VENTURING RELATIONS ENABLING TRANSFORMATIONAL INNOVATION OF ENGINEERING FIRMS

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March, 2019

Master thesis part of the master Construction Management and Engineering at the Delft University of Technology

In collaboration with Royal HaskoningDHV

Cover photo: CSO Online

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PREFACE

This graduation research completes my master 'Construction Management and Engineering' at the Delft University of Technology. Before finalising this master study, I had a background in both the construction sector and the world of entrepreneurship. My background in the construction sector was formed by a bachelor degree in architecture, an internship at Zecc Architects, an internship at contractor BAM and the first part of my master Construction Management and Engineering. My background in entrepreneurship was mainly formed by an entrepreneurial journey related to the start-up Clair that I founded in 2015. With this start-up I won the Dutch Cleantech Challenge and the DOW Chemical Challenge. Besides, with the start-up Clair I participated in the student program of incubator YesDelft. Furthermore, I started the 'Master Entrepreneurship Annotation' at the Delft University of Technology, as an addition to my master Construction Management and Engineering. The starting point of this graduation research was to combine both backgrounds. I had the ambition to combine entrepreneurship with the construction sector.

I shared my ambition to combine entrepreneurship with the construction sector with Bart Brink, director of the 'smart solutions' business unit of engineering firm Royal HaskoningDHV. He responded with enthusiasm and gave me the opportunity to carry out my graduation research at his business unit. I am honoured for the opportunity he gave me. It has been valuable for me to experience how a commercial engineering firm like Royal HaskoningDHV deals with entrepreneurial dilemma's that I only knew from theory.

I would like to express my gratitude towards the members of the graduation committee. I experienced professional but warm and personal support of each member. Besides, I acknowledge unique values in the support of each member.
In the support of Professor Wamelink, I appreciated his steering towards the bigger story and how he kept an overview over my graduation process. Furthermore, I am professor Wamelink grateful for the confidence he gave me during a personal conversation at a moment when this report felt rather far away.
In the support of supervisor Scholten, I appreciated his creativity. The conversations with Scholten always sparked new ideas and energy to explore new paths.
In the support of supervisor Lousberg, I appreciated his personal approach. He adjusted his support to my personal traits. I have appreciated greatly his tailor-made support. Furthermore, I am Lousberg grateful for his 'down to earth' approach that helped me in distinguishing 'value' from 'hot air' in my own thoughts.
I appreciated in the support of supervisor Stomph how he challenged me to have an eye for the practical implications of my conceptual thoughts.

Finally, I wish to thank my family and friends for the unconditional support they gave me.

Bram Baak
Delft
March 11, 2019

SUMMARY

The construction sector showed almost no fundamental change in the past 50 years, where other industries reaped the benefits of standardisation and digitalisation. Until recently innovation development was no issue for engineering firms active in this construction sector. At the moment however, they are progressing towards higher degrees of innovation by embracing digitalisation. This progression is influenced by an important development in the business model of engineering firms. Engineering firms were used to have exclusive insights in the value chain of the construction sector, which enabled them to sell these insights towards clients. Selling these insights as core business is threatened however, creating an urgency for a new core business. Engineering firms seem to aim for new business consisting of selling 'total solutions'. Total solutions in which knowledge and assets of external parties are integrated, in combination with a licence business model to make it scalable. Selling such total solutions is regarded as a transformational innovation for conventional engineering firms, because it has the power to transform their core business. Engineering firms however, lack perspective on how they should develop transformational innovation. They have a strong impression that external parties play a role in the appropriate strategy, but it is unknown how to relate with these external parties in such a way they have an optimal effect on the transformational innovation development. This research investigates what order of steps is beneficial for engineering firms to develop transformational innovation through relations with external parties.

A cross-case multiple case study methodology is executed in order to answer this question. Seven cases in which an innovation seeking firm makes a relation with an external venture are investigated. These cases comprise venturing relations outside the construction sector. Each case is investigated along multiple topics resulting from a literature review. The most important topics are the degrees of integration, autonomy and openness of the network. A cross-case analysis of the seven cases results in aspects that seem beneficial for (transformational) innovation development, derived from firms outside the construction sector. Subsequently, these aspects are evaluated by an expert evaluation panel consisting of three innovation experts of three leading Dutch engineering firms.

The expert evaluation results in an order of steps beneficial for transformational innovation development of engineering firms in venturing relations with external parties. It seems beneficial to create a moderate degree of operational integration when both parties have business on the same domain. Furthermore, it seems beneficial to start strategic discussions between the engineering firm and the external venture after a moderate degree of operational integration is created. After strategic discussions three aspects seem beneficial. First, the provision of extensive strategic autonomy by the engineering firm to the external venture. Second, the creation of a high degree of operational integration between the engineering firm and external venture. Third, the creation of indirect closed network configurations between the engineering firm and external venture.

The most important element in the discussion of the research is the suggestion to recognise the network characteristic 'degree of complementary relations' as a network characteristic influencing innovation development.

With regard to the limitations of this research it may be considered that only seven cases are investigated. Furthermore, from the companies involved in each case only one or two persons have been interviewed. Lastly, the research scope was limited and a possible cross-industry bias cannot be excluded.

A recommendation for further research is to investigate the role of clients in transformational innovation development, as they generally have a stringent role in the construction sector. Furthermore, the role of the rather conservative behaviour of engineers in developing transformational innovation at engineering firms is recommended to look into. Lastly, it is recommended to investigate how a special form of venturing, 'network orchestration venturing', can be applied to engineering firms.

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INTRODUCTION

For years, 'consolidation' was the adagio firms preached. Consolidation aimed at making firms more efficient. However, making their firms more efficient through consolidation is not the answer on major societal challenges that firms face at the moment. Firms are not looking for more efficient business, firms are looking for transformational new business. Especially engineering firms in the built environment are looking for transformational innovation to replace their current core business. Some engineering firms consider consolidation still to be helpful in this challenge. But most engineering firms believe that it is probably wiser to stay smaller and make innovation relations towards other firms instead of consolidating with these external parties. This thesis deals with the question how engineering firms can make innovation relations in such a way that they contribute to the development of transformational innovation.

This research report consists of 8 chapters. Chapter 1 describes the dynamics of innovation development at engineering firms and results in the research formulation. Chapter 2 describes which concepts are relevant for developing transformational innovation through collaboration. Chapter 3 describes the method used for answering the main research question. The case study methodology is the core method described here. Chapter 4 presents the results of the research. The results consist of the case highlights, the cross-case findings and the expert evaluation findings. Chapter 5 draws a conclusion based on the research results, followed by the discussion and limitations described in chapter 6. Chapter 7 describes recommendations for engineering firms and for further research. Finally, chapter 8 describes a personal reflection on the research process.

1 CONTEXT

1.1 Introduction

This first chapter describes the dynamics of innovation development at engineering firms and results in the research formulation. This chapter is based on six interviews with innovation experts from three engineering firms: Royal HaskoningDHV, Arcadis and Witteveen&Bos. This context chapter is described in subchapter 1.2 until 1.10 and the redline in these subchapters is as follows.

Research into the context of innovation development at engineering firms reveals that the construction sector can be characterised by a relatively low degree of innovation. Engineering firms, as part of this construction sector, show relatively low degrees of innovation as well. However, in the construction sector multiple innovation chances come across at the moment. Theses chances lay in the fields of the following technologies: artificial intelligence, big data, wireless sensoring, drones, robotics, smart buildings, 3d-printing etc. These technologies can have a magnetic, attracting effect on conventional engineering firms to develop transformational innovation.
These chances are not yet exploited to their full potential. Nevertheless, in and outside engineering firms there are already multiple promising innovation developments related to these chances.

Exemplary for promising innovation developments in the construction sector, but outside engineering firms, is the development of 'smart buildings' like the 'Edge'. Promising innovation developments at engineering firms are the 'digital service' 'Bluelabel' developed by Royal HaskoningDHV together with Achmea. Furthermore, it is promising to see that RoyalHaskoningDHV took a minority share in data platform company HAL24K in order to develop new digital business and that Arcadis started a partnership with Techstars in order to shape strategic partnerships aimed at innovation.

At engineering firms, a transformation from the old core business consisting of selling advice towards new core business of selling total solutions is aimed for. Engineering firms want to get rid of their business model consisting of selling consultancy hours. They see chances in selling total solutions in combination with service or licence business models. Selling licenses is scalable, selling consultancy hours is not. Furthermore, the market asks engineering firms for added value related to total solutions instead of merely expert advice. Moreover, engineering firms are losing their exclusive insight over what happens in the construction sector, this knowledge is not anymore exclusively available for them. This creates difficulties for engineering firms to retain their core business of exploiting this knowledge in the form of selling it as advice.

The transformation from selling advice towards selling total solutions can be seen as a transformational innovation.
A transformational innovation is an innovation with a product or market significantly new and unrelated to the products sold or markets served in the core business of a firm. Due to the unrelatedness with the core business, transformational innovation has the potential to transform the core business of firms.
Society is in need for transformational innovation of engineering firms because it may enhance productivity of the sector and decrease costs of construction assets. On a firm level, engineering firms have a need for transformational innovation in order to survive. Transformational innovation is required in order to replace the disappearing core business and in order to be able to compete with new players entering the domain of the construction sector.

Engineering firms have strategies for developing transformational innovation. They practice 'design thinking' with clients, build ecosystems and set-up innovation funnels in order to guide (employee) idea's into business. Nevertheless, internal innovation programmes seem not to be adequate enough for developing transformational innovation. Transformational innovation of engineering firms requires two parts: construction sector domain knowledge and digital data capabilities. Engineering firms recognise that relations with external parties could be key in providing the latter part, the digital data capabilities. In this context, both Royal HaskoningDHV and Arcadis have put strategic partnerships into place for developing transformational innovation.

Engineering firms considers relations with external parties as important for developing transformational innovation. Nevertheless, for engineering firms it is unclear how they can organise their relations with external parties in such a way that these relations have an optimal effect on the development of transformational innovation. This problem statement forms the basis for the research formulation.

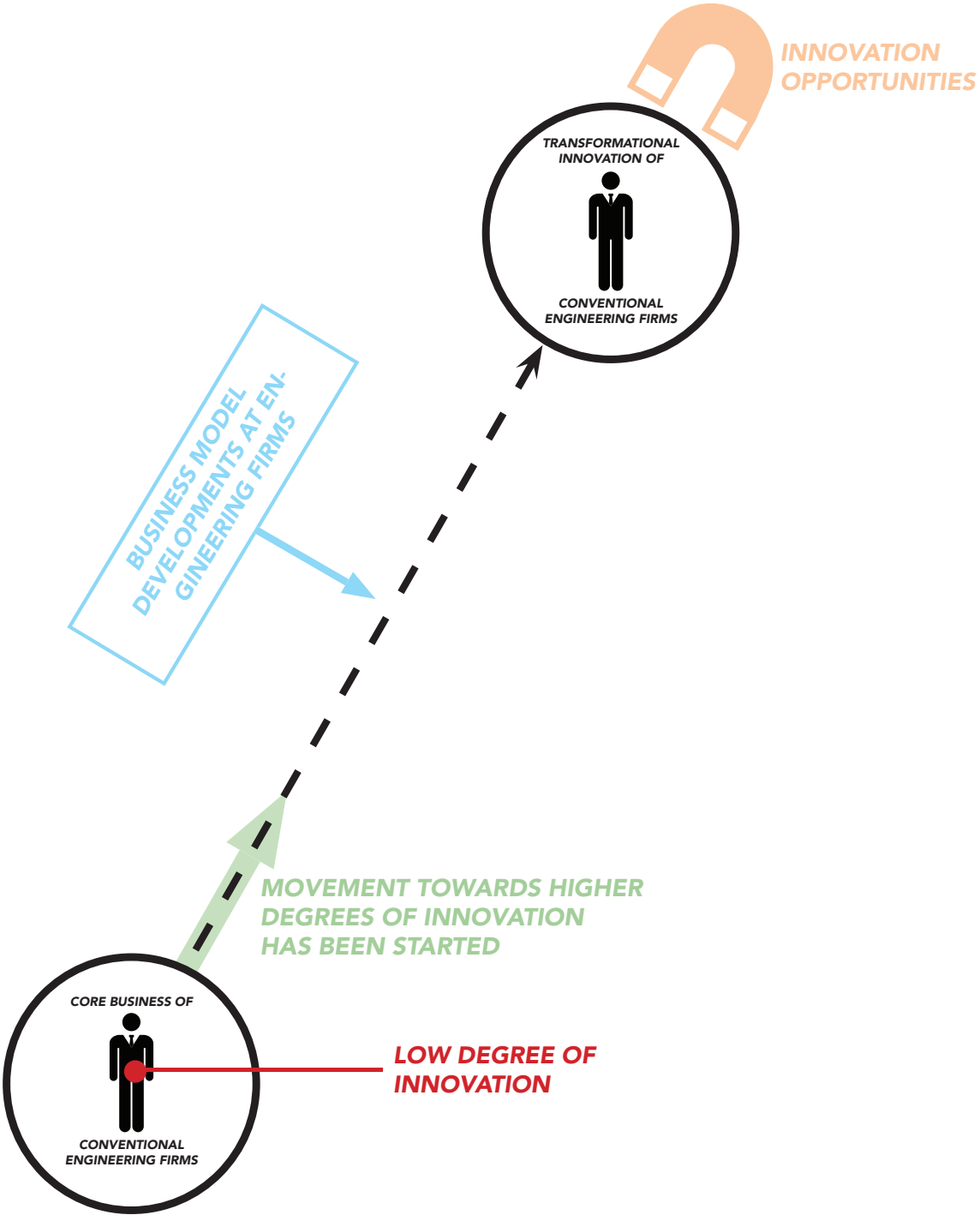


Figure 1 - Overview of chapter 1 'Context' (Own ill.)

