, looks at the respondents involved and how they correlate. The variables – in the Q-method variables are statements about the research topic (the Q-set) – are used to let the respondent express him-/herself. By a validation per statement, the respondent creates an identical pattern of statements (the Q-sort) that reflects the perspective of the respondent. The validation goes through a predefined pattern what helps to compare each individual Q-sort.

The individual Q-sorts are then studied to find the correlation between different sorts and thus between the perspectives of respondents. The outcome of this correlation study is that the Q-sorts can be grouped with other sorts that are similar. Moreover, out of the grouped Q-sorts a common perspective on the research topic can be derived. This particular outcome is most interesting for this research. What does a group find most important and what not?

Besides capturing perspectives by using statements, a questionnaire is used to document the differences in respondents. It is namely interesting to know what type of person was having this perspective. Finally, the respondent is asked why he placed the statements as he did. This last step of the Q-method is executed to get a better understanding of the respondent and eventually to get a better understanding of the respondents grouped by the correlation study.

This outcome can then be compared with the factors derived from literature. An advantage of using the Q-method, is the lower processing time per interview in comparison with face-to-face interviews. This advantage results in being able to include more participants in the Q-method.

3.3.1. Statements in the Q-set

In order to have a representative set of statements, a concourse of 200 to 400 statements has been created that covers everything about the subject (Watts & Stenner, 2012). All types of resources have been used to collect these statements. In this research, Dutch construction magazines and books have been used to create the concourse. According to Watts and Stenner (2012), selecting statements does not necessarily have to proceed through a structure. However, in this research the factors found in the literature have been used to give structure in the selecting and sampling of statements.

The sampling of the statements have resulted in a Q-set of about 40 to 80 items. The more statements that will be included in the Q-set the more the sorting process will be demanding and unwieldy (Watts & Stenner, 2012). Watts and Stenner (2012) also underline the fact that the set must always be broadly representative of the entire opinion domain.

Because the factors from the literature research have been used in the selection of the concourse, the statements were already categorised. In this research the deducting sampling method is used, whereby the statements have been sampled covering the importance of the factors from literature. The statements reflecting the factors the most are used in the Q-set. On top of that, to have the most outstanding results in the Q-sorts, contradicting and confronting statements have been used in the Q-set (Watts & Stenner, 2012). In this research, 38 statements have been selected that form the Q-set.

Finally, the Q-set has been verified by professionals in the construction industry. Mr. Oldenhof and Mr. Nijssen have separately been verified the Q-set.

3.3.2. Respondents in the P-set

The P-set is a strategically chosen set that consists of 30 to 60 people out of a group that is representative for the population where the Q-method is applied to. For the results of the Q-method, it is most interesting to have a large difference in perspectives. This diversification comes from respondents, it is thus needed to find a large diversification of respondents in the P-set. The P-set should therefore consist of all stakeholders (as described in §3.1.1) from different projects.

Due to the fact that each project has its own characteristics, a variation can be made in the different projects. In each project, a diverse range of firms form a project coalition. Each firm is participating in the coalition because of their single specialism (Brewer & Gajendran, 2011; Harty, 2005). It is therefore interesting to select a set of construction projects and find in these projects respondents for the execution of the Q-method.

The following projects have been analysed and chosen as most interesting to find respondents and construct the P-set. Because these projects vary a great deal in characteristics, which means a great variety of stakeholders and therefore interesting for the P-set. Most respondents of the P-set were found via the following projects:

- The Edge, Amsterdam

Because of the aim of this project, to create the most durable office in the world, several innovations could be implemented in the construction project (Randall, 2015). Already during the tender process, technical service providers took the lead in this project. People that worked with this project can be considered as innovative minded.

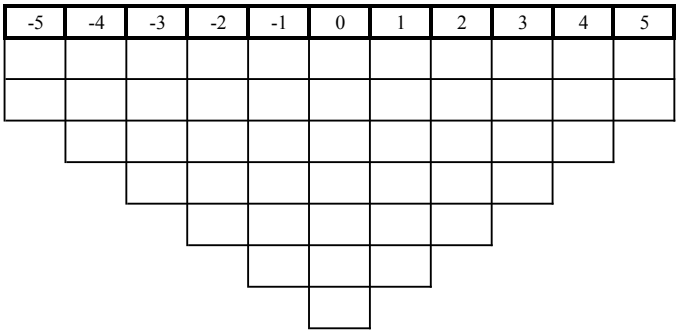

Figure 8: Example pattern of a Q-set

- Faculty of Applied Sciences (Technische Natuurwetenschappen), Delft

This new faculty building has besides offices and lecture rooms a unique vibration-free laboratory. Therefore the participating firms in the construction project need to combine several highly specialised skills in one project, which requests a very efficient collaboration.

- Office building Gazelle (bicycle manufacturer), Dieren

In comparison with the previous two office buildings, the office of Gazelle is straightforward. The old factory was renovated and a newly built office was added to the old construction. The reason for including this construction project is because of its straightforwardness, which reflects the respondent's perception of implementation of disruptive innovations.

- Rijnstraat 8, Den Haag

Former office of Dutch ministry VROM goes through a major transformation and becomes an office for multiple Dutch ministries. The reason for including this construction project is because of its size (85.000 m2) and its location. This construction project has the largest floor space of the four selected projects and is being build in a highly populated area, next to The Hague Central Station. Due to this highly populated area, there is very little workspace for the construction. Employees of this project need to be very efficient in their work.

The main source used to find these projects was the magazine Industriebouw. This monthly magazine focusses on utility buildings and discusses various construction projects. In these articles company names with its different stakeholders are mentioned. Via these companies possible respondents were found. In order to have enough respondents, the snowball effect sets in. The found respondents used their own network to find possible new ones. Respondents were also be found through cold acquisition. In this research, the final P-set consists of a group of thirty respondents.

3.3.3. The Q-methodology interviews

What has been mentioned before is that each respondent's perspective is reflected by his/her identical validation of statements. This has been done through an interactive manner. Cards with written statements were shown to the respondent. The respondent validated these cards as Totally disagree – Neutral – Totally agree. The respondent was than asked to look at the statements again and validate them from -5 to +5. This resulted in a pattern which has the format shown in Figure 8. The exact format of this pattern has been clarified in §4.1.2.

Beside capturing perspectives, it was also interesting to know what type of person was having this perspective. In order to document the differences in respondents a questionnaire has been made (see Appendix: Methodology). Structure of the questionnaire was based on other researches whereby the Q-methodology was applied.

Furthermore, since validation of the statements has been done on an interactive basis, it was needed to make face-to-face appointments with the respondents to receive data. The appointments were needed to know why the respondent placed the statements as he did. This information was than documented as personal notes and has been considered confidential, because each respondent has been participating in this research anonymously.

3.3.4. Factor extraction and analysis

When all Q-sorts were collected, they have been analysed. In order to do this a software tool was used that is able to structure and calculate all data. The PQMethod software written by Peter Schmolck has been used to analyse the data, which is recommended by Watts and Stenner (2012). After entering all Q-sorts, a couple of steps were made in order to create sense out of the data. (See Appendix: Methodology for a more thorough explanation)

Within the PQMethod there are two different methods of analysis: the Principal Component Analysis (PCA) and the Centroid Factor Analysis (CFA). In this thesis the CFA has been used, because of the "…permissiveness it allows in relation to data exploration" and it "is highly regarded by Q-methodologists" (Watts & Stenner, 2012).

The result of the CFA is an unrotated factor matrix, where all Q-sorts have been analysed on the basis of the valued statements (see Appendix: Factor matrices). From each factor the eigenvalue has been calculated which shows the importance of the factor compared to other factors.

The main reason for calculating the eigenvalue is to know how many factors are valid (EV>1,00) to use in further analysis of the data. In line with Watts and Stenner (2012) the Kaiser-Guttman criterion has been used in this thesis, where eigenvalues less than 1,00 are taken as a cut-off point for the extraction of factors. However, this method should be taken as a helpful parameter, and not as a rule to be obeyed (Watts & Stenner, 2012).

In order to further analyse the extracted factors, a more understandable factor matrix was needed. This was done by rotating the seven factors. The factor loadings were structured so that they are more equally divided on the axes of the different factors (Watts & Stenner, 2012). In the PQMethod-software there are two possibilities for factor rotation: by hand or via the varimax method. The varimax method is the result of a statistical calculation, in order to have the maximum variance. Because the method by hand is very time consuming, the varimax rotation has been used. The result of this rotation is the "rotated factor matrix" (see Appendix: Factor matrices) and a correlation matrix (see Table 3).

The factor loadings in the rotated factor matrix tell something about the representativeness of the Q-sort in that factor. The PQMethod-software selects the most representative Q-sorts per factor and uses them to create a "representative Q-sort". Meaning that per extracted factor a Q-sort is shown that represents the shared vision of the selected Q-sorts in that factor.

This representative Q-sort per factor together with the information of those respondents from the questionnaire and personal notes were the basis of the factor analysis described in §4.4. Each factor was analysed by looking at statistics, such as the eigenvalue and correlations. The group of respondents was analysed by making use of the data received from the questionnaire and personal notes. Representative Q-sort was analysed on the most excessive validated statements.

After the description per factor, §4.5. gives comparisons between the respondents per factor and the statements valued by the factors. Resulting from this comparison is a general perspective of the respondents on the research topic and the reason why some statements have been valued contrastingly by the factors.

4. RESULTS FROM THE Q-METHODOLOGY

The purpose of this chapter is to find out what perspectives people have in the Dutch construction industry of office buildings on the implementation of disruptive innovations. As described before the Q-method has been applied to find this out. The first paragraph (§4.1) of this chapter describes which respondents took part in the P-set and which statements formed the Q-set. The second paragraph (§4.2) describes the results obtained from the questionnaire. In the third paragraph (§4.3) is described how many factors are extracted and analysed in the fourth and fifth paragraph (§4.4 and §4.5). In the concluding paragraph (§4.6) the answer to the third sub-research question will be given.

4.1. P-set and Q-set

4.1.1. P-set

The final P-set consists of a group of thirty respondents (see Appendix: P-set & Q-set). These respondents come from twenty-two companies. The average amount of work experience is seventeen years per respondent. Twenty-six respondents are men and four are women. Twenty-five respondents are decision-makers concerning the implementation of innovations. The following list shows the percentages of the involvement per stakeholder group:

- 30% Initiator
- 17% Architect
- 27% Engineer
- 16% Contractor
- 10% Technical service provider

The reason for the dissimilar percentages among the different stakeholder groups is due to the low response of some stakeholder groups. Retrospect, it was difficult to find the same number of respondents in the stakeholder groups of the four approached construction projects (see §3.3.2). The reason herefore was an inefficient snowball effect and the low response on cold acquisition.

4.1.2. Q-set

Out of the concourse, 38 statements have been selected that form the Q-set (see Appendix: P-set & Q-set). In order to find maximum diversity in the selection of the statements, a range of eleven values is chosen. The respondent can value the statements between -5 and +5 (see Figure 9).

4.2. The questionnaire

The purpose of the questionnaire is to collect information from the respondent. This information is used to make a comparison between the respondents in the extracted factors. The respondents were asked some questions about how they perceive innovation. The majority of the respondents answered the following questions the same:

- Does your company work together with other firms to stimulate innovation? (26 out of 30 said yes)
- Does your company stimulate innovation via internal projects, such as innovation awards, incubators, etc.? (20 out of 30 said yes)
- Are you prepared to implement a radical innovation in your organisation? (27 out of 30 said yes)
- During day-to-day work, do you feel stimulated to innovate? (21 out of 30 said yes)

To the multiple-choice question about the reason why the respondent wants to innovate, the majority (21 out of 30) answered that they innovate because of personal reasons. Eight respondents answered that their environment forces them to innovate. One respondent gave an alternative answer, whereby he claimed that due to his function (junior) in the firm he is not able to influence the innovation process.

The question about who is responsible for innovation in the respondent's firm is not commonly answered. The following answers where given:

- Every individual in the organisation (7 out of 30).
- Each person with a budget, such as a project leader or tender manager (11 out of 30).
- An appointed department (7 out of 30).
- Only on board level (5 out of 30).

A possible reason herefore can be that people find it hard to communicate the right information to the right persons, because of the complicated organisational structures in the construction industry (see §2.2.3).

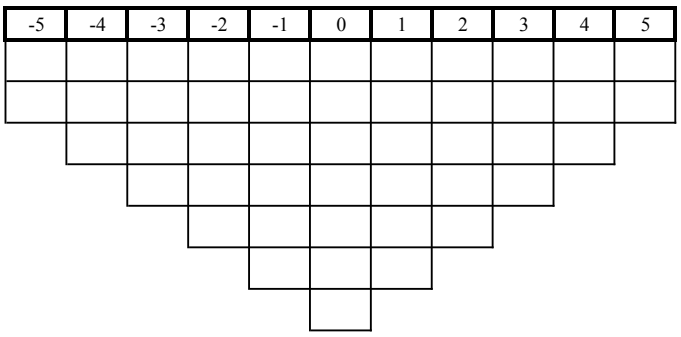

Figure 9: The Q-set pattern

The multiple-choice question about how recruitment of talented people is organised, resulted in the following answers:

- By their own department (14 out of 30)
- Online or by using their own network (10 out of 30)
- By the help of an intermediary (5 out of 30)
- Not using any method (1 out of 30, self-employed)

From these answers can be concluded the majority of the companies have their own recruitment department.

In conclusion, the majority of the respondents are willing to innovate. They observe stimulating impulses in their companies to innovate (such as innovation awards). However, there is a large variety in the perspective in who is responsible for an innovation.

4.3. Factor extraction

This paragraph shows the extracted factors that are used for further analysis. After applying the CFA (see methodology in §3.3.4), Table 1 shows the eigenvalues of the unrotated factor matrix (see Appendix: Factor matrices). It can be observed that five factors satisfy the requirement (EV>1,00), which means that F4 and F6 are not passing this criterion and thus will be eliminated out of the research. There are thus five factors extracted and used in further analysis.

The varimax factor rotation results in the rotated factor matrix (See Appendix: Factor matrices). In Table 2 the eigenvalues of this matrix is shown. When comparing the different eigenvalues, F1 has the lowest eigenvalue compared to the other four factors. This means that F1 is the least important factor. The difference between F1 and F2 (the factor with the second lowest eigenvalue) is 0,57 and is far below the other four factors and is therefore the least interesting when analysing the factors.

The correlation matrix (see Table 3) shows the correlations between the different factors. From this table can be concluded that F1, F2, and F3 correlate most with F5. Differently said, F5 correlates very much with other factors. Therefore, F5 is not having an explicit view on the research topic. For this reason, F5 is not very interesting when analysing the factors

To conclude the factor extraction, there are five factors derived from the Q-methodology. After rotating the five factors, an analysis of the eigenvalues and the correlation matrix result in: F2, F3 and F4 having the prior interest for further analysis. F1 and F5 thus have a lower interest in the analysis and a lower impact on the final conclusion of this report.

Table 1: Eigenvalues of unrotated factors

Factors	F1	F2	F3	F4	F5	F6	F7
EV	7,32	1,87	1,58	0,18	1,54	0,12	1,28

Table 2: Eigenvalues of rotated factors

Factors	F1	F2	F3	F4	F5
EV	2,16	2,73	3,00	3,05	2,76
Range	0,90				
Average	2,74				
F1 - F2	0,57				

Table 3: Correlation matrix (read horizontal)

	1	2	3	4	5
1		0,17	0,35	0,42	0,42
2	0,17		0,32	0,38	0,46
3	0,35	0,32		0,31	0,52
4	0,42	0,38	0,31		0,33
5	0,42	0,46	0,52	0,33	

4.4. Factor description

The outcome of the correlation study with respect to the Q-sorts, is that the Q-sorts are grouped with other similar sorts. A set of similar Q-sort is called a factor. Out of each factor, a common perspective on the implementation of disruptive innovations in the construction industry of office buildings can be derived. In this paragraph a description per factor is given. Detailed information per factor can be found in Appendix: Factor descriptions.

The perspectives presented in this paragraph will be compared to the literature in the next chapter (see ch. 5), the conclusion.

This paragraph will only discuss the outcomes of the Q-methodology.

Each factor description starts with a description of the respondents. The group of respondents was analysed by making use of the data received from the questionnaire and personal notes. Afterwards the representative Q-sort belonging to the common perspective is described. The representative Q-sort is analysed on the most excessive validated statements.

4.4.1. Factor 1 (F1) – Transformation in behaviour

The respondents selected in this factor are second with respect to the least years of work experience (18 years) compared to the other respondents in the other factors. They are second highest with respect to the number of employees in the company (5080 employees). In this factor, there are five Q-sorts selected and the respondents per stakeholder group vary, namely:

- One project initiator,
- one architect,
- one engineer, and
- two contractors.

Interestingly, the job-descriptions of the respondents in this group have similarities. Namely, the engineer and architect in this group are owner-directors and one of the contractors is senior strategy consultant for the largest Dutch contractor. During the interviews, it appeared that the majority in this factor has a visionary view on innovation. Meaning, they think innovations have potential and believe in the opportunities they can create. With respect to the respondents' view on innovation, average work experience, and job-descriptions, they can be characterised as visionary entrepreneurs.

The statements where the respondents agreed to most are listed below:

- The industry has to deal with old behaviour in a new world. (19)
- More effective collaboration is the most important renewal in the construction industry. (7)
- Soft skills have become a condition in the tender process and for the realisation of projects. (27)
- Innovations turn out to have a higher rate of success in times of crisis. (20)

The statements where the respondents disagreed to most are listed below:

- Profits do not justify the costs of the investments. (24)
- Henk Kamp has to make more money available for innovations in the Dutch construction industry. (22)
- The innovation process goes slowly, annoyingly slow. (36)
- Currently the construction industry transforms at an enormous pace from conservative to innovative. (34)

According to the listed statements, the common perspective in this factor on the implementation of disruptive innovations in the Dutch construction industry of office buildings is:

A *transformation in behaviour is needed* to change the implementation process.

The visionary entrepreneurs of F1 give priority to the statement that the construction industry has to deal with old behaviour in a new world (see statement 19), where soft skills have become a condition for executing projects (see statement 27). They disagree highly that the construction industry transforms at an enormous pace from conservative to innovative (see statement 34).

4.4.2. Factor 2 (F2) – Financial restrictions

The respondents in F2 have the most years of work experience (24 years), which is almost equal to the work experience in F4. They are lowest with respect to the number of employees in the company (140 employees). In this factor, there are five Q-sorts selected and the respondents per stakeholder group vary, namely:

- Two project initiators,
- One architect,
- One engineer, and
- One technical service provider.

Looking closer at the respondents, the two project initiators are both employed by a governmental organisation and have both over 25 years of work experience. The technical service provider and one project initiator are both at the age of retirement. What all respondents' functions have in common is the regulation of policies in their organisation. For this reason, the common job description of this group is characterised as policy makers.

The statements where the respondents agreed to most are listed below:

- The rule of play: Who pays, determines. (23)
- Extra investments must be earned back within one project. (26)
- Project initiators, industry and knowledge centres can collectively improve innovation. (8)
- Stakeholders in the construction industry don't want to share innovation. (14)

The statements where the respondents disagreed to most are listed below:

- There is a "war on talent" going on. (29)
- The current submission procedure is not provocative enough to deviate from standard processes. (11)
- Profits do not justify the costs of the investments. (24)
- Henk Kamp has to make more money available for innovations in the Dutch construction industry. (22)

According to the listed statements, the common perspective in this factor on the implementation of disruptive innovations in the Dutch construction industry of office buildings is:

The *financial restrictions* are limiting the implementation process, because in their opinion it is only interesting to innovate when one generates risk free profit.