1.2 Low degree of innovation in construction sector, but way up has started

According to the World Economic Forum (2017) the construction sector showed almost no fundamental change over the past 50 years. Other industries reaped the benefits of innovations related to standardisation and digitalisation, the construction sector did not (yet). The construction sector currently shows a low degree of innovation (Barbosa et al., 2017). This low degree of innovation relates to sector problems such as: being low-tech, facing low productivity, exploiting products with high costs and having little concern for demands of end-users (Meng & Brown, 2018). Productivity growth in the construction sector over the past 20 years was (on average) 1% per year. Contrasted by a productivity growth of 2.8% per year in the world economy and 3.6% per year in the manufacturing industry (Barbosa et al., 2017).
The interviewed engineering firms recognize this low degree of innovation in the construction sector. Brink, innovation manager at Royal HaskoningDHV mentions, just as literature, the low level of production growth in the construction sector.

Literature and interviews with engineering firms show that the construction sector shows a low degree of innovation. However, broadly agreed on is also that innovation in the construction sector has been started moving towards a higher degree. This movement can be recognized in innovation leaders developing promising innovations related to 3D-printing, wireless sensing and building information modelling (BIM) (World Economic Forum, 2017). The development towards higher degrees of innovation has been started, however most innovation efforts of the past 2 years are rather 'incremental' according to Stolker, innovation program manager at Arcadis. Incremental innovation is enhancing existing products for existing markets (Nagji & Tuff, 2012). Stolker explains that the incremental innovation efforts of the sector were mostly related to digitalizing existing processes. He argues that this way of innovation development is merely a way of surviving, for becoming truly competitive construction sector firms need transformational innovation. According to Stolker, these consist of new business models in which the end user is taken as a starting-point and in which this end-user receives maximal added value. The development of these transformational innovation still remain silent says Stolker.

1.3 Low degree of innovation at engineering firms, but way up has started

Interviews indicate a low degree of innovation at engineering firms, just like the degree of innovation in the sector in general. Brink explains how until a few years ago innovation development was no issue at engineering firms. It simply did not exist in an explicit manner.
Nevertheless, also at engineering firms the degree of innovation has started moving towards a higher degree. Many interviewees of engineering firms explain how their firm is starting to take innovation development serious and makes the first innovation progress. The following quotes are exemplary for this:

"Is everything oke? No. Are we doing the right things? Yes!"
Marije Hulshof, director business line 'industry and buildings' at Royal HaskoningDHV

"The train maybe not yet left the train station, but he is already moving"
Luuk Duijndam, strategy manager at Royal HaskoningDHV

"Innovation development at engineering firms has been started."
Daan Stolker, innovation program manager at Arcadis

1.4 Innovation opportunities

For all actors in the construction sector, including engineering firms in the built environment, innovation opportunities come across at the moment. These innovation chances are related to new technologies, mainly digital technologies. The opportunities for engineering firms in the built environment will be related to technologies such as artificial intelligence, big data, blockchain, wireless sensoring, drones, robotics, smart buildings and 3d-printing. These innovation opportunities could have a magnetic influence on innovation development at engineering firms (Arnoldussen, Groot, Halman, & Zwet, 2017; World Economic Forum, 2017).

1.5 Promising innovation development outside engineering firms

The construction sector is confronted with loads of innovation opportunities. Still, the degree of innovation remains at a low level. Nevertheless, at some places in the construction sector, in and outside engineering firms, promising innovation developments occur. One promising innovation development, outside engineering firms but in the construction sector is discussed: the emergence of the 'smart building'. Hence, this development could have its influences on innovation development at engineering firms.

The smart building is a rather vague concept. Nevertheless, as a tangible example of a smart building, frequently the 'Edge' developed by project developer OVG is mentioned. The edge, and the concept of 'smart building' is characterised by 'connectedness'. In smart buildings all physical things are connected, and thereby pushing the boundaries of the 'internet of things'. However, the connectedness between 'things' is merely the start. These things are also connected to sensors for example. Sensoring plays an important role in the concept of the smart building. Sensors track for example where people are. The connectedness between things and sensors enables the development of new customer journeys through buildings. In a smart building for example it can be imagined that the cleaning lady gets a message about which rooms are not used and therefore not have to be cleaned. Furthermore, employees entering a smart building office can be guided towards a workplace that fits their desired level of light, temperature and ambient noise. The connectedness between physical things and sensors demands a HUB, a place which connects all data and technology related to built environments. In turn, demanded customer journeys can be operationalised with this HUB. Emerging companies like Mapiq and LoneRooftop play an important role in sensoring technology for smart buildings. At the moment they provide sensoring technology and they offer consultancy to create customer journeys aligned to this technology. Nevertheless, strategically they may be more interested in eventually becoming the party controlling the HUB, including all data and technology related to built environments (van Hooijdonk, 2018; World Economic Forum, 2017).

Figure 2 – Picture visualising the connectedness in smart buildings ("10 IoT Smart Building Trends to look out for in 2018," n.d.)

1.6 Promising innovation developments at engineering firms

The degree of innovation at engineering firms is low, but progression towards a higher degree of innovation has started. This progression can be recognised in some promising innovation developments that are described in the three subparagraphs ahead.

1.6.1 Royal HaskoningDHV developing digital service 'Bluelabel'

Rood, former chief digital officer at Royal HaskoningDHV, describes how Royal HaskoningDHV co-developed and launched a promising digital service called 'Bluelabel'. She explains Bluelabel combines rainfall data and knowledge about the built environment in order to provide clients with valuable flood risks' insights on (their) properties. The CEO of Royal HaskoningDHV, Oostwegel, calls it a wonderful example of how engineers can combine their knowledge about the physical world with data and algorithms (Schreuder, 2018). Bluelabel is one of Royal HaskoningDHV's first digital services, meaning the engineering expertise and insights are not offered to the market via billable hours but as a scalable product (insights-as-a-service) with ongoing service and therefore a recurring earning model.

1.6.2 Royal HaskoningDHV takes a minority share in HAL24K for developing new business

Recently, Royal HaskoningDHV, took a minority share in data intelligence scale-up HAL24K. According to Duijndam, strategy manager at Royal HaskoningDHV, this investment can enable a lot of new business. The combination of the domain knowledge of Royal HaskoningDHV and the data analytics and machine learning capabilities may unlock valuable new business that eventually can replace the old core business of selling advice. Furthermore, Duijndam explains the action of Royal HaskoningDHV taking a minority share in HAL24K promising in respect to the strategy of Royal HaskoningDHV. This is a first step in making relations with external parties, in the form of corporate venturing capital, in order to enable the development of new business.

1.6.3 Arcadis starts partnership with accelerator Techstars

Arcadis is making relations with external parties in order to enable innovation as well. Arcadis started a partnership with start-up accelerator Techstars in order to accelerate innovation and shape innovation development with external parties. Ritter as 'Arcadis group executive innovation and transformation' explains that the partnership with Techstars is crucial in innovating outside-in at Arcadis ("Arcadis and Techstars partner to bring innovative solutions to the natural and built environment," 2018). Engineering firms making relations with start-up accelerators is unique.

1.7 Transformation from selling advice to selling total solution

The progression towards a higher degree of innovation at engineering firms is influenced by an important development in the business model of engineering firms. This development comprises a transformation from the current core business consisting of selling advice towards a new core business consisting of selling 'total solutions'. This transformation is visualised in figure 4. The advice is currently sold per hour and as one-off projects which makes them businesswise unattractive. The goal is to develop and sell total solutions as scalable products with recurring incomes from a service/licence business model.
The advice sold in the current core business of engineering firms is based on their knowledge gained by exclusive insight in the construction sector. The aimed for business of selling total solutions may be based on integrating knowledge and assets of actors across the construction sector. For example, initially engineering firms may sell advice based on insights about 'light shading technology' and 'wireless sensoring technology'. When selling total solutions, engineering firms may actually integrate the knowledge and assets related to light shading technology and wireless sensoring technology. Ultimately, enabling so called smart buildings in which connectedness between assets creates value.

Selling total solutions as scalable products seems to require a different structure of engineering firms. Van Nieuwenhuijzen, CTO at engineering firm Witteveen&Bos explains that selling total solutions as scalable products requires pre-investments, which are until now uncommon at engineering firms.
The transformation from selling advice towards selling total solutions is mainly influenced by two issues, these will be addressed briefly in the two paragraphs ahead. After describing these two issues, the emergence of new (digital tech) players in the construction domain will be addressed.

1.7.1 Clients demand total solutions

The first development influencing the transformation from selling advice towards selling total solutions at engineering firms is the demand of clients for total solutions. Van Nieuwenhuijzen, explains that clients, especially outside the Netherlands and the bigger type of clients, are more and more asking for total solutions instead of consultancy hours of engineers. Their demand for performance guarantees is exemplary for this total solution demand. This client demand is recognised by Stolker, he explains that clients demand 'added value' related to total solutions instead of consultancy hours with its associated performance risks. Hulshof, states that this demand for added value could be delivered by engineering firms in the form of 'performance as a service' business models.

1.7.2 Threatened knowledge broker position

The second development influencing the transformation from selling advice towards selling total solutions at engineering firms is the threatened knowledge broker position of engineering firms. Brink explains this development as follows. Engineering firms are very knowledge driven and until recently real knowledge castles. However, engineering firms face difficulties in retaining this position. Until recently engineering firms had exclusive insights in what happened at the supplier side of the value chain. Engineering firms were able to exploit this knowledge and acted according the 'knowledge is power' principle. However, nowadays knowledge about what happens at the supplier side of the value chain is not exclusively available for engineering firms. This means that engineering firms are no longer the exclusive 'knowledge stock' of the sector. A situation developed in which knowledge is everywhere in the value chain, a situation of 'knowledge flows' emerged. This has an important meaning for the business model of engineering firms and requires new roles and new business models. Merely selling insights in the construction sector seems impossible for engineering firms in the short future. They have to go beyond selling sector insights in the form of advice. The step beyond selling advice seems selling total solutions. Selling total solutions consists of integrating knowledge and assets of actors across the construction sector in such a way that value emerges.

1.7.3 Emergence of new (digital tech) players in the construction sector domain

New tech players are entering the construction sector. They see chances for exploiting total solutions with their digital data capabilities. Multiple interviewed individuals at engineering firms, explained that these tech companies as Google, IBM but consultancy firms as Accenture as well are probably very well capable in exploiting business related to total solutions in the construction sector domain.
The current core business of engineering firms consisting of selling advice cannot compete with the total solution business which the new tech players will exploit. If conventional engineering firms want to compete with the new tech players they have to develop business related to total solutions.

According to Stolker, competing with the tech players will be difficult for the engineering firms, because the digital capabilities of the tech players give them a strong competitive edge in the development of new total solution business. Furthermore, Stolker explains that these techplayers are already heavily focussing to the development of total solution business in the construction sector. For example Autodesk is investing 800 million euro each year into the development of this business. Those amounts of innovation investments are not found at conventional engineering firms. Stolker as well as Brink recognise a lack of domain knowledge at these tech players, which the conventional engineering firms do have.
According to the interviewed individuals at engineering firms, engineering firms may be able to compete with the tech players if they are able to develop digital data capabilities. The combination of construction sector domain knowledge and digital data capabilities is recognised by multiple interviewees as the key prerequisite for developing total solutions succesfully.
Duijndam, strategy manager at Royal HaskoningDHV, explains that engineering firms need relations with external parties in order to gain the yet lacking digital data capabilities which are required to transform towards an engineering firms selling total solutions.

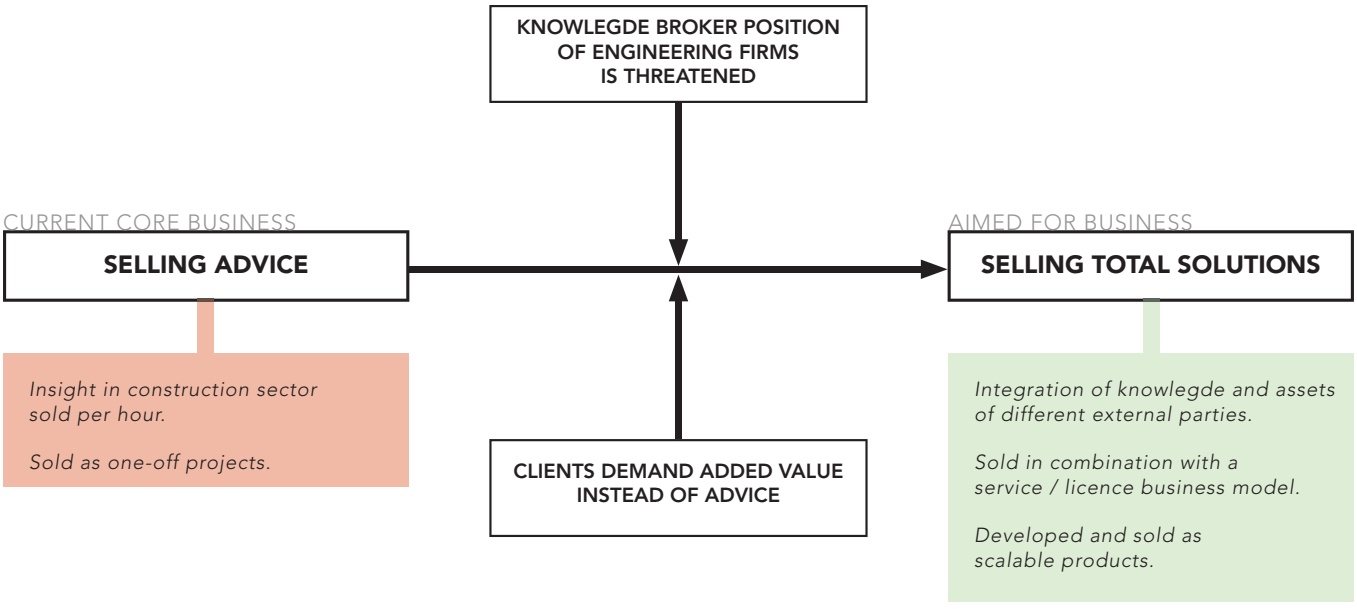


Figure 3 - Aimed for transformation at engineering firms

1.8 Transformational innovation of engineering firms

Paragraph 1.7 explained that engineering firms aim for a transformation from selling advice towards selling total solutions. This transformation can be seen as a transformational innovation as it fits in the definition of transformational innovation described in the following paragraph. Paragraph 1.8.2 describes why transformational innovation of engineering firms is required.

1.8.1 Transformational innovation explained

Several types of innovation are distinguished. Nagji and Tuff (2012) distinguishes three types of innovation as shown in the diagram: core innovation, adjacent innovation and transformational innovation

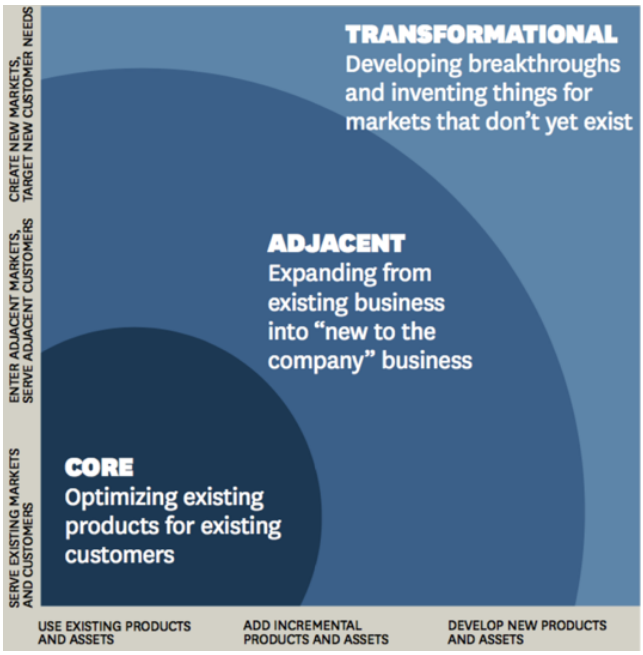


Figure 4 - Innovation types (Nagji and Tuff, 2012)

Confusion can arise between the concept of transformational innovation and the concept of radical innovation. In this research radical innovations are seen in the way O'Connor (2008) describes them as 'innovations that offer either new to the world performance features, significant improvement (5–10 times) in known performance features or significant reductions (e.g., 50%) in costs, such that new application domains open up'.
Transformational innovation as used in this research does not require new performance features, significant performance feature improvements or significant cost reductions. This research recognises a transformational innovation of a firm as '*an innovation with a product or market significantly new and unrelated to the products sold or markets served in the core business of this firm*'. Due to the unrelatedness with the core business, transformational innovation has the potential to transform the core business of firms.

Radical innovations are about 'new to the world' innovations and transformational innovations are about 'new to the company' innovations. Nevertheless, the concepts of radical innovation and transformational innovation can overlap. A radical innovation developed by a certain firm with new to the world product features can also be a transformational innovation of this firm when the product or market of the radical innovation is significant unrelated to the products sold or markets served in the core business of this firm.
Good examples of transformational innovations are iTunes and the Tata Nano car (Nagji and Tuff, 2012). Both innovations were no technology performance seekers, nevertheless the product and market of these innovations were rather unrelated to the core business of Apple and Tata Steel at the time it was developed and introduced. Eventually, these transformational innovations formed new core business, transforming the old core business.

1.8.2 Transformational innovation of engineering firms is required

Transformational innovation of engineering firms is required to contribute to the societal need for construction sector innovation, to replace the old core business of engineering firms that disappear and to make engineering firms able to compete with new tech players entering the construction domain. The three subparagraphs ahead explain this more in-depth.

Transformational innovation is required to contribute to the societal need for innovation

Engineering firms are part of the construction sector that in turn is part of society. The construction sector, and therefore engineering firms play an important role in society. The construction sector accounts for 6% of the global GDP and the construction sector enables other businesses to thrive. Society needs innovation in the construction sector, especially in order to increase the productivity and to decrease the costs of construction assets (World Economic Forum, 2017). Transformational innovation of engineering firms is required to contribute to these societal needs.

Transformational innovation is required to replace old core business which disappears

The core business of engineering firms related to selling advice will disappear. In order to survive, engineering firms have to develop transformational innovation to replace the old core business.

The tangible activities related to the core business of selling advice at engineering firms is related to drawing, calculating and managing. This core business is likely to disappear due to digitalisation developments and a changing market demand. Furthermore, retaining the knowledge broker position related to the exploitation of the current core business is impossible because engineering firms have no exclusive knowledge anymore. These latter two core business threatening dynamics are already discussed in-depth in paragraph 1.7.1 and 1.7.2.

Transformational innovation is required to be able to compete with new tech players

Interviews at engineering firms pointed out that tech players are entering the construction sector domain and the expectation is that these tech players will exploit business in rather advanced ways. With the conventional core business related to advice, engineering firms cannot compete with the business of the new players. In order to ensure a position in the new playing field, engineering firms require transformational innovation.

1.9 Strategies of engineering firms for developing transformational innovation

Engineering firms pursue the following strategies to develop transformational innovation.

1.9.1 Internal digital capability building

All the interviewed engineering firms recognise digital capabilities as crucial in developing transformational innovation. For this reason all of them have internal programmes to educate their employees with skills as machine learning, artificial intelligence, programming and data analytics.

1.9.2 Design thinking

Especially Arcadis and Royal HaskoningDHV mention design thinking as an important strategy for developing innovation. Brink explains that design thinking means for him 'starting with the client demand'. Brink argues that too often engineers forget the client demand during innovation development.
Stolker, explains how Arcadis practises design thinking during large client ideation sessions in which a lot of external parties are invited. External parties as clients, but also clients of clients and off course start-ups. For Stolker, the core of design thinking is taking the pain of the client as a starting point.

1.9.3 Innovation funnel

All interviewed engineering firms explain that an innovation funnel process is somehow the heart of their innovation development. The innovation funnel is the process entrepreneurial teams at engineering firms can move through with their innovation idea. The goal of the funnel is to develop the idea towards successful business exploitation. In general, the innovation funnel phases are as follow: ideation phase, pilot phase, commercialisation phase, roll-out phase. At all interviewed engineering firms, mentors and coaches are available to help the teams develop their idea. Royal HaskoningDHV plays with the thoughts to open up its innovation funnel and allow external parties to join their internal funnel. Or to allow internal ideas to make relations with external companies. But this idea is not yet materialised. Nevertheless, at Witteveen&Bos the innovation funnel is explicitly open for external parties which has a positive effect on innovation development according to van Nieuwenhuijzen.

1.9.4 Building ecosystems

For all interviewed engineering firms it is clear that building 'ecosystems' is essential for developing innovation. According to Brink, ecosystems enable a fast route to value. He says ecosystems should be combinations of parties which complement each other's core capabilities.
Stolker agrees with this and adds that in order to complement each other well, difference between the parties is required. He argues for example that the combination of a party from the health industry, the tech sector and a university could create very interesting innovations. Furthermore, he mentions the importance of mutual trust in developing ecosystems for innovation. Lastly, engineering firms recognise building ecosystems as key for developing especially transformational innovation because this type of innovation requires a network in order to succeed. Transformational innovation with total solution characteristics flourish by interconnectedness between multiple (different) parties, which occurs in ecosystems.

1.9.5 Acquisitions

Royal HaskoningDHV recently started acquisitions in order to enable innovation. Duijndam explains that RoyalHaskoning looks especially for companies with digital data capabilities which could complement the domain knowledge of Royal HaskoningDHV. A few months ago, the company Ynformed is bought by Royal HaskoningDHV in order to make innovation possible. Ynformed has expertise in the field of data-science which is strategically valuable for Royal HaskoningDHV. Arcadis makes acquisitions for innovation as well. Only Witteveen&Bos is not familiar with this strategy because they do not have the financial resources for it.

1.9.6 Strategic partnering

In order to have innovation profit from external parties, acquisitions are possible. However, just making a relation with external parties in the form of taking a minority share or just an innovation partnership can result in innovation profits at engineering firms as well, explains Duijndam of Royal HaskoningDHV. Both Royal HaskoningDHV and Arcadis practice strategic partnering, in the form of taking minority shares in external parties and making innovation partnerships. These strategic partnership relations fit perfect in the strategy of building ecosystems for innovation. Interesting examples of these strategic partnerships for innovation at engineering firms have already been described in paragraph 1.6.

Strategic partnering is considered by all engineering firms as key in innovation development. Especially for transformational innovation development at engineering firms, because this type of innovation requires digital data capabilities from outside engineering firms. The external venture, in a strategic partnership with an engineering firm, may provide these digital data capabilities. Strategic partnerships like this combined with the domain knowledge of engineering firms are regarded as potentially strong for the development of transformational innovation.

However, the interviewed engineering firms explain that it is unclear for them how they can manage their relations with external parties in such a way that these relations have an optimal effect on the development of transformational innovation. They face several dilemma's in their relations towards external ventures. They are insecure about the steps to undertake. Do they need to discuss strategic matters at first with a potential external venture? In order to make sure the operational integration will be focussed and goal oriented? Or is it better to start with some operational collaboration to explore operational complementarity and discuss strategic matters in a later phase? And how much operational integration is appropriate at what moment? And while working together, does the engineering firm have to be top-down about the strategic direction in order to maximise profit of the external venture? Or is it wise to take a more humble position and give the external venture freedom to determine the strategic direction? Questions like these are part of the lacking perspective of engineering firms on how they can manage their relations with external parties in such a way these relations have an optimal effect on the development of transformational innovation.

1.10 Research formulation

The lacking perspective of engineering firms on how to relate optimally towards external parties for the development of transformational innovation results in the following main research question:

"For engineering firms, what order of steps is beneficial for developing transformational innovation through relations with external parties?"

This research question is answered through three sub questions. First, literature is reviewed in order to get an understanding of the topics that play a role in the development of transformational innovation. The role of collaborations in innovation development is examined in particular. This literature review enables an answer on the first research question formulated as:

"What theoretical concepts are relevant for the development of transformational innovation through collaboration?"

Subsequently, the concepts relevant for the development of transformational innovation through collaboration are used to investigate innovation developments outside the construction sector. Innovation developments, in which an innovation seeking firm (ISF) makes a relation with an external venture (EV), are described along the topics that resulted from the literature review. Interviews with the innovation seeking firms as well as the external ventures are performed in order to enable these descriptions. The innovation developments are analysed via pattern-matching and enables an answer on the second sub question formulated as:

"What can be learned from (transformational) innovation developments at firms outside the construction sector?"

The insights emerging from innovation developments outside the construction sector are subsequently validated by a panel of innovation experts of three leading engineering firms, during an 'experts evaluation session'. This session enables an answer on the third and last sub question formulated as:

"How do construction sector experts evaluate the learnings from (transformational) innovation developments at firms outside the construction sector?"