The policy makers of F2 give priority to the statement about financial factors and financial restrictions (4 out of 8 statements, see statement 23 and 26). They strongly disagree with statement 11: the current submission procedure is not provocative enough to deviate from standard processes.

4.4.3. Factor 3 (F3) – Traditional informal control system

In comparison with the other factors, the respondents in this factor have the least work experience (10 years). With respect to the amount of employees in the company, F3 is highest (16110 employees). In this factor, five Q-sorts have been selected and the respondents per stakeholder group vary, namely:

- One project initiator,
- Two engineers,
- One contractor, and
- One technical service provider.

Three respondents, from different stakeholder groups, have junior functions. The contractor is trend watcher and advises the board of directors directly. One of the two engineers is manager of IT-projects within the engineering company. Because of the average years of work experience and the majority of junior functions in this group, the common job description of this group is defined as juniors.

The statements where the respondents agreed to most are listed below:

- Having an innovative culture and structure is essential in a fast moving environment (1)
- Retain and train talented employees is essential for innovations. (28)
- Traditional patterns are blocking renewal in the construction industry. (35)
- Another culture is the key to change the current practise. (6)

The statements where the respondents disagreed to most are listed below:

- Solutions have to come from the market. (10)
- Currently the construction industry transforms at an enormous pace from conservative to innovative. (34)
- An economic boom creates space for innovation. (21)
- Extra investments must be earned back within one project. (26)

According to the listed statements, the common perspective in this factor on the implementation of disruptive innovations in the Dutch construction industry of office buildings is:

The traditional informal control system needs to change in order to influence implementation process.

The juniors of F3 give priority to the statement about organisational factors (5 out of the 8 statements). The respondents are in favour of an innovative culture and structure in an organisation and traditional patterns are thereby blocking renewal in the construction industry (statement 1 and 35). Another culture is the key to change the current practise, which is according to the juniors achieved by retaining and training talented employees (statement 6 and 28)

4.4.4. *Factor 4 (F4) – Collaboration between people*

The respondents in this factor have an average of 23 years work experience, which is roughly the same as the work experience in F2. Just like F2, they have a low number of employees in the company (150 employees). This factor consists of five Q-sorts, where the respondents cover three stakeholder groups, namely:

- Two project initiators,
- Two architects, and
- One contractor.

In F4, one of the project initiators is employed at private investment company and is a senior project manager. The other project initiator is employed at a consultancy firm that advices governmental organisations on the start-up of building projects. The contractor is also employed at a consultancy firm and advices contractors in their tender process. One of the architects is an owner-director and the other is a project manager. They both have over 20 years of work experience. One of the two architects is close the age of retirement. Taking into account the notes of the interviews, the respondents in this factor see innovation as a long-term strategy. For this reason, the common job description of these respondents is defined as strategical managers.

The statements where the respondents agreed to most are listed below:

- Soft skills have become a condition in the tender process and for the realisation of projects. (27)
- More effective collaboration is the most important renewal in the construction industry. (7)
- To stimulate innovations, there must be more collaboration with other disciplines, such as the creative industry. (38)
- Having an innovative culture and structure is essential in a fast moving environment. (1)

The statements where the respondents disagreed to most are listed below:

- An extensive “yes-but” culture dominates all actors of the building process. (13)
- Stakeholders in the construction industry don’t want to share innovation. (14)
- Profits do not justify the costs of the investments. (24)
- Henk Kamp has to make more money available for innovations in the Dutch construction industry. (22)

According to the listed statements, the common perspective in this factor on the implementation of disruptive innovations in the Dutch construction industry of office buildings is:

An increasing collaboration between people will fasten the implementation process.

The strategic managers in F4 rate statements highest that concern a better collaboration between people (statement 27) and between different industries (statement 38). Whereby statements about human factors (4 out of the 8 statements) are rated high. However, they say that stakeholders in the construction industry do want to share innovations (statement 14).

4.4.5. Factor 5 (F5) – Exchange of knowledge and know-how

With respect to the average years of work experience (19 years), this factor is second highest. The average number of employees in the companies is 830 employees. In this factor, four Q-sorts have been selected, instead of five in the other factors. The respondents per stakeholder group vary, namely:

- One project initiator,
- Two engineers, and
- One technical service provider.

Job descriptions of the respondents are managerial functions with a strong focus on innovation. Two respondents are managers of durable programmes where they implement innovations to decrease energy costs and increase durability of work processes. For this reason, the common job description of the respondents in this group is defined as innovation managers.

The statements where the respondents agreed to most are listed below:

- In the construction industry one is afraid of competition disadvantage. (4)
- Stakeholders in the construction industry don't want to share innovation. (14)
- More effective collaboration is the most important renewal in the construction industry. (7)
- Soft skills have become a condition in the tender process and for the realisation of projects. (27)

The statements where the respondents disagreed to most are listed below:

- Extra investments must be earned back within one project. (26)
- Innovations are not part of the builder's genes. (17)
- It is good to have, with certain types of issues, a party that can function from a limited distance, but is still an extension of the project initiator. (32)
- Profits do not justify the costs of the investments. (24)

According to the listed statements, the common perspective in this factor on the implementation of disruptive innovations in the Dutch construction industry of office buildings is:

The *exchange of knowledge and know-how must increase* in order to fasten the implementation process.

Namely, the innovation managers rated statem ents with human factors (5 out of 8 statements) and especially the single human factors predominate. The respondents in this factor find it very important to exchange knowledge and know-how between others in the industry and more collaboration is important (see statement 4,14 and 7). However, they are of the opinion that people in the construction industry do innovation in their builder's genes (see statement 17).

4.5. Factor comparison and interpretation

After t he description per factor, this paragraph gives comparisons between the respondents per factor and the statements valued by the factors. The purpose of this paragraph is to find out a general perspective of the respondents on the implementation of disruptive innovations in the Dutch construction industry of office buildings. Furthermore, the purpose is also to find out what why some statements have been valued contrastingly by the respondents in the different factors.

Table 4 is a comparison of the different respondents per factor. Based on this table and on the previous paragraph (§4.4) the most interesting observation is a large variety in different stakeholder groups per factor.

With respect to the average years of work experience, average number of employees and job descriptions, many similarities can be observed between F2 and F4. On basis of these three variables, the least similarity can be observed between F2 and F3.

Interesting for further analysis is finding differences between F2 an F4. When taking the variety in stakeholders into account, F4 has a lower number of variety compared to F2. Moreover, both project initiators in F2 are employed at governmental organisations. Whereas in F4 there are no respondent employed at a public organisation. With respect to the age of retirement, two respondents in F2 are close to this age and in F4 this is only one respondent.

Table 5 shows the comparison between the different factors, whereby only the most excessive statements (+5, +4, -4, and -5) are taken into account. Besides, this table only shows statements that are rated in three or more factors at the same time. The reason to create this table is to know whether there is a common perspective among respondents. Also, it is interesting to know whether statements are contrastingly rated by the respondents in the factors.

Regarding the common perspective, the following statements have been rated equally in at least three factors:

- Statement 24 has been rated negatively in four of the five factors:
  * Profits do not justify the costs of the investments. (24)
- Statement 22 has been rated negatively in three of the five factors:
  * Henk Kamp has to make more money available for innovations in the Dutch construction industry. (22)
- Statement 27 has been rated positively in three of the five factors:
  * Soft skills have become a condition in the tender process and for the realisation of projects. (27)
- Statement 7 has been rated positively in three factors:
  * More effective collaboration is the most important renewal in the construction industry. (7)

The common perspective of all factors in this study concerns financial and human factors. The respondents in the factors assume that innovations in the Dutch construction industry of office buildings are profitable and that there is no investment needed from the Dutch government to boost the implementation of disruptive innovations (statements 24 and 22). The majority of the respondents stated that a more effective collaboration is the most important renewal (statement 7) to the implementation of these innovations. They see soft skills as

Table 4: Comparison of the different respondents per factor

	F1	F2	F3	F4	F5
Number of respondents	5	5	5	5	4
Representative respondent groups	4 out of 5	4 out of 5	4 out of 5	3 out of 5	3 out of 5
Eigenvalue	2,16	2,73	3,00	3,05	2,76
Average years of work experience	18 years	24 years	10 years	23 years	19 years
Number of employees	5080	140	16110	150	830
Job description	Visionary entrepreneurs	Policy makers	Juniors	Strategic managers	Innovation managers

Table 5: Most interesting statements according to factor scores

Statement	F1	F2	F3	F4	F5	total
24	-4	-4		-4	-5	4
26		4	-5		-4	3
22	-4	-5		-5		3
14		5		-5	5	3
7	4			5	4	3
27	5			5	4	3
34	-5		-5			2
1			5	4		2

a condition to achieve a better collaboration (statement 27).

Two statements have been rated contrastingly by the respondents, namely:

- Statement 26 is rated positively by F2 and negatively by F3 and F5:
  * Extra investments must be earned back within one project. (26)
- Statement 14 is rated positively by F2 and F5, but negatively by F4
  * Stakeholders in the construction industry don't want to share innovation. (14)

Looking at the contrastingly rated statement 26 (Extra investments must be earned back within one project.). F2 agrees to this statement. This is an interesting observation, because a disruptive innovation requires an encouraging and consistent investment that is not related to a construction project.

The respondents in F2 can be considered conservative, because in the personal notes of the interviews they reject potential success of innovation based on their experiences. They see mainly problems when speaking about innovations. F2 agrees to statement 26, which confirms the conservative view of the policy makers in this factor. Because of the above reasoning, the respondents in F2 can also be considered laggards in the innovation process of the construction industry. Namely, they do not see the current situation holding up the innovation process and only point out financial factors to be of importance in the implementation of disruptive innovations.

F3 has rated statement 26 negatively. The juniors in F3 have on average the least years of work experience and they are characterised by having an organisational perspective. From their junior perspective, it is logical that they disagree with this statement, because of their long-term view on the implementation of innovation.

F5 also disagrees with statement 26. The respondents in this factor are characterised as "innovation managers" and they see the implementation of disruptive innovations mainly as long-term goal. For this reason it is logical that this factor disagrees with the statement.

By looking at the validation on statement 14 (Stakeholders in the construction industry don't want to share innovation), F4 disagrees, and F2 and F5 are in agreement. As discussed, F2 and F4 have much in common, but they disagree with each other on this statement. This can be due to the fact that F2 (conservative policy makers) sees sharing knowledge as a competitive disadvantage (see statement 4), where the strategic managers of F4 see innovation as an opportunity to innovate (see statement 37).

It is interesting that F4 agrees and F5 disagrees with this statement. The main reason for this disagreement is because they operate on different management levels. F4 operates on a higher management level and they participate in projects to improve collaboration between stakeholders. Whereas respondents in F5 operate on a lower management level and they mainly focus on achieving their goal to implement innovations. They see sharing knowledge as competitive disadvantage (see statement 4).

4.6. Conclusion from the Q-method

The main goal of this chapter was to find perspectives of people in the Dutch construction industry of office buildings on the implementation of disruptive innovations in their industry. These perspectives were found via the Q-methodology, and are described in this chapter. The perspectives presented in this chapter will be compared to the literature in the next chapter (see ch. 5), the conclusion.

This chapter will only discuss the outcomes of the Q-methodology.

Thirty respondents from the five defined stakeholder groups participated in this study. Each respondent is participating in the subindustry utility building and in particular in the construction of office buildings. A dissimilarity between the participating stakeholder groups can be observed. The reason herefore is the low response of some stakeholder groups. Retrospect, it was difficult to find the same number of respondents in the stakeholder groups of the four approached construction projects (methodology in §3.3.2). An inefficient snowball effect and the low response on cold acquisition was the reason herefore. However, with regards to the results, the type of stakeholder group does not influence the perspective of the respondent.

According to the questionnaire, the majority of the respondents are willing to innovate disruptively in the Dutch construction industry. They observe stimulating impulses in their companies to innovate (such as innovation awards). However, there is a large variety in who is responsible for an innovation, which can be related to the complex organisational structures in the construction industry discussed in §2.2.3.

By using the Kaiser-Guttman criterion, five factors are extracted in the Q-methodology. The common perspective of all factors in this study concern financial and human perspectives. The respondents in the factors assume that innovations in the Dutch construction industry of office buildings are profitable and that there is no extra investment needed from the Dutch government (statements 24 and 22). The majority of the respondents stated that a more effective collaboration is the most important renewal (statement 7) to the implementation of these innovations. They see soft skills as a condition to achieve this (statement 27).

Two statements (14 and 26) have been rated contrastingly by some factors. The reason that this happened is the different attributes of the respondents per factor.

According to the visionary entrepreneurs in the first factor (F1), a transformation in behaviour is needed in order to influence the implementation of disruptive innovations. The respondents give priority to the statement that the construction industry has to deal with old behaviour in a new world (see statement 19), where soft skills have become a condition for executing projects (see statement 27). They disagree highly that the construction industry transforms at an enormous pace from conservative to innovative (see statement 34).

According to the policy makers in the second factor (F2), the financial restrictions on the implementation of a disruptive innovation are the common perspective in this factor. Respondents of F2 give priority to the statement about financial factors and financial restrictions (4 out of 8 statements, see statement 23 and 26). They strongly disagree with statement 11: the current submission procedure is not provocative enough to deviate from standard processes.

According to the juniors in the third factor (F3), the common perspective in this factor is: the traditional informal control system needs to change. Respondents of F3 give priority to the statement about organisational factors (5 out of the 8 statements). The respondents are in favour of an innovative culture and structure in an organisation and traditional patterns are thereby blocking renewal in the construction industry (statement 1 and 35). Another culture is the key to change the current practise, which is according to the juniors achieved by retaining and training talented employees (statement 6 and 28)

According to the strategical managers in the fourth factor (F4), an increasing collaboration between people is the common perspective. Whereby statements about human factors (4 out of the 8 statements) are rated high by F4. The respondents rate statements highest that concern a better collaboration between people (statement 27) and between different industries (statement 38). However, they say that stakeholders in the construction industry do want to share innovations (statement 14).

According to the innovation managers in the fifth factor (F5), the common perspective in this factor is: the exchange of knowledge and know-how must increase. Namely, F5 consists of statements with human factors (5 out of 8 statements) and especially single human factors predominate. The respondents in this factor find it very important to exchange knowledge and know-how between others in the industry and more collaboration is important (see statement 4,14 and 7). However, they are of the opinion that people in the construction industry do have innovation in their builder's genes (see statement 17).

By making a comparison between the factors, some conclusions can be drawn regarding the perspectives of the respondent groups on the process of implementing a disruptive innovation in the construction industry of office buildings.

One of the conclusions is that the policy makers (F2), who are described as conservative in their perspective, think that financial factors are influencing the implementation of innovations in the construction industry. During the interviews it occurred that the respondents in this group judge innovations on basis of their experience in the industry. For these reasons, they can be considered as laggards in the process of implementing disruptive innovations.

Another conclusion is the similarity in the perspectives of the visionary entrepreneurs (F1) and the juniors (F3). They both agree that change is needed in current processes in the construction industry, where the visionary entrepreneurs point out that human interactions need to change and the juniors focus on organisational processes.

The visionary entrepreneurs focus on human factors, such as hierarchy and the informal control system in the construction industry. These have evolved in a behaviour with strong defined tasks and habits that do not leave room for changes in these tasks.

The juniors address organisational processes to be of influence on the implementation of disruptive innovations in the construction industry. Since the purpose of an organisational process is to steer and control human interactions, the juniors indirectly observe a formalisation and standardisation of human factors.

Another one of the conclusions is that the strategic managers (F4) and innovation managers (F5) find common ground. They agree both about the positive effect of a more effective communication on the implementation of a disruptive innovation in the construction industry. The strategic managers point out that the collaboration between people increases their knowledge and thus the understanding of the implementation of an innovation.

The innovation managers say the same, but in other words. They point out that there must be an increase in exchanging knowledge and know-how. Because by spreading this kind of information, it increases the understanding of how to implement an innovation.

5. CONCLUSION

In this chapter the conclusion of this research will be given. This chapter starts with a brief introduction of the research topic and the problem that is being discussed in this report. The first paragraph (§5.1) gives a comparison of the results in this research. In the first subparagraph the outcomes from the literature study are given (§5.1.1), in the second subparagraph the results found via the Q-methodology are given (§5.1.2), and in the third subparagraph a comparison of the two studies is given (§5.1.3). The conclusion of this research is given in the second paragraph of this chapter (§5.2).

A problem in the industry is the limited and slow implementation of disruptive innovations in the last hundred years. Another observation is that most disruptive innovations where implemented in the construction industry only after they had proven their success in another industry.

The objective of this research is to find out which factors influence the implementation of disruptive innovations in the Dutch construction industry and if people in the industry are aware of the factors that influence the implementation of disruptive innovations.

The expectation is that this information could support the more effective and faster implementation of disruptive innovations in the Dutch construction industry.

5.1. Results

This paragraph compares the influencing factors from the literature study with the perspectives from people in the industry found by using the Q-methodology.

The first subparagraph gives four factors found via the literature study (§5.1.1), the second subparagraph gives the five perspectives found via the Q-methodology (§5.1.2), and in the third subparagraph a comparison of the two studies is given (§5.1.3).

5.1.1. Factors from literature

The goal of the literature research was to find out which factors could be derived from literature that are relevant for the implementation of disruptive innovations in the construction industry. From the literature on innovation, the following factors influence the implementation of a disruptive innovation in the construction industry:

- Human factors:

The human factor has a direct influence on the implementation of disruptive innovations, because the behaviour of the people involved limits the industry's ability to reinvent itself and learn from other sectors. This is because in the construction industry the informal control system drives people, both single and collective, to stick to their role and their experiences. This system provides very strict rules and therefore deviation from them is hard. A side effect is that there is little room left for bonding and building up trustworthy relationships.

Another effect is that firms do not see it as their responsibility to improve the skills of and/or train their employees. Furthermore, in the construction industry a belief exists that only engineers with long records in the field can succeed. Hiring people from outside the industry happens rarely and is mostly resisted by the industry itself.

- Organisational factors:

The organisational factors steer and control human interactions in the implementation of disruptive innovations in the construction industry. These can be found in formal communication and documentation processes, whereby people are forced to process information in a predefined method.

On the other hand, organisational factors originate from human interactions. When people work according to an informal process and there is a structural repetition of this process, at a certain moment this process will be formalised and standardised.

Because of the complicated organisational structures and processes in the construction industry, people in the industry are hampered to communicate the right information to the right persons.

- Financial factors:

Financial factors have a major influence on the implementation of disruptive innovations. In order to implement such an innovation, encouraging and consistent investments are needed. For example, besides the purchase of new equipment, an adjustment of current work processes is required. This adjustment requires for example the retraining of employees, which demands a fundamental investment.

Besides, in comparison with other capital and labour intensive industries, the Dutch construction industry invests a very low percentage from their revenue on R&D projects. Due to a current surplus of construction firms, project coalitions underbid others and even below cost price to get a project, in order to keep their employees at work. In this unhealthy financial situation, there is no room for R&D investments. Furthermore, the Dutch construction industry beliefs that disruptive innovations have a very low or even negative return on investment.

- Rules and regulating factors:

The factor rules and regulations influences the freedom that a disruptive innovation needs to develop. First, the construction of an office building involves many risks for both the client and the coalition. These risks and responsibility are laid down in contracts. Secondly, a logical result of adjusting current work processes is the creation of new rules. These contracts and rules form a limitation in implementing a disruptive innovation and therefor one should be aware that things should be simplified and not be complicated.