2 THEORETICAL BACKGROUND

2.1 Introduction

Previous chapter described that engineering firms lack the perspective on how they can manage their relations with external parties in such a way that these relations have an optimal effect on the development of transformational innovation.
This chapter describes a literature review in the field of venturing and actor-networks. This review enables an answer on the first sub question of what theoretical concepts are relevant for the development of transformational innovation through collaboration.

Relations with entrepreneurial entities are widely recognised as crucial for the development of transformational innovation. As venturing is exactly about innovation development with entrepreneurial entities, investigating the field of venturing is relevant for this research.
Venturing activities, specifically external venturing activities, create relations in an actor-network. Therefore, external venturing activities influence the structure of a network of relations. As, this network structure affects innovation performance, the field of actor-networks is also recognized as relevant for this research.

2.2 Method theoretical background

In order to describe this theoretical background a literature review is conducted. At Google Scholar, Scopus and Science Direct, is searched on topics related to 'venturing' and 'actor-network' theory in relation to (transformational) innovation development. Per search inquiry the first twenty sources are scanned and only the most promising sources are read in-depth. Subsequently, based on the best literature sources the theoretical fields of venturing and actor-networks are described in their relation to transformational innovation development.

2.3 Venturing as an instrument for developing transformational innovation

Corporate venturing is "the set of organizational systems, processes and practices that focus on creating business in existing or new fields, markets or industries – using internal and external means" (Narayanan, Yang & Zahra, 2009) . The core of corporate venturing is the creation of business (Sharma & Chrisman, 2007). The creation of new business using internal means is referred to internal (corporate) venturing. When external means are put into practice as well, the business creation process is referred to as external (corporate) venturing. Especially this field is relevant in investigating the development of transformational innovation. As seen in the 'context' chapter, transformational innovation is hard to develop internally. This type of innovation requires an outside-in strategy. As external venturing is about the creation of business with external means, this concept can provide the outside-in requirement.
External venturing can come in various forms like corporate venturing capital (CVC), joint venturing, licensing or acquisitions. Within this thesis, in most cases external venturing comes along in the form of corporate venturing capital.

2.3.1 A form of external venturing: Corporate Venturing Capital

Corporate venturing capital is the process of acquiring equity stakes in other businesses, typically smaller entities like start-ups and scale-ups (Birkinshaw, van Basten Batenburg, & Murray, 2002). During the Dot-com boom the use of corporate venturing capital reached a peak in popularity. Many large firms started corporate venturing capital with the idea that it would enhance growth. However, early '00 many firms, like Ericcson and Marks&Spencer closed their venturing capital activities due to bad results (Campbell, Birkinshaw, Morrison, & van Basten Batenburg, 2003). Corporate venturing capital activities did not give them what they hoped for. Venturing turned out to be more difficult than it seemed to be at times of the dot-com boom. Nevertheless, still corporate venturing capital is widely used and seen as a vehicle to create (new) business.

2.3.2 Corporate Venturing for new (transformational) business?

According to various authors, corporate venturing is an appropriate instrument for creating transformational new business, also referred to as 'new legs'. Kanter (1990) describes in his book 'When giants learn to dance' how corporate venturing can serve as a way to create new business at large corporates. Foster & Kaplan (2011) underline this reasoning in their book 'Creative destruction'.

Chesbrough (2002) described that venturing is well suited for four purposes. These different venturing purposes are formed by two variables: 'the corporate investment objective' and the 'link to operational capability'. According to Chesbrough (2002) only one of these purposes can results in transformational innovation. He explains that transformational innovation can only result as an option like strategic upside from 'emergent' venturing. Emergent venturing is described as venturing which allows exploration of potential new businesses. According to Chesbrough (2002) this venturing purpose will be enabled by having a financial corporate investment objective and a tight link between the operational capability of the investing firm and the venture.

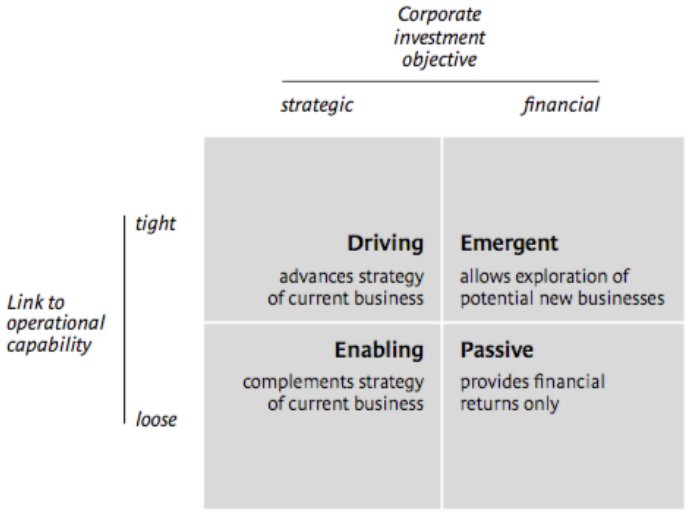


Figure 5 - Four purposes of corporate venturing (Chesbrough, 2002)

Campbell et al., (2003) build upon the theory of Chesbrough (2002). However, they state that the option like strategic upside of emergent venturing for creating new business does not exist. They state that venturing is never suited for creating 'new legs' despite of all the firms aiming for new legs via corporate venturing.

2.3.3 Exploration or exploitation

Chesbrough (2002) distinguishes multiple purposes related to venturing. Two other venturing purposes are venturing aimed at exploration of new technology, knowledge or capabilities and venturing aimed at exploitation of existing technology, knowledge or capabilities. According to Schildt, Maula, & Keil (2005) both types of venturing can put into practice for developing transformational new business.

2.3.4 Clear goal required

Multiple authors, like Birkinshaw et al. (2002) and Campbell et al. (2003) state that firms performing corporate venturing need to have clear what their goal is. Because only if you, as investing firm, have the venturing goal clear, you can adjust the right way of venture management to it, is their reasoning. Having multiple vague goals as an investing firm while performing venturing activities is a recipe for failure they state.

2.3.5 Goal and resource complementarity

In a venturing relation between venture and investing firm, both parties have their goal(s) (clear or less clear) of the venturing relation. On a meta level this is just a relation between two parties with both their own goal of a relation. Valuable cooperation between two parties is according to Duysters & Man (2003) based on well-aligned objectives and goals.

Bucklin & Sengupta (1993) add that the greater the complementarity between the goals of the two parties in a relation, the greater the effectiveness of the relation. This means that the goals, not necessarily have to be the same, they have to complement each other.

In relations, goals have to be aligned. The resources that both parties bring in have to be well aligned and have to complement each other as well (Pullen, de Weerd-Nederhof, Groen, & Fisscher, 2012). Lambe, Spekman, & Hunt (2002) describe resource complementarity as *the "Degree to which firms in an alliance are able to eliminate deficiencies in each other's portfolio of resources by supplying capabilities, knowledge and other entities physical or organisational resources for example".* Resource complementarity seems a relevant aspect in venturing relations.

2.3.6 Separation between venture and mainstream business required

Birkinshaw et al. (2002) describe that new ideas related to ventures in venturing units need to be separated from the mainstream business otherwise these ideas will be killed. They will be killed due to the fact that these ideas do not fit into the mainstream business. Nevertheless, too much separation is bad according to Birkinshaw et al. (2002) because some degree of linkage to the mainstream business is required in order to realize the potential strategic benefits of the venturing.
This dilemma of the right degree of separation between a venture and the mainstream business of a corporation can be defined as the 'separation dilemma'.
This separation dilemma counts both for transformational innovation venturing and non-transformational innovation venturing. Nagji & Tuff (2012), indicate however that transformational innovation venturing requires more separation in order to succeed than non-transformational innovation venturing. The development of transformational innovation is more prone to negative influences of existing business than non-transformational innovation. Nevertheless, for both transformational as non-transformational innovation venturing counts that finding the right degree of separation is still a matter of research.

2.3.7 What means separation between venture and mainstream business?

Birkinshaw et al. (2002) do not specify what exactly is meant by 'separation' between the venture and the mainstream business. Nevertheless, it seems possible to divide this concept of separation into two 'linkage dimensions' described by Burgelman (1984). These linkage dimensions are *administrative linkages* and *operational linkages*.

2.3.8 Operational and strategic linkages

Burgelman (1984) describes operational linkages as the extent to which skills and assets of both the venture as the corporation are integrated into one process. He proposes that the right degree of operational linkages depends on the degree of 'operational relatedness' between the venture and the investing firm. Operational relatedness is the distance between the operational skills and capabilities of employees of the venture and the investing firm. If the operational relatedness is high, Burgelman (1984) says, the operational linkages should be strong. The concept of operational linkages can also be referred to as 'operational integration'.

Burgelman (1984) describes administrative linkages as the extent to which the corporation has its say in the strategic direction of the venture and the venturing relation. He proposes that the right degree of administrative linkages depends on the degree of 'strategic importance' that the venture forms for the investing firm. The degree of strategic importance is determined by how important a venture seems to be in enabling a certain strategic direction in which the investing firm wants to move. If the strategic importance is high, Burgelman (1984) says the administrative linkages should be strong. The concept of administrative linkages can also be referred to as 'strategic autonomy'.

2.3.9 Difference between business unit and venturing unit

Covin & Miles (2007) describe the importance of distinguishing between the character of a business unit and the character of a venturing unit. Operational integration for example is something typically created between an external venture and a business unit. On the other hand, strategic discussions are more suited between a venturing unit and an external venture.

2.4 Network configurations as an instrument for developing transformational innovation

External venturing activities influence the firm's network of relations because a venturing relation forms, inherently a network relation as well. Characteristics of a firm's network of relations influence its innovation performance (Ahuja, 2000). This is not surprising as it turns out that the network configuration seems to play an important role in the process of innovation development (Padula, 2008).
The field of actor networks is investigated in this theoretical background because the field of actor-networks is influenced by venturing activities and because this field is clearly related to innovation development, the subject of this research. Especially the relation between actor-networks and innovation development is of interest.
The characteristics of a firm's network of relations, the network configuration, can be described with several concepts. These concepts are: direct tie, indirect tie, bridging tie, bonding tie, structural hole and openness of a network. These concepts are defined briefly. Subsequently, structural holes and openness of a network are discussed in relation to innovation.

2.4.1 Direct tie and indirect tie

The connections, relations, between actors are called 'ties'. A direct tie is a direct connection between two actors. An indirect tie is a path between two actors, with one actor between the actors connected via the indirect tie. In figure 6.1 one indirect tie exists between actor 1 and actor Y, which runs via actor X (Ahuja, 2000).

2.4.2 Bridging tie

A bridging tie is a relation that forms the only path between two actors in a network of relations. (Friedkin, 1980). Therefore, indirect relations are non-existing between the actors that are linked via a bridging tie. The actors on both sides of a bridging tie have their own set of direct partners. The bridging tie forms a unique path, a bridge, between these two sets of partners. Figure 6.1 visualises actor X and Y with its direct partners. In this figure the relation between actor X and Y is a bridging tie.

2.4.3 Structural hole

A structural hole occurs in a network configuration in which ego is linked to alters that in turn are not related to each other. The non-existing relation between the alters is referred to as a structural hole (Burt, 1992).
In a structural hole configuration, ego forms a 'broker'. As ego is connected to alters which in turn are disconnected, ego is able to 'broker' these connections. Figure 6.2 visualises a structural hole between actor Y and actor 4. This broker position is described multiple times in literature as a favoured network position. The advantage of a broker position is described as that the broker is able to play off his alters against one another for his own benefit (Ahuja, 2000; Burt, 1992; Haythornthwaite, 1996; Obstfeld, 2005).

An open network is a network rich in structural holes (Burt, 1992).

Due to the absence of indirect relations between the actors involved in a bridging tie, a bridging tie inherently becomes part of structural hole configurations. In figure 6.3 the structural holes are drawn that occur in the network configuration that include the bridging tie between actor X and actor Y.

2.4.4 Bonding tie

The opposite of a structural hole is a bonding tie. A bonding tie always abrogates a structural hole; if you have a structural hole between two actors and then make a direct relation between these actors, that relation will be a bonding tie. Also known as a cohesive tie (Burt,1992). In figure 6.4 an extra tie is drawn, compared with the network of figure 6.3. The extra tie in figure 6.4, a tie between actor X and actor 4, is a bonding tie.
A bonding tie forms a "tertius iungens" or "third who joins" as Obstfeld (2005) formulates is. A bonding tie creates redundancy in paths between two actors. Figure 6.5 visualises the two paths between actor X and actor 4.

A closed network is a network rich in bonding ties and sparse in structural holes (Burt, 1992).

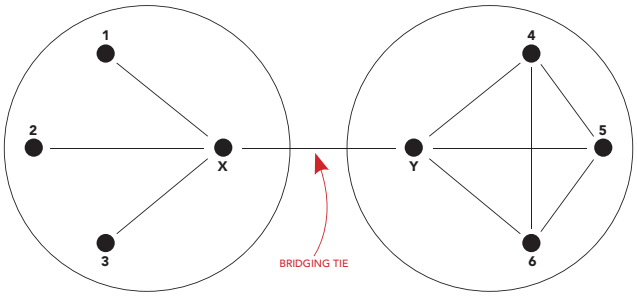


FIGURE 6.1

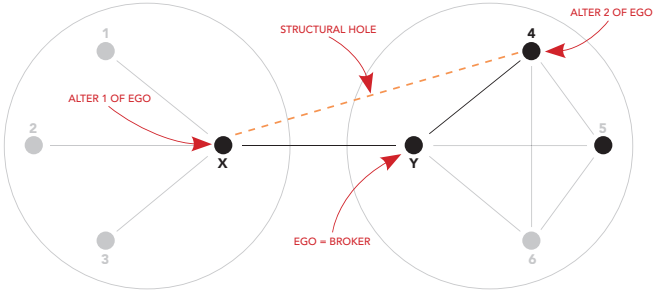


FIGURE 6.2

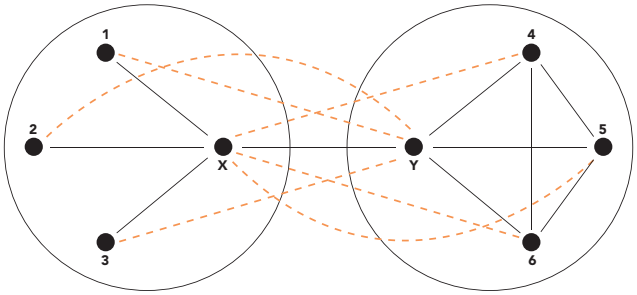


FIGURE 6.3

CHANGED NETWORK, EXTRA TIE

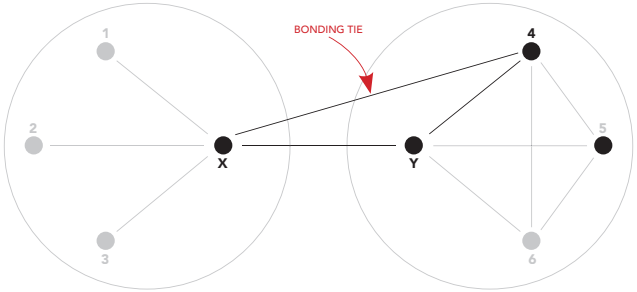


FIGURE 6.4

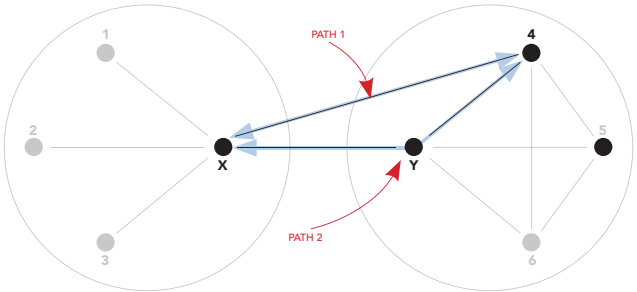


FIGURE 6.5

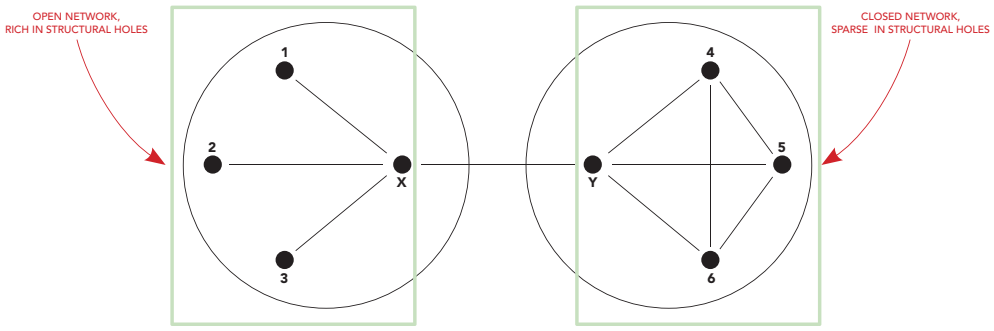


FIGURE 6.6

Figure 6 - Different network configurations and characteristics (Own ill.)

2.4.5 Structural holes and openness of the network in relation to innovation

Closed networks having a beneficial and hampering effect on innovation

According to Coleman (1988) closed networks, as they are poor in structural holes, promote trust and cooperation among its members. Ahuja (2000) builds on this and explains that due to the trust and cooperation, the communication in closed networks is efficient and the exchange of information is effective. Ahuja (2000) argues that for this reason closed networks have a beneficial effect on innovation development. According to Obstfeld (2005) closed network configurations 'reduce the obstacles to initiate coordinated action necessary to implement innovation'. Therefore, Obstfeld (2005) argues, closed networks enhance the development of innovation, especially within the 'implementation phase' of innovation development.

On the other hand, some authors argue that closed networks can have a hampering effect on innovation development as well. Rowley (1997) argues that in dense (closed) networks redundant information circulates, which makes the information in these networks not diverse. Furthermore Rowley (1997) explains that as a networks become denser, behaviour between actors in a network becomes more similar, inhibiting diverse information. Padula (2008) builds on this and describes that therefore, actors in closed networks can encounter difficulties in finding significant new pieces of information, which are required for innovation. Hence, Padula (2008) argues that in this respect, closed networks can have a hampering effect on innovation development. This phenomenon is also referred to as the 'idea' problem related to closed networks (Obstfeld, 2005).

Open networks having a beneficial and hampering effect on innovation

Hargadon & Quarterly (1997) argue that the diversity of information in open networks is large. According to them the structural holes in open networks create a situation in which on either side of the structural hole the actors have access to different information wherefore they get in contact with a wide variety of information.
Padula (2008) builds on this and describes that therefore, actors in open networks can find significant new pieces of information, which are required for innovation. Hence, Padula (2008) argues that in this respect, open networks can have a beneficial effect on innovation development. In line with Padula (2008), both Burt (1992) and McEvily & Zaheer (1999) describe how structural holes in open networks provide access to new information and opportunities. However, Burt (1992) and McEvily & Zaheer (1999) are more outspoken than Padula (2008) and argue that open networks have a more beneficial effect on innovation development than closed networks.

On the other hand, Ahuja (2000) argues that open networks have a hampering effect on innovation development due to the inefficient communication and ineffective exchange of information.

2.4.6 Both open and closed network configurations are required in innovation development

The study of Padula (2008) reveals that bridging ties create the *potential* for new knowledge development / the creation of innovation, by ensuring a flow of varied and novel knowledge streams in cohesive networks. Bonding ties, subsequently, seem to facilitate the actual realisation of the new knowledge (/ innovation) from the potential. Bonding ties facilitate the 'knowledge recombinant process' as Padula (2008) calls it. Hence, without the innovation potential ensured by the bridging ties, the bonding ties cannot realise something new. Therefore, the bonding ties and bridging ties are regarded as complementary in the development of innovation. In short, the bridging tie plays a crucial role in exploration of innovation, the bonding tie plays a crucial role in exploitation of innovation (Padula, 2008).

According to Padula (2008) the innovation potential can be exploited by bonding ties in a pre-existing cohesive network at either one of the related clusters. This is visualised in figure 7. Nevertheless, another option is that around the bridging tie a new cohesive network is built to facilitate the exploitation of innovation. This is visualised in figure 8.

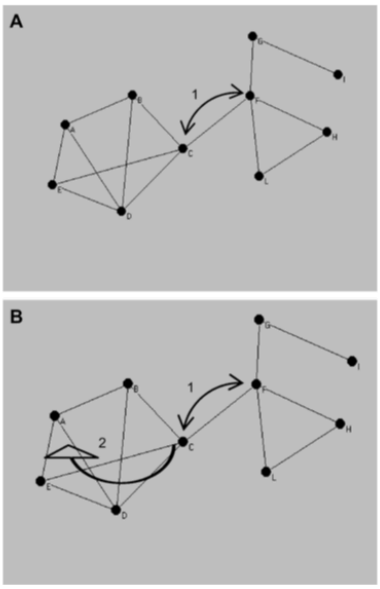


Figure 7 - Locus of innovation exploitation in pre-existing cohesive structure (Padula,2008)

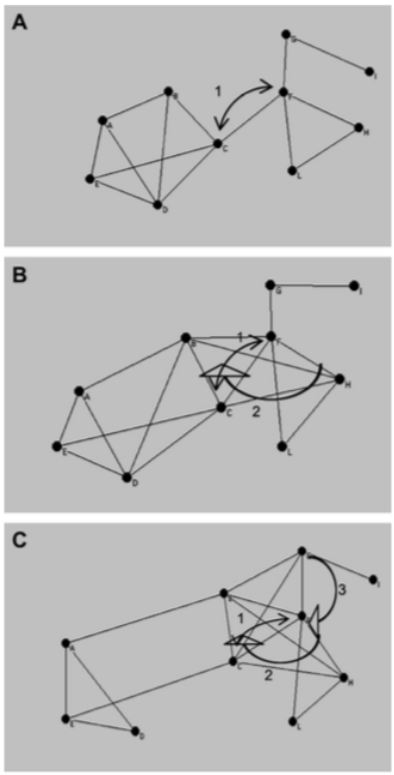


Figure 8 – Locus of innovation exploitation in newly developed cohesive structure around the bridging tie (Padula,2008)

2.5 Theory relevant to transformational innovation development through collaboration

The literature review in the field of venturing and the field of actor-networks enabled an answer on the first sub question formulated as:

"What theoretical concepts are relevant for the development of transformational innovation through collaboration?"

The following concepts seem relevant in contexts where innovation seeking firms make relations with external ventures aimed at transformational innovation. The basis for such innovation relations seem to lay in complementarity with respect to the goals of the involved actors and the resources they bring into the relation.
In venturing relations, the degree of separation between an innovation seeking firm and external venture seems to play an important role. It seems possible to divide this concept of separation into two concepts. First, the degree of operational integration between the innovation seeking firm and external venture. Second, the degree of strategic autonomy of the external venture provided by the innovation seeking firm. In turn these concepts seem related to the degree of strategic importance of the relation with the external venture for the innovation seeking firm and the degree of operational relatedness between both actors. Furthermore, the meta venturing goal of the innovation seeking firm seems to play a role in venturing relations. It seems especially important to distinguish between an exploration goal and an exploitation goal. Moreover, it seems important to considering the difference in nature between a business unit and a venturing unit of an innovation seeking firm.
From the field of actor-networks it seems relevant how the network of actors around the innovation seeking firm and external venture emerged. The openness of the network around the venturing relation seems especially relevant.

3 METHODOLOGY

3.1 Introduction

Chapter 3 describes the methodology for answering the main research question. This methodology is described in 4 subchapters, subchapter 3.2 until 3.6.

3.2 Type of research

This research about how engineering firms in the built environment can develop transformational innovation is an exploratory qualitative type of research. This research is typically exploratory because not much is known about how engineering firms, and firms in general, can develop transformational innovation. Furthermore, the research asks for an exploratory type of research because the topic is highly complex due to the large number of dependent variables involved (Sekaran & Bougie, 2016).
Furthermore, for an exploratory research is chosen because the literature study of chapter 2 showed that an overarching framework for developing transformational innovation is lacking. Nevertheless, literature did show multiple partial frameworks which seemed relevant to transformational innovation development. However, how these partial frameworks precisely relate to transformational innovation development is still unknown. This research investigates real-life transformational innovation developments, with the goal to get more insight into the relation between these partial frameworks and transformational innovation development at engineering firms in the built environment.

The exploratory nature of this research has implications for the generalisability of conclusions. Conclusions of this research cannot be statistically generalised to populations, nevertheless analytical generalisation of findings to 'meta level theory' that may be applicable in other real-life situations is possible. Paragraph 3.6.7 will discuss this more in-depth.

The research is qualitative instead of quantitative of nature because the research is more focused on 'meaning' than on hard 'facts'. Furthermore, the conclusions are drawn interpretively and not based on numerical analysis (Swaen, 2013).

3.3 Multiple-Case study methodology

The core methodology of this research is a multiple-case study. Case study research can be seen as an empirical inquiry of investigating a contemporary phenomenon in-depth and within its real-world context in which the boundaries between phenomenon and context are unclear. The phenomenon can be seen as the case. Case study research tries to illuminate a phenomenon in order to get a better understanding of it. In multiple-case study research illumination of a phenomenon is replicated, creating (cumulatively) more light on a phenomenon of interest than in single-case study research. Therefore, a multiple-case study research design enables more rigorous conclusions than single case study designs. Nevertheless, it is an enduring and time-consuming activity (Yin, 2009).