5.1.2. Perspectives from the Q-method

On basis of the thirty respondents involved in the Q-method, this research discovered five different perspectives on the implementation of a disruptive innovation in the Dutch construction industry of office buildings.

The shared perspective among the thirty respondents is that they assume that innovations are profitable and that there is no extra investment needed from the Dutch government. The majority of the respondents stated that a more effective collaboration is the most important change needed and they see soft skills as a condition to achieve this.

According to the *visionary entrepreneurs* of the first factor (F1), **a transformation in behaviour is needed** in order to influence the implementation of disruptive innovations. The respondents give priority to the statement that the construction industry has to deal with old behaviour in a new world, where soft skills have become a condition for executing projects. They disagree highly that the construction industry transforms at an enormous pace from conservative to innovative.

Among the *policy makers* of the second factor (F2), the **financial restrictions** to the implementation of a disruptive innovation is the common perspective, because in their opinion it is only interesting to **innovate when** one generates **risk free profit**. Respondents of F2 give priority to the statement about financial factors and financial restrictions. They strongly disagree with statement: the current submission procedure is not provocative enough to deviate from standard processes.

According to the *juniors* of the third factor (F3), the common perspective is: **the traditional informal control system needs to change**. Respondents of F3 give priority to the statement about organisational factors. The respondents are in favour of an innovative culture and structure in an organisation, because traditional patterns are blocking renewal in the construction industry. Another culture is the key to change the current practise, which is according to the juniors achieved by retaining and training talented employees.

Among the *strategical managers* of the fourth factor (F4), an **increasing collaboration between people** is the common perspective. Statements about human factors are rated high by F4. The respondents rate statements highest that concern a better collaboration between people and between different industries. However, they say that stakeholders in the construction industry do want to share innovations.

Among the *innovation managers* of the fifth factor (F5), the common perspective is: the **exchange of knowledge and know-how must increase.** Namely, F5 consists of statements with human factors and especially single human factors predominate. The respondents in this factor find it very important to exchange knowledge and know-how between others in the industry and more collaboration is important. However, they are of the opinion that people in the construction industry do have innovation in their builder's genes.

By making a comparison between the factors, some conclusions can be drawn regarding the perspectives of the respondent groups on the process of implementing a disruptive innovation in the construction industry of office buildings.

One of the conclusions is that the policy makers (F2), who are described as conservative in their perspective, take position that financial factors are influencing the implementation of innovations in the construction industry. During the interviews it occurred that the respondents in this group judge innovations on basis of their experience in the industry. Thereby they are led by their experience in similar situations. For these reasons, they can be considered as lag-

gards in the process of implementing disruptive innovations.

Another conclusion is the similarity in the perspectives of the visionary entrepreneurs (F1) and the juniors (F3). They both agree that change is needed in current processes in the construction industry, while the visionary entrepreneurs point out that human interactions need to change and the juniors focus on organisational processes.

The visionary entrepreneurs focus on human factors, such as hierarchy and the informal control system in the construction industry. These have evolved in a behaviour with strong defined tasks and habits that do not leave room for changes in these tasks.

The juniors address organisational processes to be of influence on the implementation of disruptive innovations in the construction industry. Since the purpose of an organisational process is to steer and control human interactions, the juniors indirectly observe a formalisation and standardisation of human factors.

Another one of the conclusions is that the strategic managers (F4) and innovation managers (F5) find common ground. They agree both about the positive effect of a more effective communication on the implementation of a disruptive innovation in the construction industry. Hereby the strategic managers point out that the collaboration between people increases their knowledge and thus the understanding of the implementation of an innovation.

The innovation managers say the same, but in other words. They point out that there must be an increase in exchanging knowledge and know-how. Because by spreading this kind of information, it increases the understanding of implementing an innovation.

5.1.3. Comparing the perspectives with the factors

The common perspective from the Q-method is that the respondents express the opinion that innovation is profitable. However, literature says there is a common belief in the Dutch construction industry that disruptive innovations in the construction industry have a very low or even negative return on investment. The wish among the majority of the respondents for a more effective collaboration can be related to the effect of the informal control system (§2.2.4). Due to the informal control system there is little room for bonding and building up trustworthy relationships. The common perspective that soft skills have become a condition in the tender process and in the realisation of projects has a logical connection with the factor from the literature that the construction industry is lacking in strategic account management and cross selling.

When comparing the view of the visionary entrepreneurs (F1) with the literature, it is concluded that they are in line with each other. The visionary entrepreneurs say that a transformation in behaviour is needed to positively influence the implementation of disruptive innovations. In literature, there seems to be a common view among most authors that the construction industry would be better off changing behaviour in accordance with the norms of other industries.

When comparing the view of the policy makers (F2) with the literature, it is concluded that they are not in line with each other. The financial restrictions, e.g. that extra investments must be earned back within one project, are holding back the implementation process. In order to implement a disruptive innovation, encouraging and consistent investments are needed.

When comparing the view of the juniors (F3) with the literature, it can be concluded that they do not agree. The juniors express their dissatisfaction with the current situation in the construction industry. The juniors find that the

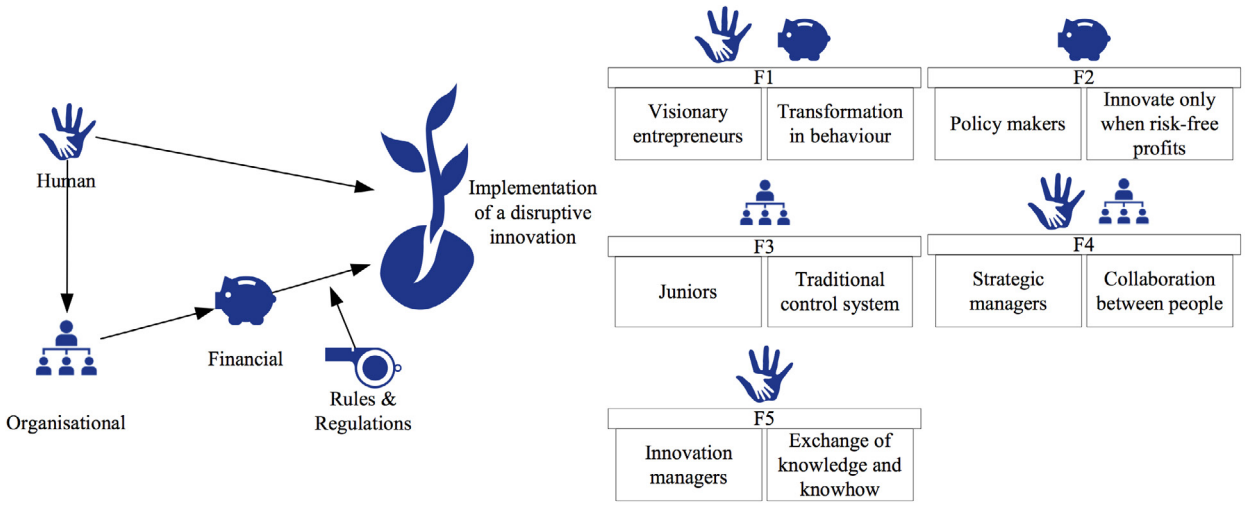

Figure 10: Relations between factors found in literature and perspectives found via the Q-method

traditional informal control system needs to change, which could be achieved by retaining and training talented employees. However, literature says that due to this informal control system, firms in the construction industry do not see it as their responsibility to improve the skills of or train their employees.

When comparing the view of the strategic managers (F4) with the literature, it can be concluded that they are in line with literature. Strategic managers find an increasing collaboration between people and other industries most important. One of the observations from literature is that a belief exists in the industry that only engineers with long records in the field can succeed. Hiring people from outside the industry happens rarely and is mostly resisted by the industry itself. The reluctance to accept input from other industries limits the industry's ability to reinvent itself and learn from other sectors.

When comparing the view of the innovations managers (F5) with the literature, it can be concluded that they are in line with literature. The innovation managers focus on the increase of exchange of knowledge and know-how. To reach this purpose a more effective collaboration is needed, which is also an observation in the literature.

The factors found in the literature and the perspectives found via the Q-method are put together in the above figure (see Figure 10).

It is interesting to observe that the policy makers (F2) do not see the current situation as a problem, where human and organisational factors are the starting point in the implementation process of a disruptive innovation in the construction industry of office buildings. The policy makers judge the success of an innovation based on their experience, i.e. they hold strongly on to the rules made in the socio-technical regime (see §2.1.2 Development of innovation).

However, the visionary entrepreneurs (F1) and the juniors (F3) observe the current situation as a problem. They see respectively human factors and organisational factors as the biggest influence on the implementation of a disruptive innovation in the construction industry of office buildings. The two groups contend that a change in the (in)formal rules made by the users in the construction industry positively influence the implementation process.

The strategic managers (F4) and the innovation managers (F5) observe this situation and according to their experience, they see communication positively influence the implementation of a disruptive innovation. The strategic managers (F4) focus on more collaboration between employees, firms, and industries. The innovation managers (F5) find the increase of exchanging knowledge and know-how more important. Both views have the same impact: a quicker acceptance and change of rules in the user groups in the construction industry.

5.2. Conclusion

The problem statement in the first chapter of this report was: Are people in the construction industry aware of the factors that influence the implementation of disruptive innovations? According to this research, the answer to this question is that the people in the Dutch construction industry of office buildings are not aware of all factors that influence the implementation of disruptive innovations.

The five respondent groups are working according to their own speciality and standards. Therefore each separate group has its own perspective on the innovations process. For this reason, people in the construction industry do not oversee the complete implementation process, which makes it hard to find any agreement in the decision-making process.

The question that in fact precedes the problem statement is if people in the Dutch construction industry are aware of the possibility of a different business case, with radical product innovation or business model innovations.

The outcome of this research is that the people included in this research have a limited awareness of this possibility. This is caused by the culture in the industry that is based on strict rules, like the informal control system. People in the Dutch construction industry do not look beyond their speciality and tasks. A logical consequence that there is little inter-industrial knowledge exchange.

Another reason why people are not aware of this possibility is the unhealthy financial situation of the Dutch construction industry at the moment. Because of a current overcapacity in the industry, firms sometimes tender construction projects below cost price. Furthermore, before the economic crisis of 2008 the construction industry invested very little in R&D and thus people in the construction industry were not used to invest in a disruptive innovation. Therefore, the current policy makers do not dare to invest in such innovations, because they are not used to this kind of investments and have little financial capacities to make these investments.

With regard to the research question, the factors from the literature study do not differ significantly from the factors from the Q-method. However, as discussed above, the respondent groups are not aware of all factors in the process of implementing a disruptive innovation in the Dutch construction industry of office buildings.

By using Figure 10, it can be seen that the financial factor influences the implementation process by reinforcing the organisational factor. The human factor has a direct influence on the implementation process. At the same time, the human factor has an influence on the organisational factor. This means that the financial and human factors play an important role in the implementation of disruptive innovations in the construction industry.

6. RECOMMENDATIONS, DISCUSSION AND REFLECTION

This chapter describes the recommendation, discussion and reflection by the researcher on the results of this research. In the first paragraph (§6.1) a recommendation is given how to improve the implementation of a disruptive innovation in the Dutch construction industry of office buildings. The second paragraph (§6.2) is the discussion of the research, where the research gives his thoughts about the results of the research. The third paragraph (§6.3) gives a reflection on the research structure and how the data have been collected.

6.1. Recommendations

In this paragraph, a recommendation is given how to improve the implementation of a disruptive innovation in the Dutch construction industry of office buildings.

The main recommendation is to aim for a transition towards a culture where people in the industry feel comfortable to exchange knowledge and know-how intra and inter-industrial. The managers in the industry should encourage this knowledge exchange and they should be aware of the positive results of this long-term strategy. The result of this is a quicker acceptance and change of rules in the user groups in the construction industry.

Creating awareness that exchanging knowledge and know-how is beneficial to the implementation of a disruptive innovation is the most important step in the process. In order to achieve this, there are several methods available. One of them is to cluster and set up information streams by improving the triple helix between university-industry-government. A knowledge centre set up by the Dutch government can function as a gathering point between the three. It is of great importance that there is a centralised way of collecting and spreading information by the knowledge centre. This will improve the clarity of the process how people in the industry can join the exchange of knowledge. An unstructured and decentralised process leads to the same situation as observed in construction projects, where people find it hard to communicate the right information to the right persons.

The creation of awareness also changes the influence of the current informal control system, which has a clear negative influence on the behaviour of people in the construction industry towards innovations and affects the implementation process of disruptive innovations. Reducing this influence could be achieved by giving the employees a better training. This must be done by schooling and by increasing the employees' knowledge about other industries. Therefore, companies should concern themselves more with the education of their employees.

Solving the before mentioned communication problem of people in the industry can also be achieved via a more comprehensible organisational structure, a better structured documentation, and better formal communication methods. However, by applying these methods, one should be aware that there exists a risk of the creation of extra rules or regulations making the process of implementing a disruptive innovation more complicated, rather than more straightforward.

By making the exchange of knowledge and know-how less complex, it is easier to create awareness and a quicker acceptance and change of rules in the user groups can be observed.

In order to increase the number of implementations, a higher percentage of revenue spend on R&D is required, since financial factors have a major influence on the implementation of a disruptive innovation. It is a fact that the construction industry currently is investing a significantly lower percentage of their revenue on R&D than of other labour and capital-intensive industries.

Furthermore, the implementation of a disruptive innovation needs encouraging and consistent investments. In the construction industry, strategies regarding innovation are mainly short term and the costs are connected to the building projects. These short-term investments must change to long-term investments.

6.2. Discussion

Based on the results of this research and the interpretation of the research, this paragraph discusses the findings.

One of the difficulties of implementing a disruptive innovation is that a company has to convince other companies in the project coalition about their choice of implementing the disruptive innovation (Winch, 2003). On company level, the decision is made to implement the disruptive innovation, which is done by the policy makers in a company.

According to the Q-methodology, these policy makers (F2) see financial restrictions limiting the innovation process. Since the policy makers are in high management positions, they decide on investment plans. In other words, they decide if structural investments are made in innovation or R&D and therefore are crucial in the early stages of the implementation of a disruptive innovation.

Because the literature research shows that implementation of disruptive innovation needs sustained and encouraging investments, the policy makers can be considered as a group of people that are having large blocking power. This is because of their early involvement in the implementation and their large influence in the decision-making process. In addition, the policy maker's judgements are considered conservative and they can be seen as laggards in the process of innovation. The result of their early involvement in the implementation of a disruptive innovation is that a potential innovation is often rejected and will not be implemented in the company.

Another characteristic of the policy makers (F2) is that they hold on, very strongly, to the rules set in the socio-technical regime, for example, the informal control system and the existing belief in the industry that only engineers with long records in the field can succeed. This characteristic together with their high management functions result in an influence of the policy makers on recruitment of employees. This results in the reluctance of the construction industry to accept input from other industries, which limits the construction industry's ability to reinvent itself and learn from other sectors (Blanco et al., 2016).

A group of younger managers that participated in this study (see the visionary entrepreneurs (F1), strategic managers (F4), and the innovations managers (F5)) see the rules of the socio-technical regime in the Dutch construction industry blocking the ability to implement disruptive innovations. They see a more effective collaboration and an increase in exchanging knowledge and know-how as most promising solutions. It the literature a similar observation can be found. When one abstracts Geels' (2002) theory, when the regime quickly adopts new rules, the duration of implementing a disruptive innovation is short.

According to the literature research, the largest difficulty with the implementation of a disruptive innovation in the construction industry is the complex multi-actor environment and the decision making during the process. These younger managers have less influence in the decision making process than the policy makers. Especially when considering the early stages of the implementation process, e.g. when deciding to invest in a disruptive innovation.

A logical result for the future is that policy makers will retire, and the group of younger managers will replace them. The decision-making process, which currently is led by policy makers, is going to be led by a new generation with a different opinion.

Unfortunately, the culture in the construction industry stays the same due to the belief in the industry that only engineers with long records in the field can succeed. In other words, the current policy makers got their positions because their predecessors taught them how to become a policy maker. A vicious circle is the result, wherein the behaviour in the construction industry stays the same.

The way that disruptive innovations develop in the Dutch construction industry is dependent on many different factors: the development of the economy and demand, the structure of the industry and supply, the institutionalisation of the relation between supply and demand, and how that shapes the culture in the sector. All these have an effect on the potential of the industry to innovate through more disruptive innovations. In order to achieve a positive effect of disruptive innovations, many hurdles will have to be overcome.

The construction sectors works in a competitive environment in which price is a major factor. Additionally, the sector works in projects that temporarily bring people together under strict boundaries of scope, budget and time. That environment is not conducive to disruptive innovations, as the risks are considered too high. It allows for sustained innovations that drive efficiency of the design and construction processes, but more radical changes of the business models that would drastically improve performance are hampered by financial risks and how they manifest themselves to those who would be the key drivers of that change.

Change will be hard. As the sector has split itself along the lines of a large number of different roles, the effort needed to come together over specific disruptive innovations is immense. New entries that would introduce these innovations find a sector relying on special-

ised knowledge, regulated and inflexible processes of market functioning, internally focused, and leverage to sustain the current situation and the existing interests.

6.3. Reflection

The reflection of this research is conducted by using a schematic overview that can be found in the appendix (see Appendix: Discussion). In order to achieve the objective of this research, two separate researches were done, a literature research and the execution of the Q-methodology. After that, this chapter will reflect on the broader question of innovation in the construction industry.

The literature research resulted in factors that are relevant for the implementation of disruptive innovations. These factors are derived from of articles that are selected by the researcher. Although he tried to be as objective as possible, the researcher took decisions on what he thought is most relevant for the research. It goes without saying that in selecting the literature, the researcher's opinion has played a role.

The second method of data collection took place via the Q-methodology. The statements that formed the Q-set were selected from the concourse. The predefined categories in the concourse are according to the factors found in the literature research. According to Watts and Stenner (2012), the selection procedure of the statements must done without any limitation or boundaries apart from the research topic, because the concourse must consists of all statements that reflect the research topic.

The reasons for using the factors from literature was to increase a goal-oriented selection of statements and to account for the choice of the statements. However, the involvement of the literature research in the Q-method leads to a point of discussion, because the selection of statements in the concourse is indirectly affected by the researcher's opinion. Not only by making use of the factors from literature, also the opinion of the researcher is involved while selecting statements in the concourse. The researcher judges whether a statement belongs to the research topic and if it evolves from literature. Despite the characteristic that the Q-method limits the involvement of researcher's subjectivity in the research, there is a strong assumption that his opinion plays a role in the research.

With regard to the research question, the predefined categories in the concourse are also leading to another point of discussion. Because using the factors from literature towards a more goal-oriented selection of statements, results in in comparable factor results in the Q-method. The answer on the research question that factors from the literature study do not differ significantly from the factors from the Q-method could be predicted when starting the research.

However, it is valid to use the factors from literature in executing the Q-method, because of the quick scan by professionals in the industry. They validated the factors found in literature, which means that the

factors are valid to use in the execution of the Q-method.

The benefit of using Q-methodology is the relatively easy manner of collecting and categorising perspectives of a large and variated group of respondents. The thorough preparation this method requires helps with a very structured start of the interview. The clear structure makes it easier for the respondent to tell about his perspective on the topic and it does not form boundaries in the conversation.

The benefit of the categorisation in the perspectives on innovation in the construction sector is that one understands better how the factors found in literature relate to the various people in the industry. They show to have a variety of views on the topic and thus have different roles and positions towards the drive to innovate.