Within this research the phenomenon of interest, the case, consists of an 'innovation seeking firm' (ISF) having a relation with an 'external venture' (EV) aimed at a certain type of innovation. An innovation seeking firm is a firm with an existing core business and the ambition to develop an incremental, adjacent or transformational innovation. An external venture is a firm that is in relation with a specific innovation seeking firm.

3.4 Why case study methodology is suited for this research

The multiple-case study research methodology fits this research well because the following three conditions are met. First, the main research question is a 'how'-question. According to Yin (2009) case study methodology is well suited for 'how' and 'why' questions.
Second, within this research the events of interest at the innovation seeking firm and the external venture are difficult to control. This makes experimentation with these events in a laboratory setting, including the use of a 'control' group, rather difficult. Third, the research investigates a contemporary phenomenon, making the 'history' and 'archival analysis' research methods not suited (Yin, 2009).

3.5 Unit of analysis

The unit of analysis consists of an innovation seeking firm (ISF), an external venture (EV) and the relation between these two firms. The analysis is on firm level. The analysis is not on the level of individuals, despite the important role individuals can have in innovation development.

3.6 Research design

3.6.1 Introduction research design

Figure 9 gives an overview of the logical plan, the blueprint of the research that forms the path towards the conclusion and recommendations. The research steps until theoretical background are already described in-depth in previous chapters. Therefore, these research steps are not described in the paragraphs ahead. Paragraph 3.6.2 until 3.6.9 describe the research design between 'Methodology' towards the end of the research.

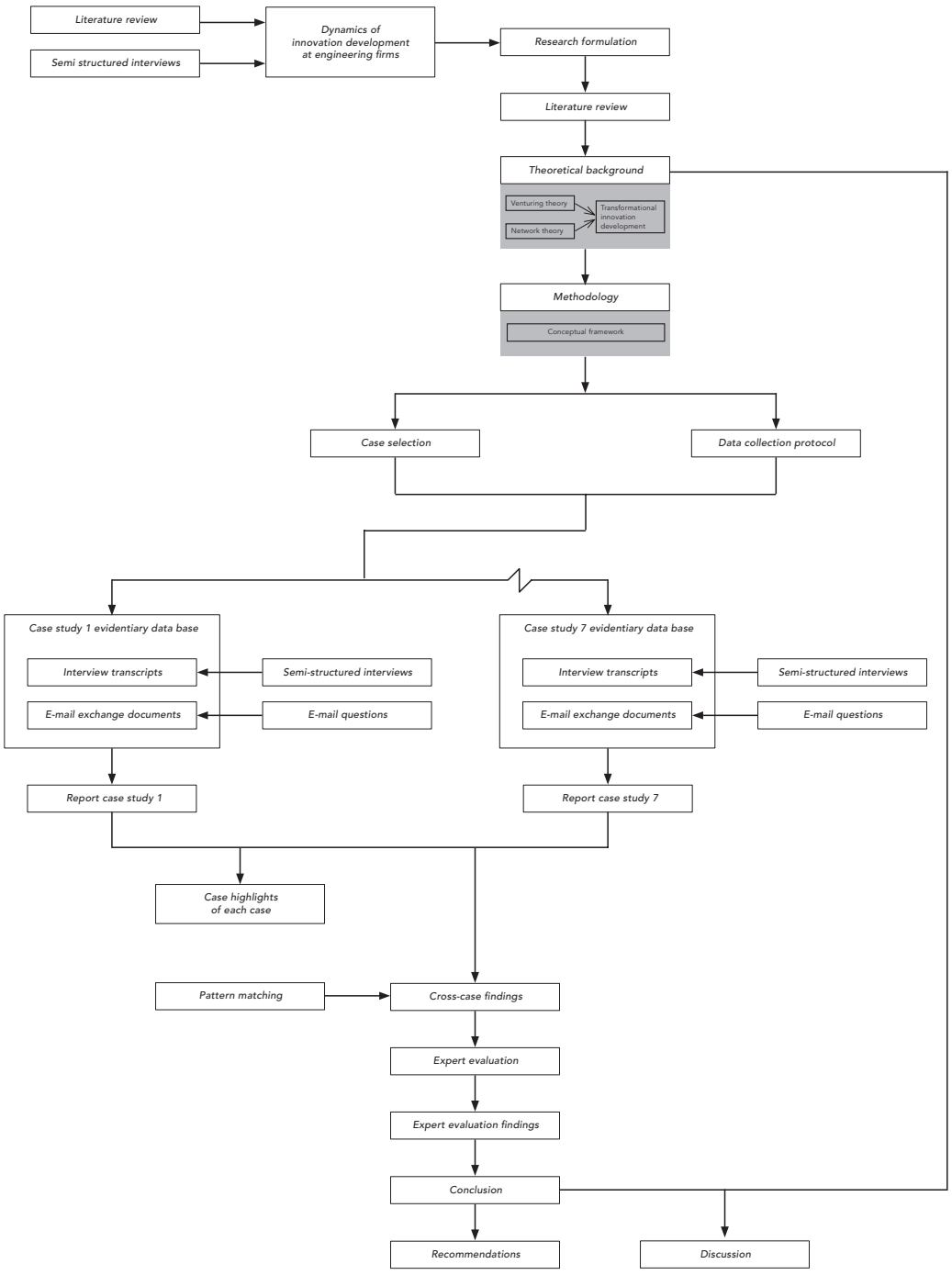


Figure 9 - Research design (Own ill.)

3.6.2 Conceptual framework

This research can be seen as an explorative research with case study research as a core methodology. The reason why this methodology has been chosen is described earlier in this chapter.
In executing the case study research, a conceptual framework is used. This conceptual framework is based on the concepts found in literature that seem relevant for the development of transformational innovation through collaboration.
Eventually, each case will be described along the topics of the conceptual framework. In order to make this possible the data collection protocol used in gathering data related to each case is closely related to the topics in the conceptual framework.
The conceptual framework consists of twelve topics which will be described briefly in the following subparagraphs.

Topic 1: Degree of goal complementarity between the ISF and EV
This topic comprises the degree of complementarity in the goals of the venturing relation of both the ISF and the EV

Topic 2: Degree of resource complementarity between the ISF and EV
This topic comprises the degree of complementarity in the resources that both the ISF and the external venture bring into the venturing relation.

Topic 3: Degree of strategic autonomy of the EV given by the ISF
This topic comprises the degree in which the ISF determines what the EV should do in respect to their business.

Indicators for determining the degree of strategic autonomy:

- Is the EV allowed to switch sector?
- Is there any reporting structure between ISF and EV?
- Is there any influence of ISF on budgeting of EV?
- Is the ISF influencing strategy of the EV?
- Does the ISF have a board seat in the supervisory board?
- Is this board member seat used with strategic purposes?

Topic 4: Eventual degree of operational integration between the ISF and EV
This topic comprises the degree in which the ISF and the EV are operationally integrated. The degree of operational integration depends on the degree of exchange of knowledge, capabilities, technology or other assets. The different degrees of operational integration are divided into five levels. An overview is given in figure 10.
The degree of operational integration may develop from low degrees of operational integration towards higher degrees. Topic 4 comprises only the eventual degree of operational integration in a venturing relation.

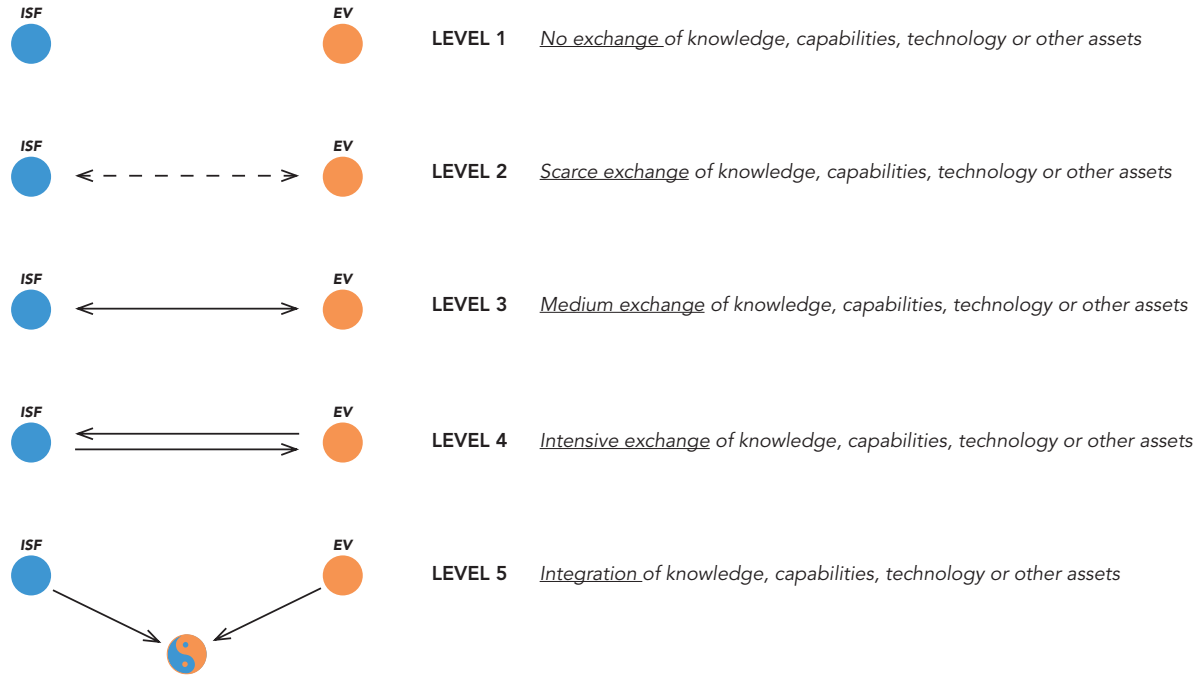


Figure 10 - Different degrees of operational integration (Own ill.)

Topic 5: Degree of operational relatedness between the ISF and EV
This topic comprises the degree in which the operations of the ISF and the EV show similarities. This is determined by comparing the core operational concept of both the ISF and the EV. Investigating the capabilities of employees and how these come back in their work is used as a guidance in finding the core operational concept.

Topic 6: Degree of strategic importance of the relation with the EV for the ISF
This topic comprises the degree in which the external venture is strategically important for the ISF's. For example, an EV can be strategically important for an ISF because it creates unique possibilities to explore a certain business direction which seems very profitable.

Topic 7: Degree of exploration or exploitation venturing goal of the ISF
This topic comprises the degree in which the ISF in the venturing relation aims for exploring innovation or exploiting innovation. Or whether the ISF in the venturing relation aims for rather direct exploitation of an already existing innovation.

Topic 8: Order in which the focused contact between the EV and a business unit of the ISF and the focused contact between the EV and a venturing unit of the ISF emerged
This topic comprises the order in which, the focused contact between the external venture and a business unit of the ISF and the focused contact between the EV and a venturing unit of the ISF, emerged. This order may tell something about the innovation development between these two parties. The contact between an external venture and an operational business unit is in most cases very different from nature than the contact of an external venture and a strategic venturing unit. Topic 8 is about how these different types of contact are developed.

Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started

This topic comprises the degree in which the EV was in the network of the ISF, just before the ISF–EV relation started. The EV can have been already in a high degree part of the network of the ISF before the ISF-EV relation started, when there were already multiple indirect relations between ISF and the EV.

On the other hand, the EV may have been rather outside the network of the ISF before the ISF-EV relation started, when there were (almost) no indirect relations between the ISF and the external venture. The visual representations of the different degrees in which the EV was in the network of the ISF, before the ISF–EV relation started are shown in figure 11.

Measurable variable topic 9

The degree in which the EV was in the network of the ISF, just before the ISF–EV relation started depends on the number of indirect relations that emerged between ISF and EV, in the period before the ISF-EV relation started. This measurable variable of topic 9 is illustrated in figure 11.

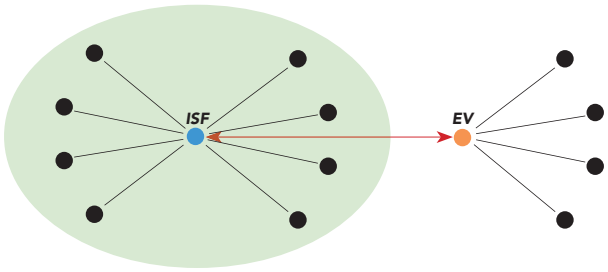
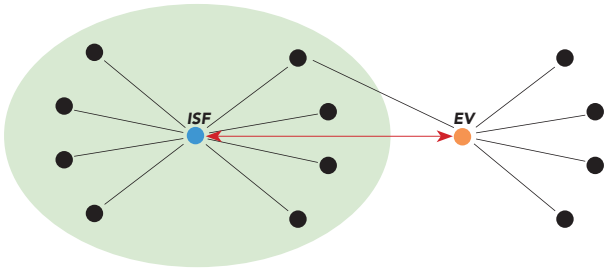
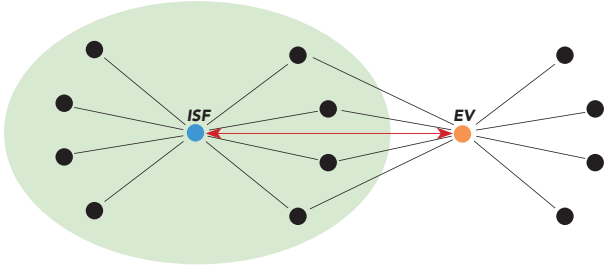
Visual representation	***Measurable variable topic 9*** *Number of indirect relations that emerged between ISF and EV, in the period before the ISF - EV relation started*
	***0***
	***1***
	***4***

Figure 11 - Visual representation of the different degrees in which the EV was in the network of ISF, before the ISF - EV relation started (Own ill.)

Topic 10: Degree of cluster integration emerged in the period after the ISF - EV relation started and thoughts about this kind of cluster integration

This topic comprises the degree of cluster integration at the moment that the ISF–EV relation started is already indicated by topic 9. Topic 10 indicates the degree in which cluster integration emerged in the period after the ISF–EV relation started. For example, the degree of cluster integration at the moment that the ISF–EV relation started can be high due to the existence of multiple indirect relations between the ISF and the EV. Nevertheless, this situation is indifferent to the degree of cluster integration, emerged in the period after the ISF-EV relation started. From a situation with a much cluster integration at the moment that the ISF–EV relation started can either much and little cluster integration emerge in the period after the ISF-EV relation started. The visual representations of the different degrees of cluster integration emerged after the ISF–EV relation started are shown in figure 12.

Furthermore, the topic 10 investigates the thoughts about cluster integration between an ISF and EV, emerging in the period after the ISF-EV relation started. Do companies recognise cluster integration as potentially beneficial for the innovation development between ISF and EV?

Measurable variable topic 10

The degree in which cluster integration emerged in the period after the ISF–EV relation started depends on the number of indirect relations that emerged between ISF and EV, in the period after the ISF-EV relation started. This measurable variable of topic 10 is illustrated in figure 12.

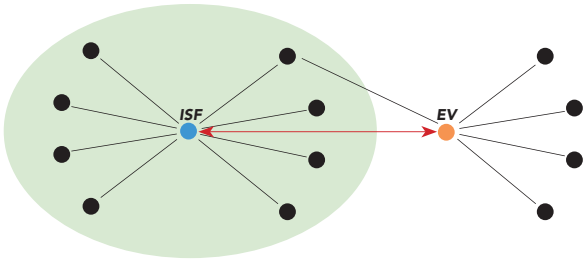
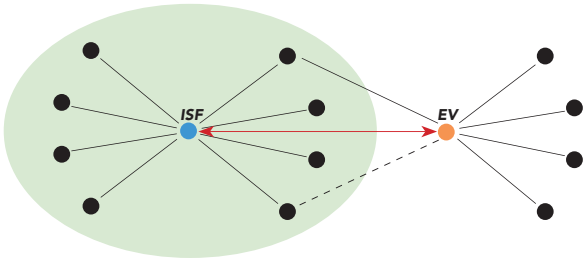
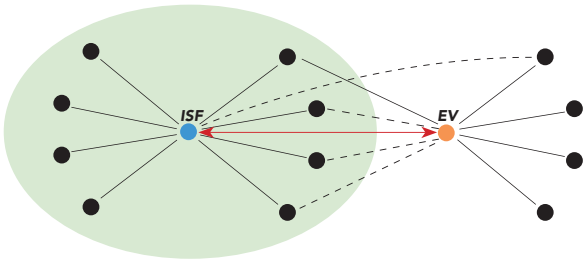
Visual representation	***Measurable variable topic 10*** *Number of indirect relations that emerged between ISF and EV, in the period after the ISF - EV relation started*
	***0***
	***1***
	***4***

Figure 12 - Visual representation of different degrees of cluster integration, emerged in the period after the ISF - EV relation started (Own ill.)

Topic 11: Degree of success of the venturing relation for the innovation seeking firm in respect to developing the aimed for innovation

This topic comprises the degree of success of the venturing relation for the ISF in respect to developing the aimed for innovation. Measuring success is difficult, however the ISF is asked to explain in what degree the venturing relation successfully contributed to the aimed for innovation. This degree of success is based on perceptions instead of hard measurements.

Topic 12: Type of innovation the ISF aims for in the venturing relation

This topic comprises the type of innovation the ISF aims for in the venturing relation. The ISF can aim for three types of innovation: incremental innovation, adjacent innovation or transformational innovation.

3.6.3 Case selection

After formulating the conceptual framework, a case selection is made and the data collection protocol is formulated.

Different criteria are used for the case selection. First, the case should consist of an ISF making a relation with an EV aimed at an incremental, adjacent or transformational innovation.
Second, the ISF should be a firm outside the construction sector. Third, the ISF should be encountered with a threatened core business and therefore a need for transformational innovation in order to survive. Fourth, the core business of the ISF should have a significant relation to large physical assets. Lastly, enough information should be available about the cases. It is preferred to have information from both key-individuals from the ISF and the EV.

The research is based on seven cases, divided in groups along the type of innovation aimed for by the innovation seeking firm. Furthermore, between the cases a division is made between successful and unsuccessful for the ISF in respect to developing the aimed for innovation. The figure below shows the seven cases, each consisting of an ISF and EV.

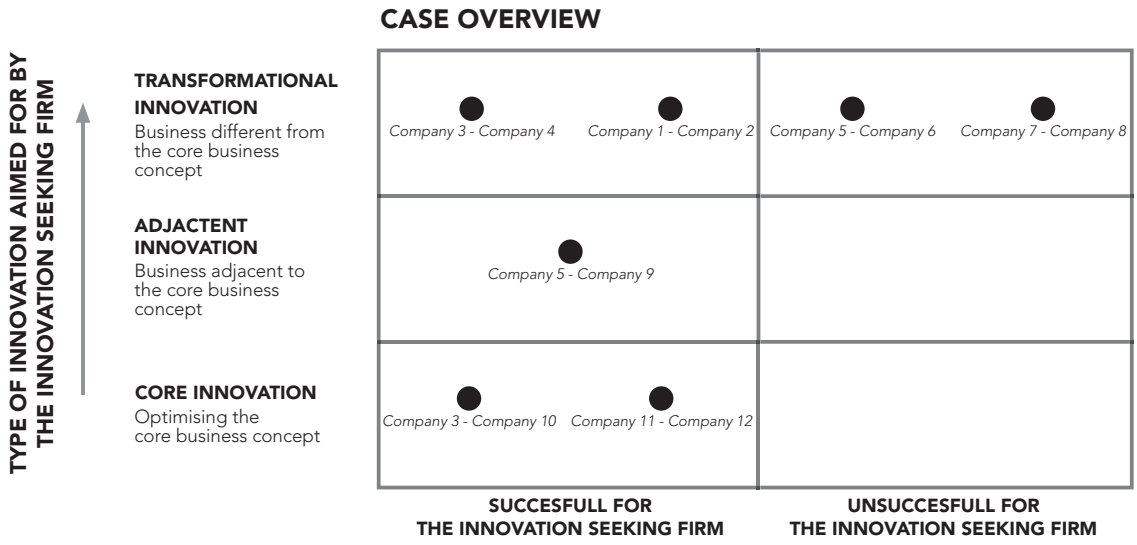


Figure 13 - Case overview (Own ill.)

3.6.4 Case study evidentiary database

Around each case a case study evidentiary database is built. This can be seen as the raw case study data. This is data without any interpretation of the researcher. Each case study evidentiary database consists of interview transcripts and e-mail exchange documents.

The interview transcripts in each case study evidentiary database are the result of a semi-structured interview with a key individual of the ISF and a matching key individual of the EV. Only in the case of Company 7 and Company 8 and the case of Company 1 and Company 2, only a key individual of the ISF was interviewed. In the case of Company 5 and Company 6, two key individuals of the ISF and one matching individual of the EV was interviewed.

The email exchange documents in each case study evidentiary data base are the result of e-mailed questions related to topic 9 and 10 of the conceptual framework. The e-mailed questions are about how the network of actors between ISF and the EV looked like. These emails are sent to several individuals, from the companies whereby the interviews did not give sufficient insight in how the actor networks looked like. This was the case for Company 1 and Company 11.

3.6.5 Case study report

Each case study evidentiary database results in a 'case study report'. Each case study report describes how the topics of the conceptual framework come along in each case. This is done by reading carefully the interview transcripts and e-mail exchange documents. Subsequently, passages in these sources are highlighted which are related to the topics of the conceptual framework or which are not related to one of the twelve topics of the conceptual framework but seem to be relevant for the research.
Subsequently, each highlighted passage (quotation) is given a code and each code is put into a code group. In the coding process fourteen code groups are differentiated, twelve code groups are related to the twelve topics of the conceptual framework. One code group contains codes which are not related to one of the twelve topics of the conceptual framework but seem to be relevant for the research and the other code group is related to the general case information. Figure 16 shows the used codes and code groups.

All quotations are categorized per code and per code group. This forms the basis for writing a case report per case.
Each case report describes how the twelve topics of the conceptual framework come along in the case at hand.
Furthermore, each case report is complemented with a description of the aspects that are not related to the topics of the conceptual framework, but seem important in respect to the main research question.

Figure 14 - Codes used in the coding process of coding the case study evidentiary database (Own ill.)

3.6.6 Results

The results of this research are described in chapter 4 and consist of three parts. The following three subparagraphs describe briefly what each result part is about.

Case highlights

The first part of the results is formed by a description of the case highlights of each case. The case highlights are enabled by looking for the most remarkable aspect in each case report related to the development of transformational innovation.

Cross-case findings

The second part of the results is formed by cross-case findings from the seven cases. According to Yin (2009) drawing cross-case findings from multiple case study reports is one of the most difficult parts of the case study methodology. Within this research, a pattern matching strategy is used. The seven case study reports are set in a row and subsequently it is examined whether patterns come to the surface, possibly indicating interesting cross-case findings.

The case highlights together with the cross-case findings enable the answer on sub question 2 *"What can be learned from (transformational) innovation developments at firms outside the construction sector?"*. This answer is described in subchapter 4.4.

Expert evaluation findings

The cross-case findings result from innovation developments outside the construction sector. In order to investigate analytical generalisation of these cross-case findings towards meta level theories applicable to engineering firms in the construction sector, an expert evaluation is conducted. In the expert evaluation, innovation experts from three different engineering firms evaluate three strategies that are based on the cross-case findings.

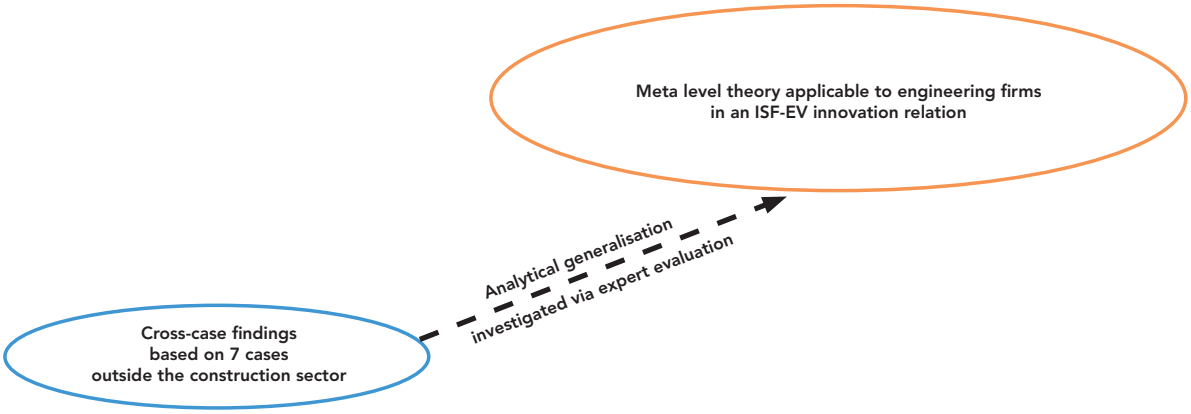


Figure 15 - Analytical generalisation of cross-case conclusions (Own ill.)

These expert evaluation findings are written as follows. First, the audio of the expert evaluation session is turned into a transcript. In this transcript relevant passages are highlighted, forming quotations. Subsequently, each quotation is coupled to a code. Furthermore, during the expert evaluation session the participants are asked to fill in three feedback forms comprising feedback on the presented strategies. In the filled-in feedback forms, also relevant passages are highlighted. These highlights form quotations which are coupled to codes. On the basis of quotations coupled to codes, from the transcript and the feedback forms, the expert evaluation findings are described in subchapter 4.5.

The expert evaluation findings enable an answer on sub question 3 *"How do construction sector experts evaluate the learnings from (transformational) innovation developments at firms outside the construction sector?"*.