An alternative methodology to find perspectives in the industry is the use of qualitative interviews. The advantage of the Q-method compared to its alternative is the larger number of respondents involved, allowing for a wider set of groups from the industry with differing perspectives. Although, like in many research methods, the researcher's opinion will show through the results, the Q-method limits that more than qualitative interviews. In this research, the interviews where led by Q-sorts made by the respondents. That helped to reduce subjectivity in phrasing the questions, for example.

With regard to the involvement of the Dutch government in innovation in the construction industry, it can be concluded that there is minor governmental involvement. The Dutch government did not define the construction industry as one of the industries in their "topsectoren" initiative (topsectoren.nl, 2017). This programme plays an important role in the innovation in an industry. In practice, knowledge centres, which are financed by the Dutch government, double the investment in innovation of private companies (Landman, 2016). For the existing knowledge centres in the Dutch construction industry this means there is very little money available to structure information processes and stimulate the triple-helix between university, industry and government.

Apparently, the Dutch government sees more financial potential in other industries. This understandable, since the construction industry has a bad track record in innovation, very limited investments in R&D, many problematic projects, and an overcapacity in the industry.

When considering the limited involvement, the Dutch government seems to hold on to a passive attitude towards changing the construction industry. This is also evident from a document (de Marktvisie) the Dutch government published giving their future perspective on the Dutch construction industry (BouwendNederland et al., 2016). In "de Marktvisie" they formulate several targets. However, they do not provide any means to achieve these targets.

On the other hand, recently the Bouwcampus was opened, which is a governmental initiative. This knowledge centre strives to bring together various organisations by being the venue where innovative ideas are created. There exists several other knowledge centres in the Dutch construction industry, this centre could be the central point of all information streams.

Unfortunately, the government does not connect "de Marktvisie" to the Bouwcampus. It would be more effective to achieve the targets by having one venue. It would bring companies in contact and encourages the exchange of knowledge. Besides, the exchange should also be inter-industrial, which is also beneficial for the other involved industries. Hereby a win-win situation will be created. Currently, the industry is unfamiliar with the benefits of joining a knowledge centre. So again, awareness must be created about the positive influence of knowledge exchange.

In The Netherlands, the link between university and industry is weak, writes the Dutch newspaper Het Financieële Dagblad (Cats & Zeemeijer, 2017). When comparing the Dutch situation with other thriving economies in Europe, their link is much stronger. According to the Dutch State Secretary of Education, Mr. Dekker, Dutch scientists that do not follow the culture of 'publish or perish' are barely rewarded. In other words, it is more rewarding to publish scientific work than working together with industry to find new products or services.

In this research, in only one of the interviews the role of universities in he construction industry has been mentioned. During that interview, the respondent's main concern was the lack of general and practical knowledge of students about the industry itself. He had in mind students from universities and universities of applied sciences (Dutch: hbo-studenten).

In the eyes of the researcher, universities and industry could play a more important role in finding innovations for the construction industry and students can be part of that. The reason why there is little involvement arise from both university and industry. The technological universities (of applied sciences) are lacking in involving current developments in society. On the other hand, industry does not see the advantages of being part of the education programme.

When implementing a disruptive innovation, it is important that a bridge is created between the industry where the innovation is found and the industry where an innovation is implemented. Large consulting companies play an important role in creating such a bridge, since they operate in several dif-

ferent industries and therefore have very specialised knowledge and know-how on a broad terrain. Especially considering business-model innovations, where it is of main concern that an industry adapts to the innovation. For this reason, it is important that there is specialised knowledge available of two industries and the knowledge of organisational change.

With regard to the implementation of a disruptive innovation, it is often observed that a company's perspective on the success of the implementation fails. Generally, the company beliefs that the innovation is successfully implemented when the needed equipment is bough and a select group of employees is trained. However, more processes in the company must be changed than the company initially believes. Each person in the company must be willing to make changes, regarding the disruptive innovation.

An example is the implementation of BIM (Building Information Modelling) in the construction industry. Changes in the process are mostly visible in the transition of 2D to 3D building models, but changes do not only occur in the drawing department. Also other departments have to change their processes, such as planning and procurement, since the innovation is only successful when the BIM model is applied to each process in the company.

It is helpful when implementing such an innovation to involve a company that has knowledge and know-how of both the industry where the innovation is found and the one where the innovation must be implemented. Such a company knows what processes are affected by the implementation, and it knows the possibilities of the disruptive innovation itself. By knowing both, a strategy can be made to implement it most successfully.

Looking back at this research, one of the shortcomings was that the researcher did not foresee the large amount of variables influencing the implementation of disruptive innovations in the Dutch construction industry. Although it was a challenge to structure them and to make a coherent piece of work, the researcher managed to get a grip on the complex matter.

The researcher's aim was to find reason for issues he discovered in previous research and work experience. By this research, he created a better understanding of these issues and it is an important added value to his knowledge of the industry.

During the execution of this research, KPMG's department Major Projects Advisory facilitated many things. One of these was that KPMG simplified making connection with respondents, because of the corporate image the company has. Furthermore, the director of the department (Michiel Oldenhof) helped solving practical issues in executing this research and therefore was a great sparring partner during the process.

With respect to possible future research, the Dutch construction industry is a complex industry. Because of this complexity, several aspects of innovation in this industry could benefit from future research. This research cleared up just a part of the unclear process.

Regarding the applicability of this research to other disciplines in the construction industry, it is a reliable assumption that executing the Q-method on another discipline in the industry would give similar results. The respondent's perspective on the implementation of disruptive innovations in the Dutch construction industry does not depend on the place he has in the supply chain, rather on his involvement in the implementation process and his position in the company.

Possible future research could for example be to find out what the effect of the triple helix is in the Dutch construction industry. A comparison with one industries defined in the "topsectoren" policy in The Netherlands would be very interesting. It would be interesting to know in what way the Dutch government influences the innovation process in a "topsector" and how can this influence be applicable to a not-"topsector", like the construction industry?

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Appendix: Qualitative interviews

Mr. Nijssen – Ingenieursbureau Rotterdam

Mr. Nijssen has gained experience in the construction industry for more than 25 years. Until 2008 he worked at public organisation Gemeentewerken Rotterdam (GWR). The last seven years of his career at GWR he was managing director of the engineering department (Het Ingenieursbureau Rotterdam), where he managed over a thousand employees that delivered work to all disciplines in the construction industry.

In 2008 Mr. Nijssen started his own consultancy company, where he gives advice about information technology and information management, related to the construction industry.

Looking at Mr. Nijssen's past, he has a very broad field of interest in the construction industry and has been involved in various innovative projects. He describes his personality as: a person that is constantly trying to prepare for the future. He really wants to avoid a standstill and wants to invest in opportunities in the future. During his career at GWR his employer gave him a lot of freedom in development of innovations.

The added value to interview Mr. Nijssen is mainly due to his broad experience in the industry and his personal interests. Due to his experience he has a well-developed overview of the industry and together with his personal interests in innovation he is able to define factors that stimulate or withhold innovation processes.

To explain how a radical innovation can successfully be implemented, Mr. Nijssen uses the example of his involvement with the introduction of the computer at GWR. He concludes that the development of such an innovation only works when internal processes on the work floor are fitting well together. Comparing with other industries, like the automotive industry, work processes in the construction industry are currently very badly organised. "The work place is the place where new things need to be developed. Stimulating impulses must be created to encourage innovative thoughts. Management needs to support these impulses, because innovations are a result of trial-and-error." Mr Nijssen addresses explicitly that the management plays an important role in the development of innovation. Especially in large organisations, where employees can find it paralysing to innovate. Therefore flexibility on the work place is needed to prevent this paralysing effect. Others, with a more innovative mind, are able to create time for themselves to innovate. At a certain moment this last group of people will come to a manager with a request for a helping hand, usually in terms of time or money. The stimulating impulses that Mr. Nijssen discovered during his career, were mostly in times of need. People innovate when there is a request for something or when there is a problem to be solved.

A characteristic of the construction industry today is that the whole industry is decentralised, in particular when looking at information management and the gathering of knowledge. This can be seen through the example of the implementation of Building Information Modelling (BIM). Mr. Nijssen's observation is that people are not sharing knowledge to develop this radical innovation. BIM is a very promising technology. E.g. the architect that invested in BIM managed to bind their clients. The once that didn't invest in BIM did not survive the economic crisis.

However, the implementation of BIM in the construction industry is very poor and the speed of development is low. Mr. Nijssen recalls that this is due to the fact that people are doing their own thing and not sharing their knowledge. It is worst now than when he was a board manager of the knowledge centre CUR (Centrum Uitvoering Regelgeving).

The now closed down centre gathered information from public, private and educational institutes in order to find innovative solutions to problems or ideas to innovate current work processes or methods. Besides gathering knowledge, this centre had another very important purpose, which was: sharing knowledge.

Mr. Nijssen compares his former board function with the current situation where young people learned to work together and share their knowledge. The example he uses are the open source programmes, where people share knowledge to develop products and services. This, as he calls the new world, in comparison with the construction industry where people do not share their information. "By making this comparison, especially with other industries where knowledge sharing is highly stimulated, it is almost sad to look at the construction industry. If we leave this situation, only than I believe that the construction industry is able to change."

The reason for not sharing information is according to Mr. Nijssen due to commercial benefit. Interesting information in the construction industry is kept within the industry in order to create a commercial benefit in upcoming projects. This is of course a very short term strategy. This cycle of not sharing knowledge is the reason why innovations are not developed.

Knowledge decentralisation in the construction industry is cause by the use of new contracts in the industry. There has been a shift in the preparation phase of construction projects. Where in the past public organisations were used to gather knowledge for the preparation of a project, private firms are now having this responsibility. The main difference here is that private firms have often less financial flexibility to do research on a certain topic, because of commercial gains. The construction industry is really in need of researchers.

Concluding, Mr. Nijssen thinks that processes in the construction industry are not well organised, which can have paralysing effects on employees, especially in large firms. Management is a key factor to stimulate their employees, because the workplace is where new developments are formed. Mr. Nijssen experienced that impulses are stimulating employees to innovate and these are mostly developed during times of need.

Mr. Nijssen characterises the construction industry, in particular in the field of information management, as decentralised. This characterisation is mostly based on the fact that people in the industry are not sharing their knowledge. By not sharing knowledge the development and speed of implementation of innovations is very slow.

A solution to this problem is a knowledge centre that is able to gather and share knowledge of different parties. Hereby he refers to his former board function at the knowledge centre CUR, where they created such an environment.

List of stimulating and withholding factors according to Mr. Nijssen:

+ Stimulating impulses are needed to create innovative thoughts.

+ Flexibility on the work place is a must to stimulate innovation.

+ Stimulating impulses are developed in times of need.

- (Internal) Processes are not well organised in the construction industry.

- Large organisations can be paralysing for people.

- Knowledge is not been shared.

Mr. Oldenhof – KPMG

Mr. Oldenhof is head of the department Major Projects Advisory at KPMG, where he is director of a department that advices large construction projects in The Netherlands. In his career of almost 20 years, his major experience lies with infrastructural construction projects. Due to his functions the last 10 years, as director of several leading Dutch construction companies, the added value of this interview is because of his managerial perspective on innovation in the construction industry.

Mr. Oldenhof starts the interview by explaining how the decision making process went with the implementation of an innovation at a large construction project he worked at. He explains that at a PPS-project (a project involving public and private organisations) there is always a discussion between the project team and the financing party. Because, the financer always wants a study that the innovation is proven to reduce costs. The financer in these projects is usually a public party, they don't want to take any financial risks.

Mr. Oldenhof gives another example, also in a PPS project: in order to spare maintenance costs the project team advised to use LED lightning instead of regular lightning. This meant higher initial costs, but in the long run it would be a cheaper solution. "The client didn't ask for such a solution. He requested a price for the cheapest solution, at this moment." Mr. Oldenhof explains. "Maintenance was not their concern, it was the concern of another district."

With these two examples, Mr. Oldenhof wants to express the continuous discussion between the requesting and delivering party. The main factor in this discussion is a financial one. Mr. Oldenhof claims that this is because the construction industry is only looking at costs and not at benefits or profits an investment can create.

The reason that this culture has been created lies in the former ways of contracting, where the requesting party had a plan that the delivering party had to execute. The delivering party, led by the main contractor, divided the total work among different sub-contractors. This situation resulted in sub-ordinated workers that were seen easily as costs, instead as partner in the project. Today a trend can be observed that people are willing to work together and want to see one another as equal parties.

The construction industry has low profit margins, which also enhances the continuous discussion on costs. Plus, "it is easier to spend 2% on innovation when you have 20% profit margin." Explains Mr. Oldenhof. These low profit margins also cause a short term vision in management team meetings. Mr. Oldenhof says: "In my career I spent 10 years in

management functions. In board rooms or MT-meetings I never heard a discussion about the future. How would our world be like in 10 years? I initiated it many times, but they only talk about current projects, current tenders, or upcoming projects. There is only a short term vision."

It is also a logical reaction, since profit margins are low there is a constant need for work. So when a current project is being executed, the competition already starts for the next project. The cheapest bidder will lead the next project. The result is that an innovation is used only as cost reduction and thus mostly coupled to a project.

Unfortunately, in this competition only sustained innovations are used to win a tender. Implementing disruptive innovations usually comes with risks that are relatively too large for the profit margins. When the situation allows implementing a disruptive innovation, risks will be embedded in contracts. The innovation process is thus getting into a very inflexible situation, which eventually withholds the development of an innovation.

Mr. Oldenhof also addresses the strong culture that characterises the construction industry. A culture where people immediately want to see result from invested money and mostly take decisions for quick wins. Together with strong competition in the construction industry, this is causing minor differences between the companies. "Each company does in essence the same work. The only difference can be observed in brain capacity and entrepreneurship. Some companies find cheaper methods and others are more entrepreneurial minded."

The first reason Mr. Oldenhof addresses this strong culture is that there is no cooperation with other industries. "Look at the current CEO's; they all started their career in the construction industry." On top of that, "when a billion euro project is started, the best bricklayer will be project manager. Not an industrial engineer. Imagine that he says something smarter than the CEO does! It is much safer to keep everything internally, within the construction industry itself." In addition, when they involve another industry, they only make a comparison between an observed industry and themselves. "Safely from a distance, without any risks."

Secondly, because of the strong hierarchy in the industry a radical change can only come from higher management. But higher management positions are not attractive in the construction industry. When comparing them with other industries higher management in the construction industry is lower paid. So in the construction industry it is not attractive for people to become a CEO. Mr. Oldenhof argues: "The CEO of Unilever is not going to be CEO of Royal Dutch BAM Group. Because the salary he receives at Unilever is three times higher."

"The attitude and behaviour in this industry is really a cultural problem". Mr. Oldenhof calls the construction industry incestuous and very hierarchical. This is a rude statement, but sadly enough it is true. Mr. Oldenhof says that the construction industry doesn't dare to do something radically different, because of the above mentioned cultural problem.

Mr. Oldenhof tries to be optimistic, by saying: "Luckily there are people that want to innovate and change the industry." For example the people in concrete constructions are much further in optimising work methods than in asphalt constructions. Concrete elements are used for the construction of utility buildings. Precise preparation is needed in order to fit all concrete elements together, whereas with asphalt the fitting of the elements takes place on the job. "There is a large cultural difference between these two sectors. In the concrete business, people are more used to change and thus easier to adopt an innovation." Mr. Oldenhof thinks that for this reason the concrete business is ahead of the asphalt business with organisational and technical innovations. Plus, in the asphalt business there is low educated workforce, which also reflects the low level of innovations in that business.

List of stimulating and withholding factors according to Mr. Oldenhof

- Construction industry is only looking at costs and not at benefits or profits of an investment.
- Low profit margins are the reason for short-term vision.
- Innovations are mainly project related.
- Radical innovations are avoided, because they are more long-term strategies.
- Risks concerning disruptive innovations are too large in comparison with the profit margins.
- Risks concerning disruptive innovations are embedded in complicated contracts, which lead to an inflexible situation.
- There is no cooperation with other industries
- The industry is very hierarchical and thus only higher management can implement radical innovations.
- The construction industry is not attractive to join, because of its low pay, and especially for management functions.
- The industry does not dare to do something radically different.
- There is a lot of low educated workforce involved, which reflects the low level of innovation.

Mr. Kerpel, Mrs. De Lint-Zorge, and Mr. Mol – Rijksvastgoedbedrijf

The company Rijksvastgoedbedrijf (RVB) is a Dutch governmental organisation that is responsible for the maintenance and management of Dutch governmental real estate. Roughly, 25% of the real estate portfolio covers office buildings, another 25% are military bases and the rest are courthouses and museums. Mr. Kerpel concludes that their main field of interest is in utility buildings, with a focus on office buildings. The three interviewees all are working in this organisation and will be introduced underneath.

Mr. Kerpel:

Mr. Kerpel is head of the section Durability and Comfort. His section gives advice on building projects, improvements of buildings, and on processes with climate and durable aspects. In his section, innovation is a large topic, since complex cases need to be solved, and current technologies cannot always function as a solution.

Mrs. De Lint-Zorge:

Mrs. De Lint – Zorge is programme manager at the Green Technologies programme (PGT). The programme is an initiative from the RVB, where the main goal of this programme is to find ways to an energy neutral building environment. The focus in this programme is on technological innovations that will lead to the energy neutrality.

Mr. Mol:

Mr. Mol is head of Procurement and Contract Management. In his function, he tries to stimulate process innovations on procurement. He recently started this function, after his function as head of Procurement at Rijkswaterstaat (RWS). RWS is also a governmental organisation, with the main focus on maintenance and management of Dutch infrastructure.

Mr. De Lint-Zorge explains that the Green Technology programme is initiated to stimulate innovations. In the programme, there are three types of innovation defined, and thus the available budget is spread over these three.

- Core innovations – Innovations that improve current products or services.
- Adjacent innovations – Existing innovations from other markets (for example the car industry) that can be transferred to the real estate and building markets.
- Transformational innovations – Innovations that are radically new and have a disruptive effect on the market.

An example of a transformational innovation where the PGT-programme invested money in, is Plant-e. Plant-e is a spinoff from the University Wageningen, where they developed a technique to generate electricity from plants. Mrs. Lint-Zorge explains that this technology is radically new and is able to create a transformational or disruptive effect on the renewable energy market. Wind and solar energy are currently used the most as renewable energy source in The Netherlands. Plant-e has a very large potential to be an extra source of energy. It has no visible impact on the landscape and it is not dependent on sun or wind, and therefore an interesting new form of energy supply.

Because of this future perspective, the PGT decided to invest in the start-up. The benefits of this investment are difficult to measure because of the long development time and the uncertainties during that development. Arguments that led to a positive investment decision were: available budget to spend on transformational innovations; the amount invested was a small percentage from the annual budget; a very high potential for an extra renewable energy source and the positive signal it gives to the stakeholders and contractors of the RVB.

Mrs. Lint-Zorge explains that making this decision beforehand caused many difficulties, because people wanted to have a business model, wanted to know the payback time, or wanted to know why the RVB would invest public money in such an innovation.

She describes this reaction as logical, however the investment was in line with the predefined plan of the programme, plus the investment was a relatively low amount with respect to their total budget. “We ourselves felt uncomfortable with this situation, and we should be. There is a possibility that the project could turn out to be a wrong investment. But if we wouldn’t have invested in this start-up, we will never know the result.” Mrs. Lint-Zorge says. Mr. Kerpel adds to that: “When you keep calling for innovation, but don’t dare to make an investment the situation stays the same. Sometimes you have to put energy and money in projects to stimulate innovations.”

On March 2014, RVB announced to be launching customer for Plant-e. Still, after almost 2,5 years, “there is a form of fear around publicity of the project.” Says Mrs. Lint-Zorge. This is mainly because people tend to say that public money was spent on a project that does not pay itself back. Which is true on the one hand. But on the other hand, the payback time should be seen differently. This investment is a stimulation to find other sources of renewable energy and therefore important. Mrs. Lint – Zorge says regretfully that she thinks that such a decision will not be made a second time, due to the political sensitivity of public money.

Mrs. Lint – Zorge says that RVB did manage to share the knowledge gained through project Plant-e, but with difficul-

ties. “Sharing knowledge and working together, especially with transformational innovations like Plant-e, is very important to make it a success. Doing this alone is not an option.” Another effect of this project was that it was received very well by the construction industry. It shows contractors and other actors in the industry that an initiator like RVB is willing to take risks and wants to stimulate innovation.

In order to stimulate knowledge sharing, the RVB organised an event to find accelerators that could stimulate the step to energy neutrality. The RVB Café was initiated to be able to get informally in touch with the market. Furthermore, the RVB is working closely together with the Green Village, an initiative of Delft UT. This initiative which can put theoretical concepts into practice. This initiative also works together with the Bouwcampus, which functions as knowledge centre. Mr. Kerpel says that the RVB uses knowledge of Delft UT, which is far more precise and more internationally orientated, and the RVB find ways to put this in practice.

Although the RVB is trying to work together with private parties in the industry and joins knowledge centres, there are points to improve. Mrs. Lint – Zorge thinks that their communication needs to improve. She argues that communication is far more effective when there is a visible product, only then the conversation can really start. Mr. Mol adds: “It is important to brief people beforehand what the plan is.” Making a plan or strategic agenda is very important to communicate to colleagues internally and externally. When there is a transparent vision how the organisation wants to deal with innovations, people expect the innovations. Currently an innovations arises, people are more willing to accept changes in their work. From an external perspective, when the RVB formulates a vision for innovation, it is a stimulation for external companies to find use for these innovations in their markets.

Another factor Mr. Kerpel addresses is that some innovations happen by accident. When someone gets in touch with an innovation, it is possible they will use it in a project. However, a condition is that the person introducing these innovations must have convincing power. Introducing an innovation, like with the project Plant-e, generats many questions that are not in favour of stimulating the innovation process. The person introducing the innovation, the spokesperson, must be able to answer these questions convincingly. Mr. Kerpel says that a convincing spokesperson is essential for the creation of an area of support. By enlarging the area of support, an innovation comes to life.

Furthermore, Mr. Kerpel addresses the importance of timing of entry. An innovation has the largest potential to succeed in the beginning of a project. When the contract of a building project is signed, there is no room left for innovation. Mr. Mol continues that project managers are not educated in that way, because their prior focus is to complete a project within time and budget.

Mr. Mol starts with a new topic where he compares his former employer RWS with RVB. He mentions the different visions on the stimulation of innovation. He noticed that the RVB is investing in innovation, where RWS tried to stimulate the industry to innovate. This observation led to a small discussion between the interviewees about who is responsible for innovations in the construction industry: initiators of building projects or the delivering parties. Should the initiator, in this case RVB, come up with innovations that the market should implement? Alternatively, should RVB come with a request, in order to let the industry think about innovative solutions?

Mr. Mol is one the authors of a new long-term strategy for the construction industry, which is named the Marktvisie. Does he see the construction industry changing according to that? He says, based on his experience, the industry is always looking at governmental organisations like RWS or RVB for their long-term strategy. Hereby he stresses that the construction industry seems to work with short term strategies. It thus seems to be that they do not ask themselves the question if they are ready for the future. Revenue has been created through projects and a construction company is thus working from project to project. In addition, the economic crisis with shrinking revenues, resulted in cuts in the budget for innovations.

Another characteristic of the industry Mr. Mol addresses is a low diversification between companies within the industry. Every company does the same work and they don’t distinguish from each other. Mrs. Lint – Zorge thinks that companies from other industries will enter the construction industry and will cause diversification. Where Mr. Kerpel replies that profit margins, that are currently very low, will be higher with the implementation of techniques from other industries. This “sexy work” is likely to create higher margins.

List of stimulating and withholding factors according to Mrs. Lint – Zorge, Mr. Mol and Mr. Kerpel

+ You should dare to make an investment to innovate.
+ Some innovations happen on accident.
+ A spokesperson with convincing power is needed.
+ Area of support.
+ Timing of entry.
+ “Sexy work” will create higher profit margins.
- Business model is needed for a radical innovation.
- There needs to be a payback time.

- Why invest money in something that does not pay itself back?
- Sharing knowledge is hard.
- Communication methods can be better.
- Construction industry is based on short-term strategies.
- Small differentiation between companies in the industry.
- Profit margins are too low.

Questionnaire

Innovatie in de bouw

Deze questionnaire is ter behoeve van gezamenlijk onderzoek tussen de TU Delft en KPMG. Het doel van het onderzoek is om stimulerende factoren en barrières te vinden die het innovatie proces in de bouw beïnvloeden. De methode hiervoor is om perspectieven uit de sector op dit onderwerp vast te leggen. De doelgroep in dit onderzoek zijn vooral stakeholders die betrokken zijn bij de realisatie van kantoorgebouwen.
De perspectieven zullen worden vastgelegd door middel van een korte vragenlijst en een langere questionnaire. De gehele questionnaire zal rond 30 tot 40 minuten duren. Vanwege de gevoeligheid van persoonlijke informatie, zal de questionnaire anoniem worden afgenomen.

Contextuele vragen:

Organisatie grootte en stakeholdergroep

1. Wat is de grootte van de organisatie waarin u werkt? (+/-) ..... FTE

2. Binnen welke stakeholdergroep kan de organisatie worden gecategoriseerd?
O Initiatiefnemer O Architect O Ingenieur O Aannemer O Installateur

Innovation in de organisatie

3. In uw organisatie wordt innovatie gestuurd door:
O Elk individu in de organisatie
O Ieder persoon met een eigen budget, zoals projectleiders of tendermanagers.
O Een aangestelde afdeling
O Alleen op directie niveau
O Niemand
O Anders, namelijk.....

Stimulatie

4. Wordt innovatie binnen uw organisatie gestimuleerd d.m.v. daarvoor opgezette projecten? Denk hierbij aan: Innovaton award, Google dag, Denktank, incubators, etc.
Ja / Nee / Geen idee

5. Werkt jullie bedrijf samen met andere bedrijven om innovatie te stimuleren?
Ja / Nee / Geen idee

Individu

6. Bent u bereid radicale innovaties door te voeren in uw organisatie?
Ja / Nee / Geen idee

7. Tijdens uw dagelijkse werkzaamheden, voelt u zich gestimuleerd om te innoveren?
Ja / Nee / Geen idee

8. Wat motiveert u om te innoveren?
O Om persoonlijke redenen
O Vanwege uw omgeving
O Innovatie wordt mij opgelegd
O Anders, namelijk .....

Recruitment

9. Hoe haalt uw organisatie getalenteerde mensen binnen?
O We hebben onze eigen recruitment afdeling.
O Door tussenpersonen
O Online vacatures of onze eigen netwerk
O Geen
O Anders, namelijk ……..

Ervaring

10. Hoeveel jaar heeft u werkervaring?
O 1 – 5 jaar
O 6 – 10 jaar
O 11 – 15 jaar
O 16 – 20 jaar
O Meer dan 25 jaar

Factor extraction

Principal component analysis versus centroid factor analysis

First an analysis must be done on the raw data itself and results in a unrotated factor matrix, which will be declared later. First a selection must be made how this matrix will be created. There are namely two different methods of analysis: the Principal Component Analysis and the Centroid Factor Analysis.

The key difference is that Principal Component Analysis will resolve itself into a single, mathematically best solution. The conclusion out of this analysis is that there is only one solution that should be accepted. Generally this isn't attractive in a Q-methodology study, since Q-sorts are reflecting perspectives of people. These perspectives differ from each other on a non-mathematical way, so it can be interpreted differently. The Centroid Factor Analysis however leaves all possible solution open and "it allows to legitimately explore the possibilities through rotation and it enables to defer a decision about the best solution and the best criteria for making that decision until we have explored data further." "Yet the centroid method is still highly regarded by Q-methodologists precisely because of the permissiveness it allows in relation to data exploration" (Watts & Stenner, 2012).

The unrotated factor matrix and factor extraction

As recommended, the centroid factor analysis is going to be executed. The analysis results in a factor matrix where all Q-sorts have been analysed and put into seven factors. Factors can be seen as the previously discussed groups. Seven factors are automatically produced with this methodology.

The loadings in each factor are calculated to maximise output of the eigenvalue on the first factor. The eigenvalue is a number that tells how much the factor is in common with others in the studied group. By following this formula an eigenvalue can be calculated:

$$EV(factor\ 1) = (Qsort\ 1\ loading\ on\ factor\ 1)^2 + (Qsort\ 2\ loading\ on\ factor\ 1)^2 + \cdots + (Qsort\ N\ loading\ on\ factor\ 1)^2$$

The main reason for calculating the eigenvalue is to know how many factors are valid to use in further analysis of the data. Watts and Stenner use the Kaiser-Guttman criterion, where "eigenvalues less than 1,00 are taken as a cut-off point for the extraction and of factors" (Watts & Stenner, 2012).

Other methods for extracting the right number of factors are Humphrey's rule and selecting on significance. Humphrey's rule says that a factor is significant if the cross-product of its two highest ladings (ignoring the sign) exceeds twice the standard error. Where the standard error is calculated as:

$$Standard\ error\ for\ example\ study = \frac{1}{\sqrt{N\ Qsorts}}$$

The third method for extracting factors is selection on significance. A factors is selected when it has two or more significant factor loadings. Factor loadings are calculated as following:

$$Significant\ factor\ loading\ for\ example\ study = 2{,}58 * \frac{1}{\sqrt{N\ Qsorts}}$$

According to Watts and Stenner, these methods should be used as "helpful parameters, and not rules to be obeyed" (Watts & Stenner, 2012). This is because the study is on basis of perspectives of respondents. So when picking according to one of these rules an amount of factors to analyse further, this doesn't have to be the exact number of factors to end up with. It can be the case that four factors are passing the Kaiser-Guttman criterion. When analysing them more in depth, it seems after further analysis that two of the four are very much correlating on their statements and/or types of respondents. From a mathematical perspective these two factors should be taken separately, but from an analytical perspective these can be seen as one. Additional to that, from the same reason a concrete conclusion on what method is most suitable for factor extraction cannot be drawn at this moment.

Other information that can be extracted from the unrotated factor matrix, which is equal information to the eigenvalue, but then related to each Q-sort instead of a factor, is the communality. This number shows how much the Q-sort is in common with others. “A high communality signals that the Q-sort is typical or highly representative of the group as a whole”. The calculation of the communality is as following:

$$h^2(Qsort\ 1) = (Qsort1\ loading\ on\ Factor\ 1)^2 + (on\ F2)^2 + \cdots + (on\ F7)^2$$

Another observation from this matrix is that there are positive and negative factor loadings. Later these loadings can be relevant when interpreting the factors, which is done after rotation of the factors.

Factor Rotation

When the previous steps have been taken, a number of factors have been extracted to use at further analysis. In order to execute analysis on the chosen factors, a more understandable factor matrix is needed. By doing a factor rotation the factors and their loadings will be structured in such a way that the loadings are more equally divided among the axes of the different factors. This is resulting can be seen in the rotated factor matrix, where the same calculations can be done as at the unrotated factor matrix. The eigenvalues are ones whereon the most easily can be seen what the rotation did to the loadings.

In the PQMethod software there is a possibility to do factor rotation by hand or the varimax factor rotation. Varimax rotates the factors for you and positions them according to statistical manners, in order to have the maximum study variance. Furthermore, “varimax is an excellent means of revealing a subject matter from viewpoints that almost everybody might recognize and consider to be of importance” (Watts & Stenner, 2012).
As Watts and Stenner write on the time consuming factor rotation by hand and their recommendation to use the varimax factor, this rotation method is going to be used.

Invoer	Afkorting	Factor	Functie	Grootte organisatie	Geslacht	Stakeholdergroep	Sturing van innovatie	Stimulatie door	Samenwerking	Doorvoeren van radicale innovaties	Motivatie tijdens werkzaamheden	Reden tot innovatie	Recruitment	Ervaring
1	I1S1A5	5	Directeur	1000	M	Installateur	2	Ja	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	> 20
2	I3S5A3	5	Manager Energie en Duurzame ontwikkeling	70	M	Installateur	1	Ja	Ja	Ja	Ja	Persoonlijk	Tussenpersoon	11 - 15
3	I4S1A4		Hoofd Inkoop	1742	M	1 Initiatiefnemer	3	Ja	Ja	Ja	Ja	Persoonlijk	Afdeling	16 - 20
4	I5S1A44	1	Hoofd Duurzaamheid en Comfort	1742	M	Initiatiefnemer	3	Ja	Ja	Ja	Ja	Persoonlijk	Afdeling	16 - 20
5	I6S1A3	5	Programmamanager Duurzaamheid en Comfort	1742	V	Initiatiefnemer	3	Ja	Ja	Ja	Ja	Persoonlijk	Afdeling	11 - 15
6	I7S1PA4		Sr. Projectmanager	275	V	Initiatiefnemer	2	Nee	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	16 - 20
7	I8S2A3	2	Associate Partner	20	M	Architect	1	Nee	Ja	Ja	Nee	Persoonlijk	Online of eigen netwerk	11 - 15
8	I9S4A3	4	Head of Major Project Advisory	500	M	Aannemer	3	Ja	Nee	Ja	Nee	Omgeving	Afdeling	16 - 20
9	I10S1PA2	4	Sr. Projectmanager	150	M	Initiatiefnemer	3	Ja	Ja	Nee	Ja	Omgeving	Tussenpersoon	6 - 10
10	I11S4A4	1	Projectleider	600	M	Aannemer	1	Nee	Nee	Ja	Ja	Persoonlijk	Afdeling	16 - 20
11	I12S4A4	1	Senior Tenderstrateeg	23000	M	Aannemer	3	Nee	Ja	Ja	Ja	Omgeving	Afdeling	6 - 10
12	I13S2A5	4	Project Manager	50	M	Architect	4	Ja	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	> 20
13	I14S2A5	1	Eigenaar	10	M	Architect	4	Ja	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	> 20
14	I15S1A5	2	ZZD	1	M	Initiatiefnemer	1	Nee	Nee	Nee	Ja	Persoonlijk	Geen	> 20
15	I16S4A5	3	Social Media Manager	23000	M	Aannemer	1	Nee	Ja	Nee	Ja	Persoonlijk	Afdeling	> 20
16	I17S3A3	1	Eigenaar	50	M	Ingenieur	1	Nee	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	11 - 15
17	I18S3A3	3	Projectleider bouwinformatica	23000	M	Ingenieur	3	Ja	Ja	Ja	Ja	Persoonlijk	Afdeling	11 - 15
18	I19S3A5		Afdelingshoofd	23000	M	Ingenieur	2	Ja	Ja	Ja	Nee	Persoonlijk	Afdeling	> 20
19	I20S3A1		Adviseur	23000	M	Ingenieur	2	Ja	Ja	Ja	Ja	Omgeving	Afdeling	0 - 5
20	I21S3A1	3	Consultant	23000	M	Ingenieur	2	Nee	Ja	Ja	Ja	Omgeving	Afdeling	0 - 5
21	I22S4A4		Directeur vest. Gr	80	M	Aannemer	2	Ja	Ja	Ja	Ja	Omgeving	Online of eigen netwerk	16 - 20
22	I23S3A3	2	Accountmanager	80	M	Ingenieur	4	Nee	Ja	Ja	Ja	Persoonlijk	Tussenpersoon	11 - 15
23	I24S5A1	3	Engineer	550	M	Installateur	2	Ja	Ja	Ja	Nee	Anders,	Afdeling	0 - 5
24	I25S5A5	2	Senoir Consultant	550	M	Installateur	2	Ja	Ja	Ja	Ja	Persoonlijk	Afdeling	> 20
25	I26S1A5	2	Directeur	48	V	Initiatiefnemer	2	Ja	Ja	Ja	Ja	Omgeving	Online of eigen netwerk	> 20
26	I27S3A5	5	Projectmanager	500	M	Ingenieur	2	Ja	Ja	Ja	Ja	Omgeving	Online of eigen netwerk	> 20
27	I29S1A2	3	Adviseur	11000	M	Initiatiefnemer	2	Ja	Ja	Ja	Geen idee	Persoonlijk	Afdeling	6 - 10
28	I30S2A5	4	Directeur	8	M	Architect	4	Ja	Ja	Ja	Ja	Persoonlijk	Tussenpersoon	> 20
29	I31S2A5		Directrise	8	V	Architect	4	Ja	Ja	Ja	Ja	Persoonlijk	Tussenpersoon	> 20
30	I31S1A5	4	Directeur	25	M	Initiatiefnemer	1	Nee	Ja	Ja	Ja	Persoonlijk	Online of eigen netwerk	> 20

The P-set
Statements in the Q-set

Single and collective human factors

Because literature writes firmly about the culture in the construction industry and the human interaction in the implementation disruptive innovations, human factors have been separated into two sub-categories. First, factors from a single human perspective that are representing the culture from an individual in the construction industry. Secondly, statements that are representing collective human interaction are selected. These reflect the culture in the industry overall.

Single human

1. Everyone does what he always does and the application of new technologies is constantly postponed.
2. Stakeholders in the construction industry don't want to share innovation.
3. New ambitions stays out and thus is a problem.
4. Innovations are not part of the builder's genes.
5. The construction industry starts innovating when a problem needs to be solved.
6. Soft skills have become a condition in the tender process and for the realisation of projects.
7. Too much project managers see innovations as an extra risk.

Collective human

1. In the construction industry one is afraid of competition disadvantage
2. People tend to go into conflict and point at one another when something goes wrong
3. Another culture is the key to change the current practise.
4. More effective collaboration is the most important renewal in the construction industry.
5. The construction industry is evidence based innovation
6. An extensive "yes-but" culture dominates all actors of the building process.
7. The industry has to deal with old behaviour in a new world.

Inter- and intra-organisational factors

What has been found in the previous chapter, is the organisational processes are important when implementing a disruptive innovations, which is the main reason for having a large amount of statements collected in this category. In the sub-category intra-organisational processes, statements have been selected that are reflecting on what happens internally in companies. Here the themes as, culture, talent management and process management are covered by the statements.

The sub-category inter-organisational processes consist out of statements that reflect the industry more as a whole. Here is collaboration is the theme that is the largest represented, in order to find out what the industry find important in the industry.

Intra-organisational process

1. Having an innovative culture and structure is essential in a fast moving environment
2. In order to really change the market, we must accept fast changing responsibilities
3. Retain and train talented employees is essential for innovations.
4. There is a "war on talent" going on.
5. There is too little coaching and education for new employees.
6. Time to try out is rarely available in the tight planning during realisation.

Inter-organisational process

1. Project initiators, industry and knowledge centres can collectively improve innovation.
2. Solutions have to come from the market
3. The construction industry has a traditional, drowsy image.
4. It is good to have, with certain types of issues, a party that can function from a limited distance, but is still an extension of the project initiator.
5. Assistance is needed in order to not reinvent the wheel.

6. Currently the construction industry transforms at an enormous pace from conservative to innovative.
7. Traditional patterns are blocking renewal in the construction industry.
8. To stimulate innovations, there must be more collaboration with other disciplines, such as the creative industry.

Financial factors

At this category, statements have been collected that are related to economics. Statements reflecting slow developing trends, such as economic crisis, are selected. Same goes for the role of the government in stimulating innovations and what are the financial hierarchical understandings among stakeholders.

1. Innovations turn out to have a higher rate of success in times of crisis.
2. An economic boom creates space for innovation.
3. Henk Kamp has to make more money available for innovations in the Dutch construction industry.
4. The rule of play: Who pays, determines.
5. Profits do not justify the costs of the investments.
6. Profit margins swing years around break-even, whereby investment in innovation hardly proceeds.
7. Extra investments must be earned back within one project.

Rules and regulating factors

The final categorisation reflects statements that are unmanageable, which reflect statements concerning governmental procedures and facts in general.

1. Too severe requirements on favourable plans.
2. The current submission procedure are not provocative enough to deviate from standard processes.
3. The innovation process goes slowly, annoyingly slow.

List of statements

Number	Statement	
1	Having an innovative culture and structure is essential in a fast moving environment	Intra
2	In order to really change the market, we must accept fast changing responsibilities	Intra
3	Everyone does what he always does and the application of new technologies is constantly postponed.	Single
4	In the construction industry one is afraid of competition disadvantage	Coll
5	People tend to go into conflict and point at one another when something goes wrong	Coll
6	Another culture is the key to change the current practise.	Coll
7	More effective collaboration is the most important renewal in the construction industry.	Coll
8	Project initiators, industry and knowledge centres can collectively improve innovation.	Inter
9	Too severe requirements on favourable plans	Unm
10	Solutions have to come from the market	Inter
11	The current submission procedure are not provocative enough to deviate from standard processes	Unm
12	The construction industry is evidence based innovation	Coll
13	An extensive "yes-but" culture dominates all actors of the building process.	Coll
14	Stakeholders in the construction industry don’t want to share innovation.	Single
15	New ambitions stays out and thus is a problem.	Single
16	The construction industry has a traditional, drowsy image.	Inter
17	Innovations are not part of the builder's genes.	Single
18	The construction industry starts innovating when a problem needs to be solved.	Single
19	The industry has to deal with old behaviour in a new world.	Coll
20	Innovations turn out to have a higher rate of success in times of crisis.	Fin
21	An economic boom creates space for innovation.	Fin
22	Henk Kamp has to make more money available for innovations in the Dutch construction industry.	Fin
23	The rule of play: Who pays, determines.	Fin
24	Profits do not justify the costs of the investments.	Fin
25	Profit margins swing years around break-even, whereby investment in innovation hardly proceeds.	Fin
26	Extra investments must be earned back within one project.	Fin
27	Soft skills have become a condition in the tender process and for the realisation of projects.	Single
28	Retain and train talented employees is essential for innovations.	Intra
29	There is a "war on talent" going on.	Intra
30	There is too little coaching and education for new employees.	Intra
31	Time to try out is rarely available in the tight planning during realisation.	Intra
32	It is good to have, with certain types of issues, a party that can function from a limited distance, but is still an extension of the project initiator.	Inter
33	Assistance is needed in order to not reinvent the wheel.	Inter
34	Currently the construction industry transforms at an enormous pace from conservative to innovative.	Inter
35	Traditional patterns are blocking renewal in the construction industry.	Inter
36	The innovation process goes slowly, annoyingly slow.	Unm
37	Too much project managers see innovations as an extra risk.	Single
38	To stimulate innovations, there must be more collaboration with other disciplines, such as the creative industry.	Inter

Unrotated factor matrix

		Factors							Communality	
Q-sort		1	2	3	4	5	6	7	h^2	
1	I1S1A5	0,57	-0,09	0,36	0,07	0,24	0,05	-0,31	0,62	62%
2	I3S5A3	0,49	-0,37	0,14	0,08	0,22	0,04	-0,30	0,54	54%
3	I4S1A4	0,49	0,39	0,10	0,10	-0,06	0,00	-0,29	0,51	51%
4	I5S1A44	0,45	0,30	0,07	0,06	0,26	0,06	0,20	0,41	41%
5	I6S1A3	0,55	-0,30	0,24	0,08	-0,26	0,05	-0,24	0,58	58%
6	I7S1PA4	0,68	-0,09	-0,06	0,00	-0,13	0,01	0,11	0,50	50%
7	I8S2A3	0,45	-0,24	0,12	0,03	0,04	0,00	0,30	0,36	36%
8	I9S4A3	0,50	0,09	0,17	0,02	-0,43	0,15	0,08	0,50	50%
9	I10S1PA2	0,58	0,24	0,07	0,04	-0,18	0,02	0,33	0,54	54%
10	I11S4A4	0,63	0,27	0,31	0,10	0,09	0,01	-0,10	0,59	59%
11	I12S4A4	0,42	-0,03	0,31	0,05	0,10	0,01	0,22	0,33	33%
12	I13S2A5	0,50	0,28	-0,07	0,05	-0,23	0,04	0,20	0,43	43%
13	I14S2A5	0,14	0,05	0,31	0,06	0,23	0,04	0,12	0,19	19%
14	I15S1A5	0,42	-0,29	-0,10	0,04	-0,43	0,15	0,14	0,50	50%
15	I16S4A5	0,57	-0,25	-0,40	0,12	0,30	0,08	-0,21	0,70	70%
16	I17S3A3	0,38	0,22	0,22	0,06	0,43	0,17	0,04	0,46	46%
17	I18S3A3	0,56	0,11	-0,14	0,02	0,27	0,06	-0,26	0,50	50%
18	I19S3A5	0,38	-0,19	-0,04	0,02	0,16	0,02	0,20	0,25	25%
19	I20S3A1	0,73	0,12	-0,23	0,04	-0,12	0,01	-0,13	0,63	63%
20	I21S3A1	0,61	-0,02	-0,21	0,02	0,18	0,03	-0,07	0,46	46%
21	I22S4A4	0,64	0,25	0,31	0,09	-0,03	0,00	-0,25	0,64	64%
22	I23S3A3	0,56	-0,48	-0,07	0,13	0,16	0,02	0,17	0,62	62%
23	I24S5A1	0,36	0,11	-0,15	0,02	0,16	0,02	0,06	0,19	19%
24	I25S5A5	0,32	-0,40	0,04	0,08	-0,35	0,10	0,30	0,49	49%
25	I26S1A5	0,31	-0,38	-0,29	0,12	-0,14	0,01	0,03	0,36	36%
26	I27S3A5	0,65	-0,10	-0,03	0,00	-0,11	0,01	-0,39	0,60	60%
27	I29S1A2	0,38	0,02	-0,56	0,18	0,12	0,01	-0,07	0,51	51%
28	I30S2A5	0,27	0,16	0,10	0,02	-0,31	0,07	-0,10	0,21	21%
29	I31S2A5	0,11	0,42	-0,33	0,17	-0,07	0,00	0,03	0,33	33%
30	I31S1A5	0,47	0,15	-0,20	0,04	-0,15	0,01	0,17	0,33	33%
	EV	7,32	1,87	1,58	0,18	1,54	0,12	1,28		
	Variance	24,40	6,22	5,26	0,61	5,12	0,40	4,26		
Sign.	Factor loading	16,00	0,00	0,00	0,00	0,00	0,00	0,00		
	Humphrey's rule	25,00	2,00	0,00	0,00	1,00	0,00	0,00		

Rotated factor matrix

		Factors							Communality	
Q-sort		1	2	3	4	5	6	7	h^2	
1	I1S1A5	0,41	0,09	0,13	-0,01	0,09	-0,01	**0,65**	0,62	62%
2	I3S5A3	0,18	0,28	0,21	-0,01	-0,11	-0,02	**0,61**	0,54	54%
3	I4S1A4	0,19	-0,21	0,23	0,07	0,49	0,03	0,37	0,51	51%
4	I5S1A44	**0,51**	0,00	0,29	-0,02	0,25	0,04	-0,01	0,41	41%
5	I6S1A3	0,01	0,39	-0,01	0,02	0,28	-0,02	**0,59**	0,58	58%
6	I7S1PA4	0,15	0,42	0,31	-0,09	0,38	0,08	0,21	0,50	50%
7	I8S2A3	0,30	**0,49**	0,09	-0,05	0,10	0,09	0,07	0,36	36%
8	I9S4A3	0,09	0,29	-0,04	-0,03	**0,61**	-0,08	0,17	0,50	50%
9	I10S1PA2	0,32	0,26	0,16	-0,04	**0,57**	0,10	-0,05	0,54	54%
10	I11S4A4	**0,48**	-0,02	0,16	0,03	0,43	0,07	0,39	0,59	59%
11	I12S4A4	**0,45**	0,27	-0,01	-0,02	0,17	0,08	0,14	0,33	33%
12	I13S2A5	0,15	0,15	0,23	0,00	**0,57**	0,05	-0,05	0,43	43%
13	I14S2A5	**0,42**	0,02	-0,08	0,02	-0,02	0,00	0,08	0,19	19%
14	I15S1A5	-0,15	**0,57**	0,08	-0,02	0,35	-0,10	0,10	0,50	50%
15	I16S4A5	0,05	0,26	**0,70**	0,00	-0,08	-0,06	0,35	0,70	70%
16	I17S3A3	**0,61**	-0,08	0,21	-0,03	0,07	-0,10	0,16	0,46	46%
17	I18S3A3	0,23	-0,04	**0,53**	-0,07	0,14	-0,02	0,37	0,50	50%
18	I19S3A5	0,25	0,35	0,24	-0,07	-0,01	0,04	0,06	0,25	25%
19	I20S3A1	0,05	0,17	0,52	-0,05	0,48	0,06	0,30	0,63	63%
20	I21S3A1	0,19	0,19	**0,54**	-0,08	0,16	0,03	0,25	0,46	46%
21	I22S4A4	0,35	-0,04	0,13	0,04	0,48	0,06	0,51	0,64	64%
22	I23S3A3	0,21	**0,63**	0,33	0,00	-0,08	0,05	0,24	0,62	62%
23	I24S5A1	0,19	0,06	**0,36**	-0,04	0,14	0,03	0,03	0,19	19%
24	I25S5A5	-0,04	**0,66**	-0,07	0,02	0,21	-0,04	0,03	0,49	49%
25	I26S1A5	-0,19	**0,47**	0,28	0,06	0,02	0,00	0,12	0,36	36%
26	I27S3A5	-0,02	0,17	0,33	-0,06	0,31	0,02	**0,60**	0,60	60%
27	I29S1A2	-0,09	0,11	**0,69**	0,10	0,08	-0,01	0,02	0,51	51%
28	I30S2A5	-0,02	0,02	-0,03	0,02	**0,43**	-0,05	0,17	0,21	21%
29	I31S2A5	-0,04	-0,21	0,34	0,17	0,31	0,00	-0,21	0,33	33%
30	I31S1A5	0,08	0,21	0,33	-0,03	**0,41**	0,06	-0,05	0,33	33%
	EV	2,16	2,73	3,00	0,09	3,05	0,09	2,76		

Output Factor 1 (F1)

Summary

Eigenvalue	2,16	(Lowest)
Lowest correlation with F2	0,17	(Overall lowest)
Highest correlation with F5	0,42	
Average amount of employees:	5080 employees	
Average work experience:	18 years	
Variance:	7,2%	

Respondents

Four respondents are significantly associated with this factor:

Input	Function	Stakeholder	Experience	Gender
I5S1A4	Hoofd Duurzaamheid en Comfort	Project Initiator	16 - 20	M
I11S4A4	Projectleider	Contractor	16 - 20	M
I12S4A4	Senior Tenderstrateeg	Contractor	6 - 10	M
I14S2A5	Eigenaar	Architect	> 20	M
I17S3A3	Eigenaar	Engineer	11-15	M

Q-sort

No.	Items ranked at +5 and +4	Value
19	The industry has to deal with old behaviour in a new world.	5
27	Soft skills have become a condition in the tender process and for the realisation of projects.	5
20	Innovations turn out to have a higher rate of success in times of crisis.	4
7	More effective collaboration is the most important renewal in the construction industry.	4
	Items ranked higher by factor 1 than by any other factor	
9	Too severe requirements on favourable plans	3
3	Everyone does what he always does and the application of new technologies is constantly postponed.	3
	Items ranked lower by factor 1 than by any other factor	
	None	
	Items ranked at -5 and -4	
24	Profits do not justify the costs of the investments.	-4
22	Henk Kamp has to make more money available for innovations in the Dutch construction industry.	-4
36	The innovation process goes slowly, annoyingly slow.	-5
34	Currently the construction industry transforms at an enormous pace from conservative to innovative.	-5

	Statement		Factor									
			1		2		3		4		5	
Coll	19 De sector worstelt met oud gedrag in een nieuwe wer	19	1,76	5	0,36	1	0,75	2	1,13	3	0,02	0
Single	27 Soft skills zijn voorwaardelijk geworden voor het t	27	1,3	5	-0,48	-2	-0,77	-2	2,06	5	1,27	4
Fin	20 Innovaties blijken kansrijker tijdens crisistijd	20	1,27	4	-0,2	-1	0,11	0	-0,5	-1	-0,83	-2
Coll	7 Effectiever met elkaar samenwerken is de belangrijks	7	1,16	4	0,08	0	-0,89	-2	1,72	5	1,33	4
Unm	9 Te strenge eisen aan kansrijke plannen	9	1,05	3	-0,89	-2	-0,63	-1	-0,45	0	-1,04	-2
Single	3 Iedereen doet wat hij altijd doet en het toepassen v	3	1,01	3	-0,47	-2	0,55	1	-0,5	-1	0,6	1
Coll	4 Men is in de bouw bang voor concurrentienadeel	4	0,93	2	1,09	3	0,02	-1	-0,84	-2	1,96	5
Fin	23 De spelregel: Wie betaalt, die bepaalt	23	0,93	3	1,71	5	-0,22	-1	0,6	1	-0,53	-2
Unm	11 De huidige aanbestedingsprocedure vormen weinig uit	11	0,83	2	-1,99	-5	-0,12	-1	-0,49	-1	-0,21	0
Intra	1 Het beschikken over een innovatieve cultuur en struc	1	0,81	2	1,03	3	2,1	5	1,53	4	0,86	2
Intra	2 Om een echte omslag in de markt te maken, moeten we	2	0,74	2	-0,24	-1	0,83	3	0,68	1	0,25	0
Inter	35 Traditionele patronen staan vernieuwing van de bouw	35	0,63	1	0,64	2	1,58	4	1,03	2	0,76	2
Inter	38 Om innovatie te stimuleren moet meer worden samenge	38	0,51	1	-0,36	-1	0,23	1	1,6	4	0,94	3
Intra	28 Het behouden en ontwikkelen van talentvolle medewer	28	0,49	1	0,96	3	1,47	4	1,43	3	0,47	1
Single	37 Veel projectmanager zien innovatie als extra risico	37	0,47	1	-0,12	0	0,09	0	-1,11	-3	0,84	2
Coll	13 Er heerst een wijdverbreide ja-maarcultuur bij alle	13	0,45	1	-0,97	-3	0,21	1	-1,22	-4	-0,41	-1
Single	17 Innovatie zit niet in de genen van bouwers	17	0,24	0	-1,34	-3	0,16	0	-1,07	-3	-1,36	-4
Intra	29 Er is een "war on talent" gaande	29	0,24	0	-1,36	-4	-1,04	-3	-0,46	0	-0,49	-1
Inter	8 Opdrachtgevers, -nemers en kennisinstellingen kunnen	8	0,19	0	1,11	4	0,65	2	0,74	2	1,14	3
Coll	5 Men gaat eerder de confrontatie aan en wijzen naar e	5	0,14	0	0,44	1	0,06	0	-0,01	1	0,31	1
Inter	10 Oplossingen moeten uit de markt komen.	10	0,12	0	0,63	2	-1,31	-4	-0,58	-1	-0,23	0
Inter	16 Aan de bouwsector kleeft een traditioneel, suffig i	16	0,08	-1	-0,59	-2	0,56	2	-0,92	-3	0,3	1
Inter	33 Ondersteuning is nodig om niet overal het wiel opni	33	0,08	0	-0,38	-1	0,33	1	-0,76	-2	-0,15	0
Coll	6 De sleutel om de praktijk te doorbreken ligt bij een	6	-0,07	-1	0,49	1	1,78	5	1,15	3	1,14	3
Single	15 Het uitblijven van nieuwe ambities is een punt van	15	-0,25	-1	0,15	0	-0,84	-2	0,82	2	-0,4	-1
Single	14 Bouwers willen innovatie niet delen	14	-0,38	-1	1,96	5	0,08	0	-1,56	-5	1,93	5
Inter	32 Het is goed dat er bij dit soort vraagstukken een p	32	-0,45	-1	0,29	0	-0,99	-2	0,94	2	-2,1	-5
Single	18 De bouw begint pas met innoveren als een probleem m	18	-0,71	-2	0,46	1	0,76	2	-0,31	0	0,83	2
Fin	26 Extra investering moet liefst binnen het project wo	26	-0,77	-2	1,42	4	-1,82	-5	-0,02	0	-1,21	-4
Intra	31 Tijd voor uitproberen is er zelden binnen de strakk	31	-0,82	-2	0,89	2	1,06	3	0,16	1	-0,26	-1
Intra	30 Er is te weinig coaching en scholing van nieuw pers	30	-0,88	-2	0,59	1	-0,51	-1	-0,06	0	-0,34	-1
Coll	12 De bouw is evidence-based innoveren	12	-0,92	-3	0,64	2	1,12	3	0,59	1	0,57	1
Fin	25 De winstmarges schommelen al jaren rond breakeven,	25	-1,18	-3	0,09	0	0,15	0	-0,76	-2	-1,05	-3
Fin	21 Hoogconjuctuur geeft ruimte voor innovatie	21	-1,33	-3	-0,01	0	-1,69	-4	-0,44	0	-0,76	-2
Fin	24 De opbrengsten wegen niet op tegen de kosten die de	24	-1,7	-4	-1,9	-4	-1	-3	-1,13	-4	-1,93	-5
Fin	22 Henk Kamp moet meer geld uittrekken voor innovatie	22	-1,81	-4	-2,24	-5	-1,12	-3	-1,72	-5	-1,12	-3
Unm	36 Innovatie gaat langzaam, tergend langzaam.	36	-1,87	-5	-0,38	-1	0,28	1	-0,75	-2	0,08	0
Inter	34 De bouw transfomeert momenteel in giga-tempo van co	34	-2,31	-5	-1,13	-3	-2,02	-5	-0,52	-1	-1,18	-3

Output Factor 2 (F2)

Summary

Eigenvalue	2,73	
Lowest correlation with F1	0,17	(Overall lowest)
Highest correlation with F5	0,46	
Average amount of employees:	140 employees	(Least)
Average work experience:	24 years	(Odest)
Variance		9,09%

Respondents

Five respondents are significantly associated with this factor

Input	Function	Stakeholder	Experience	Gender
I15S1A5	ZZP	Project Initiator	> 20	M
I23S3A3	Accountmanager	Engineer	11 - 15	M
I25S5A5	Senior Consultant	Tech. Service Provider	> 20	M
I26S1A5	Directeur	Project Initiator	> 20	F
I8S2A3	Associate Partner	Architect	11 - 15	M

Q-sort

No.	**Items ranked at +5 and +4**	Value
14	Stakeholders in the construction industry don't want to share innovation.	5
23	The rule of play: Who pays, determines.	5
26	Extra investments must be earned back within one project.	4
8	Project initiators, industry and knowledge centres can collectively improve innovation.	4
	Items ranked higher by factor 1 than by any other factor	
	None	
	Items ranked lower by factor 1 than by any other factor	
	None	
	Items ranked at -5 and -4	
29	There is a "war on talent" going on.	-4
24	Profits do not justify the costs of the investments.	-4
11	The current submission procedure are not provocative enough to deviate from standard processes	-5
22	Henk Kamp has to make more money available for innovations in the Dutch construction industry.	-5

	Statement		Factor									
			1		2		3		4		5	
Single	14 Bouwers willen innovatie niet delen	14	-0,38	-1	1,96	5	0,08	0	-1,56	-5	1,93	5
Fin	23 De spelregel: Wie betaalt, die bepaalt	23	0,93	3	1,71	5	-0,22	-1	0,6	1	-0,53	-2
Fin	26 Extra investering moet liefst binnen het project wo	26	-0,77	-2	1,42	4	-1,82	-5	-0,02	0	-1,21	-4
Inter	8 Opdrachtgevers, -nemers en kennisinstellingen kunnen	8	0,19	0	1,11	4	0,65	2	0,74	2	1,14	3
Coll	4 Men is in de bouw bang voor concurrentienadeel	4	0,93	2	1,09	3	0,02	-1	-0,84	-2	1,96	5
Intra	1 Het beschikken over een innovatieve cultuur en struc	1	0,81	2	1,03	3	2,1	5	1,53	4	0,86	2
Intra	28 Het behouden en ontwikkelen van talentvolle medewer	28	0,49	1	0,96	3	1,47	4	1,43	3	0,47	1
Intra	31 Tijd voor uitproberen is er zelden binnen de strakk	31	-0,82	-2	0,89	2	1,06	3	0,16	1	-0,26	-1
Inter	35 Traditionele patronen staan vernieuwing van de bouw	35	0,63	1	0,64	2	1,58	4	1,03	2	0,76	2
Coll	12 De bouw is evidence-based innoveren	12	-0,92	-3	0,64	2	1,12	3	0,59	1	0,57	1
Inter	10 Oplossingen moeten uit de markt komen.	10	0,12	0	0,63	2	-1,31	-4	-0,58	-1	-0,23	0
Intra	30 Er is te weinig coaching en scholing van nieuw pers	30	-0,88	-2	0,59	1	-0,51	-1	-0,06	0	-0,34	-1
Coll	6 De sleutel om de praktijk te doorbreken ligt bij een	6	-0,07	-1	0,49	1	1,78	5	1,15	3	1,14	3
Single	18 De bouw begint pas met innoveren als een probleem m	18	-0,71	-2	0,46	1	0,76	2	-0,31	0	0,83	2
Coll	5 Men gaat eerder de confrontatie aan en wijzen naar e	5	0,14	0	0,44	1	0,06	0	-0,01	1	0,31	1
Coll	19 De sector worstelt met oud gedrag in een nieuwe wer	19	1,76	5	0,36	1	0,75	2	1,13	3	0,02	0
Inter	32 Het is goed dat er bij dit soort vraagstukken een p	32	-0,45	-1	0,29	0	-0,99	-2	0,94	2	-2,1	-5
Single	15 Het uitblijven van nieuwe ambities is een punt van	15	-0,25	-1	0,15	0	-0,84	-2	0,82	2	-0,4	-1
Fin	25 De winstmarges schommelen al jaren rond breakeven,	25	-1,18	-3	0,09	0	0,15	0	-0,76	-2	-1,05	-3
Coll	7 Effectiever met elkaar samenwerken is de belangrijks	7	1,16	4	0,08	0	-0,89	-2	1,72	5	1,33	4
Fin	21 Hoogconjuctuur geeft ruimte voor innovatie	21	-1,33	-3	-0,01	0	-1,69	-4	-0,44	0	-0,76	-2
Single	37 Veel projectmanager zien innovatie als extra risico	37	0,47	1	-0,12	0	0,09	0	-1,11	-3	0,84	2
Fin	20 Innovaties blijken kansrijker tijdens crisistijd	20	1,27	4	-0,2	-1	0,11	0	-0,5	-1	-0,83	-2
Intra	2 Om een echte omslag in de markt te maken, moeten we	2	0,74	2	-0,24	-1	0,83	3	0,68	1	0,25	0
Inter	38 Om innovatie te stimuleren moet meer worden samenge	38	0,51	1	-0,36	-1	0,23	1	1,6	4	0,94	3
Inter	33 Ondersteuning is nodig om niet overal het wiel opni	33	0,08	0	-0,38	-1	0,33	1	-0,76	-2	-0,15	0
Unm	36 Innovatie gaat langzaam, tergend langzaam.	36	-1,87	-5	-0,38	-1	0,28	1	-0,75	-2	0,08	0
Single	3 Iedereen doet wat hij altijd doet en het toepassen v	3	1,01	3	-0,47	-2	0,55	1	-0,5	-1	0,6	1
Single	27 Soft skills zijn voorwaardelijk geworden voor het t	27	1,3	5	-0,48	-2	-0,77	-2	2,06	5	1,27	4
Inter	16 Aan de bouwsector kleeft een traditioneel, suffig i	16	0,08	-1	-0,59	-2	0,56	2	-0,92	-3	0,3	1
Unm	9 Te strenge eisen aan kansrijke plannen	9	1,05	3	-0,89	-2	-0,63	-1	-0,45	0	-1,04	-2
Coll	13 Er heerst een wijdverbreide ja-maarcultuur bij alle	13	0,45	1	-0,97	-3	0,21	1	-1,22	-4	-0,41	-1
Inter	34 De bouw transfomeert momenteel in giga-tempo van co	34	-2,31	-5	-1,13	-3	-2,02	-5	-0,52	-1	-1,18	-3
Single	17 Innovatie zit niet in de genen van bouwers	17	0,24	0	-1,34	-3	0,16	0	-1,07	-3	-1,36	-4
Intra	29 Er is een "war on talent" gaande	29	0,24	0	-1,36	-4	-1,04	-3	-0,46	0	-0,49	-1
Fin	24 De opbrengsten wegen niet op tegen de kosten die de	24	-1,7	-4	-1,9	-4	-1	-3	-1,13	-4	-1,93	-5
Unm	11 De huidige aanbestedingsprocedure vormen weinig uit	11	0,83	2	-1,99	-5	-0,12	-1	-0,49	-1	-0,21	0
Fin	22 Henk Kamp moet meer geld uittrekken voor innovatie	22	-1,81	-4	-2,24	-5	-1,12	-3	-1,72	-5	-1,12	-3

Output Factor 3 (F3)

Summary

Eigenvalue	3,00	
Lowest correlation with F4	0,31	
Highest correlation with F5	0,52	(Overall highest)
Average amount of employees:	16100 employees	
Average work experience:	10 years	(Youngest)
Variance:	10,00%	

Respondents

Five respondents are significantly associated with this factor

Input	Function	Stakeholder	Experience	Gender
I16S4A5	Social Media Manager	Contractor	> 20	M
I18S3A3	Projectleider bouwinformatica	Engineer	11 - 15	M
I21S3A1	Consultant	Engineer	0 - 5	M
I24S5A1	Engineer	Tech. Service Provider	0 - 5	M
I29S1A2	Adviseur	Project Initiator	6 - 10	M

Q-sort

No.	Items ranked at +5 and +4	Value
1	Having an innovative culture and structure is essential in a fast moving environment	5
6	Another culture is the key to change the current practise.	5
35	Traditional patterns are blocking renewal in the construction industry.	4
28	Retain and train talented employees is essential for innovations.	4
	Items ranked higher by factor 1 than by any other factor	
12	The construction industry is evidence based innovation	3
31	Time to try out is rarely available in the tight planning during realisation.	3
2	In order to really change the market, we must accept fast changing responsibilities	3
18	The construction industry starts innovating when a problem needs to be solved.	2
	Items ranked lower by factor 1 than by any other factor	
	None	
	Items ranked at -5 and -4	
10	Solutions have to come from the market	-4
21	An economic boom creates space for innovation.	-4
26	Extra investments must be earned back within one project.	-5
34	Currently the construction industry transforms at an enormous pace from conservative to innovative.	-5

	Statement		Factor									
			1		2		3		4		5	
Intra	1 Het beschikken over een innovatieve cultuur en struc	1	0,81	2	1,03	3	2,1	5	1,53	4	0,86	2
Coll	6 De sleutel om de praktijk te doorbreken ligt bij een	6	-0,07	-1	0,49	1	1,78	5	1,15	3	1,14	3
Inter	35 Traditionele patronen staan vernieuwing van de bouw	35	0,63	1	0,64	2	1,58	4	1,03	2	0,76	2
Intra	28 Het behouden en ontwikkelen van talentvolle medewer	28	0,49	1	0,96	3	1,47	4	1,43	3	0,47	1
Coll	12 De bouw is evidence-based innoveren	12	-0,92	-3	0,64	2	1,12	3	0,59	1	0,57	1
Intra	31 Tijd voor uitproberen is er zelden binnen de strakk	31	-0,82	-2	0,89	2	1,06	3	0,16	1	-0,26	-1
Intra	2 Om een echte omslag in de markt te maken, moeten we	2	0,74	2	-0,24	-1	0,83	3	0,68	1	0,25	0
Single	18 De bouw begint pas met innoveren als een probleem m	18	-0,71	-2	0,46	1	0,76	2	-0,31	0	0,83	2
Coll	19 De sector worstelt met oud gedrag in een nieuwe wer	19	1,76	5	0,36	1	0,75	2	1,13	3	0,02	0
Inter	8 Opdrachtgevers, -nemers en kennisinstellingen kunnen	8	0,19	0	1,11	4	0,65	2	0,74	2	1,14	3
Inter	16 Aan de bouwsector kleeft een traditioneel, suffig i	16	0,08	-1	-0,59	-2	0,56	2	-0,92	-3	0,3	1
Single	3 Iedereen doet wat hij altijd doet en het toepassen v	3	1,01	3	-0,47	-2	0,55	1	-0,5	-1	0,6	1
Inter	33 Ondersteuning is nodig om niet overal het wiel opni	33	0,08	0	-0,38	-1	0,33	1	-0,76	-2	-0,15	0
Unm	36 Innovatie gaat langzaam, tergend langzaam.	36	-1,87	-5	-0,38	-1	0,28	1	-0,75	-2	0,08	0
Inter	38 Om innovatie te stimuleren moet meer worden samenge	38	0,51	1	-0,36	-1	0,23	1	1,6	4	0,94	3
Coll	13 Er heerst een wijdverbreide ja-maarcultuur bij alle	13	0,45	1	-0,97	-3	0,21	1	-1,22	-4	-0,41	-1
Single	17 Innovatie zit niet in de genen van bouwers	17	0,24	0	-1,34	-3	0,16	0	-1,07	-3	-1,36	-4
Fin	25 De winstmarges schommelen al jaren rond breakeven,	25	-1,18	-3	0,09	0	0,15	0	-0,76	-2	-1,05	-3
Fin	20 Innovaties blijken kansrijker tijdens crisistijd	20	1,27	4	-0,2	-1	0,11	0	-0,5	-1	-0,83	-2
Single	37 Veel projectmanager zien innovatie als extra risico	37	0,47	1	-0,12	0	0,09	0	-1,11	-3	0,84	2
Single	14 Bouwers willen innovatie niet delen	14	-0,38	-1	1,96	5	0,08	0	-1,56	-5	1,93	5
Coll	5 Men gaat eerder de confrontatie aan en wijzen naar e	5	0,14	0	0,44	1	0,06	0	-0,01	1	0,31	1
Coll	4 Men is in de bouw bang voor concurrentienadeel	4	0,93	2	1,09	3	0,02	-1	-0,84	-2	1,96	5
Unm	11 De huidige aanbestedingsprocedure vormen weinig uit	11	0,83	2	-1,99	-5	-0,12	-1	-0,49	-1	-0,21	0
Fin	23 De spelregel: Wie betaalt, die bepaalt	23	0,93	3	1,71	5	-0,22	-1	0,6	1	-0,53	-2
Intra	30 Er is te weinig coaching en scholing van nieuw pers	30	-0,88	-2	0,59	1	-0,51	-1	-0,06	0	-0,34	-1
Unm	9 Te strenge eisen aan kansrijke plannen	9	1,05	3	-0,89	-2	-0,63	-1	-0,45	0	-1,04	-2
Single	27 Soft skills zijn voorwaardelijk geworden voor het t	27	1,3	5	-0,48	-2	-0,77	-2	2,06	5	1,27	4
Single	15 Het uitblijven van nieuwe ambities is een punt van	15	-0,25	-1	0,15	0	-0,84	-2	0,82	2	-0,4	-1
Coll	7 Effectiever met elkaar samenwerken is de belangrijks	7	1,16	4	0,08	0	-0,89	-2	1,72	5	1,33	4
Inter	32 Het is goed dat er bij dit soort vraagstukken een p	32	-0,45	-1	0,29	0	-0,99	-2	0,94	2	-2,1	-5
Fin	24 De opbrengsten wegen niet op tegen de kosten die de	24	-1,7	-4	-1,9	-4	-1	-3	-1,13	-4	-1,93	-5
Intra	29 Er is een "war on talent" gaande	29	0,24	0	-1,36	-4	-1,04	-3	-0,46	0	-0,49	-1
Fin	22 Henk Kamp moet meer geld uittrekken voor innovatie	22	-1,81	-4	-2,24	-5	-1,12	-3	-1,72	-5	-1,12	-3
Inter	10 Oplossingen moeten uit de markt komen.	10	0,12	0	0,63	2	-1,31	-4	-0,58	-1	-0,23	0
Fin	21 Hoogconjuctuur geeft ruimte voor innovatie	21	-1,33	-3	-0,01	0	-1,69	-4	-0,44	0	-0,76	-2
Fin	26 Extra investering moet liefst binnen het project wo	26	-0,77	-2	1,42	4	-1,82	-5	-0,02	0	-1,21	-4
Inter	34 De bouw transfomeert momenteel in giga-tempo van co	34	-2,31	-5	-1,13	-3	-2,02	-5	-0,52	-1	-1,18	-3

Output Factor 4 (F4)

Summary

Eigenvalue	3,05	(Highest)
Lowest correlation with F3	0,31	(Overall lowest)
Highest correlation with F1	0,42	
Average amount of employees:	150 employees	(Lowest)
Average work experience:	23 years	(Second highest)
Variance:		10,18%

Respondents

Five respondents are significantly associated with this factor

Input	Function	Stakeholder	Experience	Gender
I9S4A3	Head of Major Project Advisory	Contractor	16 - 20	M
I10S1PA2	Sr. Projectmanager	Project Initiator	6 - 10	M
I13S2A5	Project Manager	Architect	> 20	M
I30S2A5	Directeur	Architect	> 20	M
I31S1A5	Directeur	Project Initiator	> 20	M

Q-sort

No.	Items ranked at +5 and +4	Value
27	Soft skills have become a condition in the tender process and for the realisation of projects.	5
7	More effective collaboration is the most important renewal in the construction industry.	5
38	To stimulate innovations, there must be more collaboration with other disciplines, such as the creative industry.	4
1	Having an innovative culture and structure is essential in a fast moving environment	4
	Items ranked higher by factor 1 than by any other factor	
	None	
	Items ranked lower by factor 1 than by any other factor	
	None	
	Items ranked lower by factor 1 than by any other factor	
24	Profits do not justify the costs of the investments.	-4
13	An extensive "yes-but" culture dominates all actors of the building process.	-4
14	Stakeholders in the construction industry don’t want to share innovation.	-5
22	Henk Kamp has to make more money available for innovations in the Dutch construction industry.	-5

	Statement		Factor									
			1		2		3		4		5	
Single	27 Soft skills zijn voorwaardelijk geworden voor het t	27	1,3	5	-0,48	-2	-0,77	-2	2,06	5	1,27	4
Coll	7 Effectiever met elkaar samenwerken is de belangrijks	7	1,16	4	0,08	0	-0,89	-2	1,72	5	1,33	4
Inter	38 Om innovatie te stimuleren moet meer worden samenge	38	0,51	1	-0,36	-1	0,23	1	1,6	4	0,94	3
Intra	1 Het beschikken over een innovatieve cultuur en struc	1	0,81	2	1,03	3	2,1	5	1,53	4	0,86	2
Intra	28 Het behouden en ontwikkelen van talentvolle medewer	28	0,49	1	0,96	3	1,47	4	1,43	3	0,47	1
Coll	6 De sleutel om de praktijk te doorbreken ligt bij een	6	-0,07	-1	0,49	1	1,78	5	1,15	3	1,14	3
Coll	19 De sector worstelt met oud gedrag in een nieuwe wer	19	1,76	5	0,36	1	0,75	2	1,13	3	0,02	0
Inter	35 Traditionele patronen staan vernieuwing van de bouw	35	0,63	1	0,64	2	1,58	4	1,03	2	0,76	2
Inter	32 Het is goed dat er bij dit soort vraagstukken een p	32	-0,45	-1	0,29	0	-0,99	-2	0,94	2	-2,1	-5
Single	15 Het uitblijven van nieuwe ambities is een punt van	15	-0,25	-1	0,15	0	-0,84	-2	0,82	2	-0,4	-1
Inter	8 Opdrachtgevers, -nemers en kennisinstellingen kunnen	8	0,19	0	1,11	4	0,65	2	0,74	2	1,14	3
Intra	2 Om een echte omslag in de markt te maken, moeten we	2	0,74	2	-0,24	-1	0,83	3	0,68	1	0,25	0
Fin	23 De spelregel: Wie betaalt, die bepaalt	23	0,93	3	1,71	5	-0,22	-1	0,6	1	-0,53	-2
Coll	12 De bouw is evidence-based innoveren	12	-0,92	-3	0,64	2	1,12	3	0,59	1	0,57	1
Intra	31 Tijd voor uitproberen is er zelden binnen de strakk	31	-0,82	-2	0,89	2	1,06	3	0,16	1	-0,26	-1
Coll	5 Men gaat eerder de confrontatie aan en wijzen naar e	5	0,14	0	0,44	1	0,06	0	-0,01	1	0,31	1
Fin	26 Extra investering moet liefst binnen het project wo	26	-0,77	-2	1,42	4	-1,82	-5	-0,02	0	-1,21	-4
Intra	30 Er is te weinig coaching en scholing van nieuw pers	30	-0,88	-2	0,59	1	-0,51	-1	-0,06	0	-0,34	-1
Single	18 De bouw begint pas met innoveren als een probleem m	18	-0,71	-2	0,46	1	0,76	2	-0,31	0	0,83	2
Fin	21 Hoogconjuctuur geeft ruimte voor innovatie	21	-1,33	-3	-0,01	0	-1,69	-4	-0,44	0	-0,76	-2
Unm	9 Te strenge eisen aan kansrijke plannen	9	1,05	3	-0,89	-2	-0,63	-1	-0,45	0	-1,04	-2
Intra	29 Er is een "war on talent" gaande	29	0,24	0	-1,36	-4	-1,04	-3	-0,46	0	-0,49	-1
Unm	11 De huidige aanbestedingsprocedure vormen weinig uit	11	0,83	2	-1,99	-5	-0,12	-1	-0,49	-1	-0,21	0
Single	3 Iedereen doet wat hij altijd doet en het toepassen v	3	1,01	3	-0,47	-2	0,55	1	-0,5	-1	0,6	1
Fin	20 Innovaties blijken kansrijker tijdens crisistijd	20	1,27	4	-0,2	-1	0,11	0	-0,5	-1	-0,83	-2
Inter	34 De bouw transfomeert momenteel in giga-tempo van co	34	-2,31	-5	-1,13	-3	-2,02	-5	-0,52	-1	-1,18	-3
Inter	10 Oplossingen moeten uit de markt komen.	10	0,12	0	0,63	2	-1,31	-4	-0,58	-1	-0,23	0
Unm	36 Innovatie gaat langzaam, tergend langzaam.	36	-1,87	-5	-0,38	-1	0,28	1	-0,75	-2	0,08	0
Inter	33 Ondersteuning is nodig om niet overal het wiel opni	33	0,08	0	-0,38	-1	0,33	1	-0,76	-2	-0,15	0
Fin	25 De winstmarges schommelen al jaren rond breakeven,	25	-1,18	-3	0,09	0	0,15	0	-0,76	-2	-1,05	-3
Coll	4 Men is in de bouw bang voor concurrentienadeel	4	0,93	2	1,09	3	0,02	-1	-0,84	-2	1,96	5
Inter	16 Aan de bouwsector kleeft een traditioneel, suffig i	16	0,08	-1	-0,59	-2	0,56	2	-0,92	-3	0,3	1
Single	17 Innovatie zit niet in de genen van bouwers	17	0,24	0	-1,34	-3	0,16	0	-1,07	-3	-1,36	-4
Single	37 Veel projectmanager zien innovatie als extra risico	37	0,47	1	-0,12	0	0,09	0	-1,11	-3	0,84	2
Fin	24 De opbrengsten wegen niet op tegen de kosten die de	24	-1,7	-4	-1,9	-4	-1	-3	-1,13	-4	-1,93	-5
Coll	13 Er heerst een wijdverbreide ja-maarcultuur bij alle	13	0,45	1	-0,97	-3	0,21	1	-1,22	-4	-0,41	-1
Single	14 Bouwers willen innovatie niet delen	14	-0,38	-1	1,96	5	0,08	0	-1,56	-5	1,93	5
Fin	22 Henk Kamp moet meer geld uittrekken voor innovatie	22	-1,81	-4	-2,24	-5	-1,12	-3	-1,72	-5	-1,12	-3

Output Factor 5 (F5)

Summary

Eigenvalue	2,76	
Lowest correlation with F1	0,42	
Highest correlation with F3	0,52	(Overall highest)
Average amount of employees:	830 employees	
Average work experience:	19 years	
Variance:	9,19%	

Statistics

Eigenvalue	2,76
Variance	9,19%

Respondents

Four respondents are significantly associated with this factor:

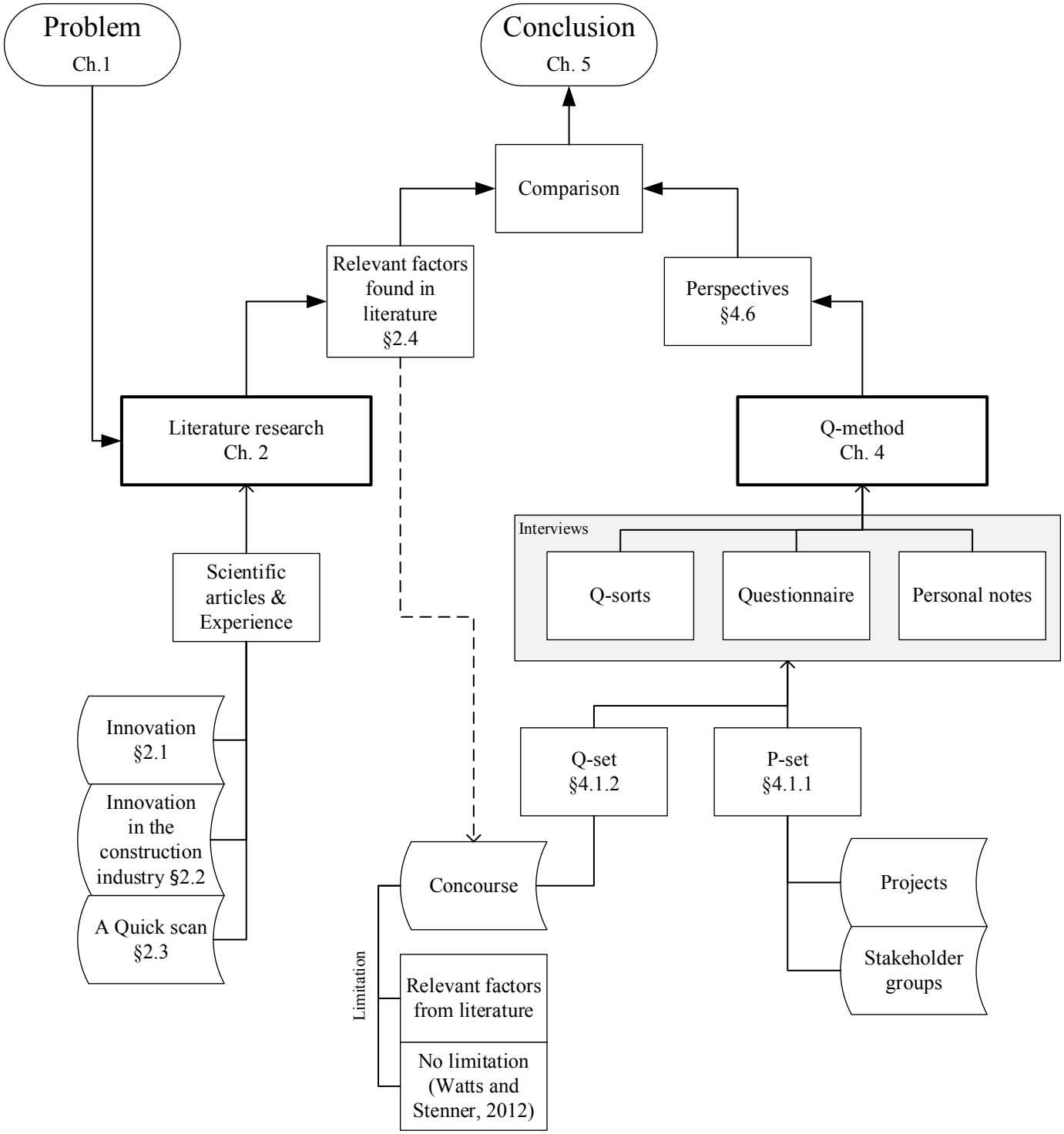
Input	Function	Stakeholder	Experience	Gender
I1S1A5	Directeur	Engineer	> 20	M
I3S5A3	Manager Energie en Duurzame ontwikkeling	Tech. Service Provider	11 - 15	M
I6S1A3	Programmamanager Duurzaamheid en Comfort	Project Initiator	11 - 15	F
I27S3A5	Projectmanager	Engineer	> 20	M

Q-sort

Z	**Items ranked at +5 and +4**	V
4	In the construction industry one is afraid of competition disadvantage	5
14	Stakeholders in the construction industry don’t want to share innovation.	5
7	More effective collaboration is the most important renewal in the construction industry.	4
27	Soft skills have become a condition in the tender process and for the realisation of projects.	4
	Items ranked higher by factor 1 than by any other factor	
	None	
	Items ranked lower by factor 1 than by any other factor	
	None	
	Items ranked at -5 and -4	
26	Extra investments must be earned back within one project.	-4
17	Innovations are not part of the builder's genes.	-4
24	Profits do not justify the costs of the investments.	-5
32	It is good to have, with certain types of issues, a party that can function from a limited distance, but is still an extension of the project initiator.	-5

	Statement		Factor									
			1		2		3		4		5	
Coll	4 Men is in de bouw bang voor concurrentienadeel	4	0,93	2	1,09	3	0,02	-1	-0,84	-2	1,96	5
Single	14 Bouwers willen innovatie niet delen	14	-0,38	-1	1,96	5	0,08	0	-1,56	-5	1,93	5
Coll	7 Effectiever met elkaar samenwerken is de belangrijks	7	1,16	4	0,08	0	-0,89	-2	1,72	5	1,33	4
Single	27 Soft skills zijn voorwaardelijk geworden voor het t	27	1,3	5	-0,48	-2	-0,77	-2	2,06	5	1,27	4
Coll	6 De sleutel om de praktijk te doorbreken ligt bij een	6	-0,07	-1	0,49	1	1,78	5	1,15	3	1,14	3
Inter	8 Opdrachtgevers, -nemers en kennisinstellingen kunnen	8	0,19	0	1,11	4	0,65	2	0,74	2	1,14	3
Inter	38 Om innovatie te stimuleren moet meer worden samenge	38	0,51	1	-0,36	-1	0,23	1	1,6	4	0,94	3
Intra	1 Het beschikken over een innovatieve cultuur en struc	1	0,81	2	1,03	3	2,1	5	1,53	4	0,86	2
Single	37 Veel projectmanager zien innovatie als extra risico	37	0,47	1	-0,12	0	0,09	0	-1,11	-3	0,84	2
Single	18 De bouw begint pas met innoveren als een probleem m	18	-0,71	-2	0,46	1	0,76	2	-0,31	0	0,83	2
Inter	35 Traditionele patronen staan vernieuwing van de bouw	35	0,63	1	0,64	2	1,58	4	1,03	2	0,76	2
Single	3 Iedereen doet wat hij altijd doet en het toepassen v	3	1,01	3	-0,47	-2	0,55	1	-0,5	-1	0,6	1
Coll	12 De bouw is evidence-based innoveren	12	-0,92	-3	0,64	2	1,12	3	0,59	1	0,57	1
Intra	28 Het behouden en ontwikkelen van talentvolle medewer	28	0,49	1	0,96	3	1,47	4	1,43	3	0,47	1
Coll	5 Men gaat eerder de confrontatie aan en wijzen naar e	5	0,14	0	0,44	1	0,06	0	-0,01	1	0,31	1
Inter	16 Aan de bouwsector kleeft een traditioneel, suffig i	16	0,08	-1	-0,59	-2	0,56	2	-0,92	-3	0,3	1
Intra	2 Om een echte omslag in de markt te maken, moeten we	2	0,74	2	-0,24	-1	0,83	3	0,68	1	0,25	0
Unm	36 Innovatie gaat langzaam, tergend langzaam.	36	-1,87	-5	-0,38	-1	0,28	1	-0,75	-2	0,08	0
Coll	19 De sector worstelt met oud gedrag in een nieuwe wer	19	1,76	5	0,36	1	0,75	2	1,13	3	0,02	0
Inter	33 Ondersteuning is nodig om niet overal het wiel opni	33	0,08	0	-0,38	-1	0,33	1	-0,76	-2	-0,15	0
Unm	11 De huidige aanbestedingsprocedure vormen weinig uit	11	0,83	2	-1,99	-5	-0,12	-1	-0,49	-1	-0,21	0
Inter	10 Oplossingen moeten uit de markt komen.	10	0,12	0	0,63	2	-1,31	-4	-0,58	-1	-0,23	0
Intra	31 Tijd voor uitproberen is er zelden binnen de strakk	31	-0,82	-2	0,89	2	1,06	3	0,16	1	-0,26	-1
Intra	30 Er is te weinig coaching en scholing van nieuw pers	30	-0,88	-2	0,59	1	-0,51	-1	-0,06	0	-0,34	-1
Single	15 Het uitblijven van nieuwe ambities is een punt van	15	-0,25	-1	0,15	0	-0,84	-2	0,82	2	-0,4	-1
Coll	13 Er heerst een wijdverbreide ja-maarcultuur bij alle	13	0,45	1	-0,97	-3	0,21	1	-1,22	-4	-0,41	-1
Intra	29 Er is een "war on talent" gaande	29	0,24	0	-1,36	-4	-1,04	-3	-0,46	0	-0,49	-1
Fin	23 De spelregel: Wie betaalt, die bepaalt	23	0,93	3	1,71	5	-0,22	-1	0,6	1	-0,53	-2
Fin	21 Hoogconjuctuur geeft ruimte voor innovatie	21	-1,33	-3	-0,01	0	-1,69	-4	-0,44	0	-0,76	-2
Fin	20 Innovaties blijken kansrijker tijdens crisistijd	20	1,27	4	-0,2	-1	0,11	0	-0,5	-1	-0,83	-2
Unm	9 Te strenge eisen aan kansrijke plannen	9	1,05	3	-0,89	-2	-0,63	-1	-0,45	0	-1,04	-2
Fin	25 De winstmarges schommelen al jaren rond breakeven,	25	-1,18	-3	0,09	0	0,15	0	-0,76	-2	-1,05	-3
Fin	22 Henk Kamp moet meer geld uittrekken voor innovatie	22	-1,81	-4	-2,24	-5	-1,12	-3	-1,72	-5	-1,12	-3
Inter	34 De bouw transfomeert momenteel in giga-tempo van co	34	-2,31	-5	-1,13	-3	-2,02	-5	-0,52	-1	-1,18	-3
Fin	26 Extra investering moet liefst binnen het project wo	26	-0,77	-2	1,42	4	-1,82	-5	-0,02	0	-1,21	-4
Single	17 Innovatie zit niet in de genen van bouwers	17	0,24	0	-1,34	-3	0,16	0	-1,07	-3	-1,36	-4
Fin	24 De opbrengsten wegen niet op tegen de kosten die de	24	-1,7	-4	-1,9	-4	-1	-3	-1,13	-4	-1,93	-5
Inter	32 Het is goed dat er bij dit soort vraagstukken een p	32	-0,45	-1	0,29	0	-0,99	-2	0,94	2	-2,1	-5

No.		No.		No.		No.		No.		No.		No.		No.		No.		No.	
	1 vs 2		1 vs 3		1 vs 4		1 vs 5		2 vs 3		2 vs 4		2 vs 5		3 vs 4		3 vs 5		4 vs 5
11	2,82	27	2,07	20	1,77	20	2,10	26	3,24	14	3,52	26	2,63	14	1,64	17	1,52	32	3,04
9	1,94	7	2,05	4	1,77	9	2,09	10	1,94	4	1,93	32	2,39	16	1,48	31	1,32	15	1,22
27	1,78	9	1,68	13	1,67	19	1,74	23	1,93	26	1,44	23	2,24	13	1,43	1	1,24	26	1,19
29	1,60	10	1,43	37	1,58	32	1,65	14	1,88	10	1,21	31	1,15	17	1,23	25	1,20	23	1,13
17	1,58	29	1,28	3	1,51	17	1,60	21	1,68	23	1,11	25	1,14	37	1,20	32	1,11	19	1,11
3	1,48	20	1,16	9	1,50	23	1,46	32	1,28	37	0,99	30	0,93	33	1,09	28	1,00	28	0,96
20	1,47	23	1,15	11	1,32	11	1,04	30	1,10	25	0,85	10	0,86	18	1,07	20	0,94	24	0,80
13	1,42	26	1,05	17	1,31	13	0,86	4	1,07	18	0,77	21	0,75	3	1,05	24	0,93	27	0,79
19	1,40	19	1,01	14	1,18	29	0,73	15	0,99	31	0,73	20	0,63	36	1,03	35	0,82	1	0,67
7	1,08	11	0,95	16	1,00	2	0,49	7	0,97	30	0,65	15	0,55	25	0,91	19	0,73	38	0,66
2	0,98	4	0,91	33	0,84	26	0,44	34	0,89	5	0,45	28	0,49	31	0,90	6	0,64	34	0,66
38	0,87	15	0,59	10	0,70	3	0,41	8	0,46	21	0,43	19	0,34	4	0,86	13	0,62	9	0,59
16	0,67	32	0,54	29	0,70	10	0,35	5	0,38	33	0,38	1	0,17	6	0,63	2	0,58	2	0,43
37	0,59	3	0,46	19	0,63	33	0,23	27	0,29	8	0,37	9	0,15	20	0,61	12	0,55	31	0,42
33	0,46	37	0,38	23	0,33	24	0,23	25	-0,06	36	0,37	5	0,13	22	0,60	33	0,48	7	0,39
22	0,43	21	0,36	5	0,15	15	0,15	31	-0,17	16	0,33	12	0,07	1	0,57	9	0,41	20	0,33
24	0,20	38	0,28	2	0,06	27	0,03	37	-0,21	20	0,30	34	0,05	35	0,55	23	0,31	21	0,32
35	-0,01	13	0,24	22	-0,09	28	0,02	9	-0,26	13	0,25	14	0,03	12	0,53	16	0,26	17	0,29
4	-0,16	5	0,08	18	-0,40	1	-0,05	18	-0,30	12	0,05	24	0,03	11	0,37	36	0,20	25	0,29
1	-0,22	17	0,08	35	-0,40	25	-0,13	20	-0,31	3	0,03	17	0,02	2	0,15	11	0,09	30	0,28
5	-0,30	2	-0,09	25	-0,42	35	-0,13	29	-0,32	17	-0,27	8	-0,03	24	0,13	22	0,00	35	0,27
15	-0,40	33	-0,25	8	-0,55	5	-0,17	19	-0,39	35	-0,39	35	-0,12	5	0,07	3	-0,05	29	0,03
28	-0,47	34	-0,29	7	-0,56	7	-0,17	12	-0,48	9	-0,44	33	-0,23	28	0,04	18	-0,07	12	0,02
10	-0,51	30	-0,37	24	-0,57	16	-0,22	28	-0,51	28	-0,47	18	-0,37	8	-0,09	30	-0,17	6	0,01
6	-0,56	8	-0,46	1	-0,72	37	-0,37	38	-0,59	1	-0,50	36	-0,46	9	-0,18	5	-0,25	11	-0,28
32	-0,74	14	-0,46	26	-0,75	38	-0,43	36	-0,66	22	-0,52	2	-0,49	19	-0,38	15	-0,44	5	-0,32
23	-0,78	16	-0,48	27	-0,76	30	-0,54	33	-0,71	34	-0,61	13	-0,56	30	-0,45	8	-0,49	10	-0,35
8	-0,92	22	-0,69	30	-0,82	31	-0,56	24	-0,90	32	-0,65	6	-0,65	29	-0,58	29	-0,55	8	-0,40
18	-1,17	24	-0,70	21	-0,89	21	-0,57	35	-0,94	6	-0,66	4	-0,87	10	-0,73	26	-0,61	22	-0,60
34	-1,18	35	-0,95	28	-0,94	22	-0,69	3	-1,02	15	-0,67	29	-0,87	23	-0,82	38	-0,71	33	-0,61
25	-1,27	28	-0,98	31	-0,98	8	-0,95	2	-1,07	19	-0,77	16	-0,89	21	-1,25	37	-0,75	13	-0,81
21	-1,32	1	-1,29	15	-1,07	4	-1,03	1	-1,07	24	-0,77	37	-0,96	38	-1,37	34	-0,84	36	-0,83
30	-1,47	25	-1,33	38	-1,09	34	-1,13	22	-1,12	29	-0,90	3	-1,07	34	-1,50	21	-0,93	3	-1,10
36	-1,49	18	-1,47	36	-1,12	6	-1,21	16	-1,15	2	-0,92	22	-1,12	15	-1,66	10	-1,08	18	-1,14
12	-1,56	6	-1,85	6	-1,22	12	-1,49	13	-1,18	11	-1,50	7	-1,25	26	-1,80	14	-1,85	16	-1,22
31	-1,71	31	-1,88	32	-1,39	18	-1,54	6	-1,29	7	-1,64	38	-1,30	32	-1,93	4	-1,94	37	-1,95
26	-2,19	12	-2,04	12	-1,51	36	-1,95	17	-1,50	38	-1,96	27	-1,75	7	-2,61	27	-2,04	4	-2,80
14	-2,34	36	-2,15	34	-1,79	14	-2,31	11	-1,87	27	-2,54	11	-1,78	27	-2,83	7	-2,22	14	-3,49


Problem
Ch.1
Conclusion
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Comparison
Relevant factors found in literature §2.4
Perspectives §4.6
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Q-method Ch. 4
Interviews
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Innovation in the construction industry §2.2
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Q-set §4.1.2
P-set §4.1.1
Concourse
Projects
Stakeholder groups
Limitation
Relevant factors from literature
No limitation (Watts and Stenner, 2012)