3.6.7 Conclusion

Based upon the research results of chapter 5 the main research question is answered. This answer forms the conclusion of the research and is described in chapter 6.

3.6.8 Discussion and limitations

The discussion sheds light on some research conclusions and brings them in relation to the theoretical background. The discussion is described in chapter 7, together with the limitations of the research.

3.6.9 Recommendations

Based on the research conclusion, recommendations for engineering firms are formulated about how they can manage their external relations in such a way that these relations have an optimal effect on the development of transformational innovation. These recommendations are formulated in chapter 8, together with recommendations for further research.

4 RESULTS

4.1 Introduction

Chapter 5 describes the research results and the answers to sub question 2 and 3. The research results consist of the 'case highlights', the 'cross-case finding' and the 'expert evaluation findings'. The 'case highlights' together with the 'cross-case finding' enable an answer on the second sub question of this research. The 'expert evaluation findings' forms an answer on the third sub question.

4.2 Case highlights

The following case highlights result from analysing the case reports.

Case highlights case Company 1 – Company 2

The venturing relation between Company 1 and Company 2 was focused on exploring the new market of 'smart energy grids and e-mobility'. In this venturing relation the e-mobility unit of Company 1 worked closely together with Company 2 in order to develop e-mobility services. Company 1 designed in this relation the overall business model of a new e-mobility service and Company 2 brought in expertise related to the ICT-backoffice systems especially suited for e-mobility services.

Remarkable in this venturing relation is that around the relation between Company 2 and Company 1 a new network emerged which had a beneficial effect on the innovation development between Company 1 and Company 2. Company 2 made relations with three partners of Company 1. Moreover, a partner of Company 1 made contact with a partner of Company 2. Multiple relations in this set of indirect relations were complementary to each other. For example, the e-mobility service development between Company 1 and Company 2 was directly complementary with a technology development occurring in the indirect relation between Company 1 and Company 2 formed by Company 1, Company 13 and Company 2.

Another striking aspect of the Company 1 – Company 2 venturing case is that Company 1 explained that this venturing relation was part of their 'network orchestration venturing' strategy. This strategy entails first sketching a value chain they consider to be required for transformational innovation. Subsequently, they look for companies which can form this sketched value chain and they take minority shares in these companies. They try to 'orchestrate' the value chain they had in mind through their relations with these companies. They hope that this eventually enables their desired transformational innovation.

Case highlights case Company 3 - Company 4

The venturing relation between Company 3 and Company 4 was centred around the exploration of new energy services with the ultimate goal for Company 3 to become the energy manager in the domain of consumers. The venturing relation enabled this exploration by a joint development in which Company 3 brought in knowledge about new forms of energy and Company brought in battery technology.

Notable in this venturing relation is a specific order in which the contact between Company 4 and the different units of Company 3 emerged. Company 4 first had contact with business unit 2 of Company 3. Subsequently, Company 4 also made a low degree of operational integration with business unit 1 of Company 3. After having these orientations with two business units of Company 3, Company 4 focused its contact on the strategic venturing unit of Company 3. These discussions resulted in joint development agreements and gave an impulse towards an high degree of operational integration between Company 4 and both business unit 1 and 2 of Company 3. This specific order of contact between Company 4 and Company 3 was beneficial for the development of transformational innovation of Company 3.

Case highlights case Company 5 - Company 6

The venturing relation between Company 5 and Company 6 was by Company 5 initiated to explore the market of 'smart buildings'. However, Company 6 had another priority: Company 6 wanted Company 5 as reseller of their product. Company 6 had no appetite in pure exploration so it refused to bring their technology into the relation, which hampered the exploration as Company 5 wished. Despite reselling was not their main goal, Company 5 tried to make the resell goal of

Company 6 a success. But this failed because they were not able to offer the right resell clients. In short, the venturing goals and resources brought into the relation were not complementary which both companies recognized as a main reason for failure of the innovation development between Company 5 and Company 6.
Furthermore, strikingly in this case is that Company 6 was not willing to give Company 6 strategic autonomy. In two fields, Company 5 violated the autonomy of Company 6: in the field of the type of client Company 6 had in mind and in respect to the planning method Company 6 preferred. In both cases Company 5 overruled Company 6.

Case highlights case Company 7 – Company 8

The venturing relation between Company 7 and Company 8 was centred around the exploration of a car parking app to be used in crowded cities for finding a parking spot. The idea was that company 8 would bring in the digital technology and that Company 7 would bring in their customer base. As Company 7 was an energy firm, the innovation related to this venturing relation was rather transformational.

Prominent in discussing the venturing relation between Company 7 and Company 8 was the lack of market research of company 8. They only focused on the technology and overestimated the market traction for their technology. In the venturing relation the venturing unit of Company 7 started a short, but intense, pilot project in order to test the market traction in Warsaw: one of the most crowded cities in the world to park your car. It turned out that the technology of Company 8 was not ready for markets like these, therefore Company 7 decided to withdraw from the venturing relation.

Case highlights case Company 5 – Company 9

The venturing relation between Company 5 and company 9 was focused on Company 5 reselling the Company 9 product to clients of Company 5. Company 9 offered a cyber security product related to physical assets. Company 5 initially sold only normal cyber security products to large industry clients with physical assets. Company 5 did not sell any cyber security products that directly addressed the cyber security issues related to these physical assets. The venturing relation between company 9 and Company 5 enabled enlargement of the Company 5 cyber security products that is could sell to existing clients with physical assets. For Company 9 this was also beneficial because they were not able to address these large clients. Partially because they could not offer a total cyber security package.

It is distinctive in this case that Company 9 trained employees of Company 5. In order to enable the best possible resell construction this training was set-up in order to develop knowledge about the product of Company 9 in the sales team of Company 5.

Case highlights case Company 3 - Company 10

The venturing relation between Company 3 and Company 10 was focused on the development of lightweight composite pipes which enable deep-sea oil and gas exploitation. The goal for Company 3 in this relation is to get access to commercially attractive composite pipes.

Remarkable in this case was that Company 3 helped Company 10 in developing indirect relations between Company 3 and Company 10. With their trustworthiness, Company 3 coupled Company 10 with partners of Company 3. Without Company 3, Company 10 was not able to get in business with these players. These partners of Company 3 formed new clients of Company 10 which it needed, because selling their product was quite difficult. Due to the trust of Company 3 towards these players, Company 10 was able to sell their composite pipes to them which subsequently enhanced their business development. Eventually, these indirect relations between Company 3 and Company 10 was also beneficial for Company 3. They new clients improved the business model of Company 10 and made composite pipes more commercially accessible for Company 3.

Case highlights case Company 11 - Company 12

The venturing relation between Company 11 and Company 12 was focussed on developing the business model of Company 12. The goal of the venturing relation for Company 11 was to get access to the wifi technology and payment solutions for airplanes that were offered by Company 12.
Noteworthy, before the venturing relation between Company 11 and Company 12 started, Company 12 was already connected with eleven partners of Company 11. Company 12 required technological approvals from these eleven partners of Company 11, before Company 11 was interested in a strategic partnership with Company 12.

4.3 Cross-case findings

This subchapter describes the cross-case findings. These cross-case findings resulted from analysing the case reports. In this analysis the 'case results overview table' of table 2 plays an important role.

The 'case results overview table' shows the research variables set out against the seven investigated innovation cases. The columns distinguish the twelve topics of the conceptual framework complemented with two research variables that emerged as relevant for answering the main research question. The rows distinguish the seven investigated cases. Each box of the table contains a very concise form of how the research variable related to the box is assessed in the case related to the box. This assessment comes from the case reports. The case result overview table creates a clear overview of the case results of all seven cases.

In order to formulate the cross-case findings, the clear case result overview of table 2 has been instrumental in searching for patterns between the research variables. These patterns eventually resulted in the formulation of the cross-case findings.

In paragraphs 4.3.1 until 4.3.5 the cross-case findings are described.

– –	Very low degree
–	Low degree
+/–	Medium degree
+	High degree
++	Very high degree
LVL 1	Refers to the level of operational integration, level 1 in this example.
2 ir	Number of indirect relations, in this case 2
R	Relation focused on exploration
I	Relation focused on exploitation
R/I	Relation focused on both exploitation and exploration
BU VU BU	Contact of EV was first focused on an operational business unit of ISF, secondly on a strategic venturing unit of ISF and thirdly on an operational business unit of ISF again
VU BU	Contact of EV was first focused on a strategic venturing unit of ISF and secondly on an operational business unit of ISF
VU RD	Contact of EV was first focused on a strategic venturing unit of ISF and secondly on a research and development unit of ISF
VU	Contact of EV was only focused on a strategic venturing unit of ISF
TR	Venturing relation focused on the development of a transformational innovation of the ISF
A D J	Venturing relation focused on the development of an adjacent innovation of the ISF
IN CR	Venturing relation focused on the development of an incremental innovation of the ISF

Table 1 – Legend of case results overview table (Own ill.)

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 - Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 - Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 - Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 - Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 - Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 - Company 10	+	+	+	LVL 2 and 4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 - Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 2 – Case results overview table (Own ill.)

4.3.1 Cross-case finding 1: Innovation seeking firm and external venture having activities on the same domain, at the moment of starting a moderate degree of collaboration, seems beneficial

It seems beneficial for innovation development between an innovation seeking firm and external venture when the innovation seeking firms is already active in the domain of the external venture at the moment that the venturing relation starts.

In all successful innovation cases the innovation seeking firm and the external venture had activities on the same domain before the collaboration started. This appeared to create an anchor point for effective and meaningful communication between the innovation seeking firm and the external venture, which increased insight in each other's operations.
In the two innovation failure cases (Company 7 - Company 8 and Company 5 – Company 6) the innovation seeking firms lacked any activities in the external venture domain, which seemed to hamper meaningful and effective communication. See table 3 below.

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 – Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 – Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 – Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 – Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 – Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 – Company 10	+	+	+	LVL 2&4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 – Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 3 – Case results overview table highlighting relevant aspects for cross-case finding 1 (Own ill.)

4.3.2 Cross-case finding 2: Low goal and resource complementarity between an innovation seeking firm and external venture seems unbeneficial

It seems that a lack of goal complementarity and resource complementarity between an innovation seeking firm and an external venture is unbeneficial for transformational innovation development. The case of Company 5 – Company 6 clearly shows that the lack of goal complementarity and resources complementarity contributed to the failure of this case. Both Company 5 and Company 6 mention this as the main reason for failure of the collaborative innovation development.

The main goal of Company 5 in the relation with Company 6 was to learn from Company 6 and to explore business opportunities related to the domain of smart buildings. This was not at all aligned with the relation goal of Company 6 which was to exploit their existing smart building product. They had no interest in entering an exploration process, they wanted Company 5 as a pure reseller of their product.
In the resell goal of Company 6, Company 5 would bring the 'resell clients' into the relation in order to resell the smart building product that Company 6 would bring in. However, Company 5 was not able to offer the right resell clients. In the exploration goal of Company 5, Company 5 would bring into the relation their willingness to explore and Company 6 would bring in their technology. However, Company 6 did not want to bring in their technology because they feared that Company 5 would steal their intellectual property.

The case results show that complementarity in goals and resources can result in both success and failure of a venturing relation. From the six cases with goal and resource alignment, five cases were successful. In only one out of the six cases with goal and resource alignment, the venturing relation failed.
Furthermore, there was one case in which the goals and resources were not aligned and in this case the venturing relation failed. Lastly, all successful venturing cases have in common that goal and resources were aligned. Having the goals and resources aligned is therefore no guarantee for success, but seems to be a precondition. See figure 4.

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 – Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 – Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 – Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 – Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 – Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 – Company 10	+	+	+	LVL 2&4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 – Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 4 – Case results overview table highlighting relevant aspects for cross-case finding 2 (Own ill.)

4.3.3 Cross-case finding 3: Strategic discussions between an innovation seeking firm and an external venture, starting when they have moderate operational integration, seems beneficial

This cross-case finding is based on analysing the degree of operational integration between an innovation seeking firm and external venture at the moment that the strategic discussions between them started.
Strategic discussions between an external venture and a venturing unit of an innovation seeking firm, while having a moderate degree of operational integration (level 2 or 3), seems beneficial for transformational innovation development between these firms. No operational integration between an innovation seeking firm and an external venture (level 1), at the moment that the strategic direction is discussed, seems unbeneficial for the development of transformational innovation between these parties. The strategic discussions seem the require a sufficient degree of insight in each other's operations, which can be provided by a moderate degree of operational integration.
Figure 16 illustrates the seemingly beneficial and unbeneficial degrees of operational integration at moment that the strategic venturing discussions starts between an ISF and an EV.

Subsequently, strategic discussions started with moderate operational integration seem to create an impulse for high degrees of operational integration, which in turn have a positive effect on the innovation development between an ISF and an EV. These high degrees of operational integration come mostly in the form of joint developments influenced by joint development agreements made during the strategic discussions.

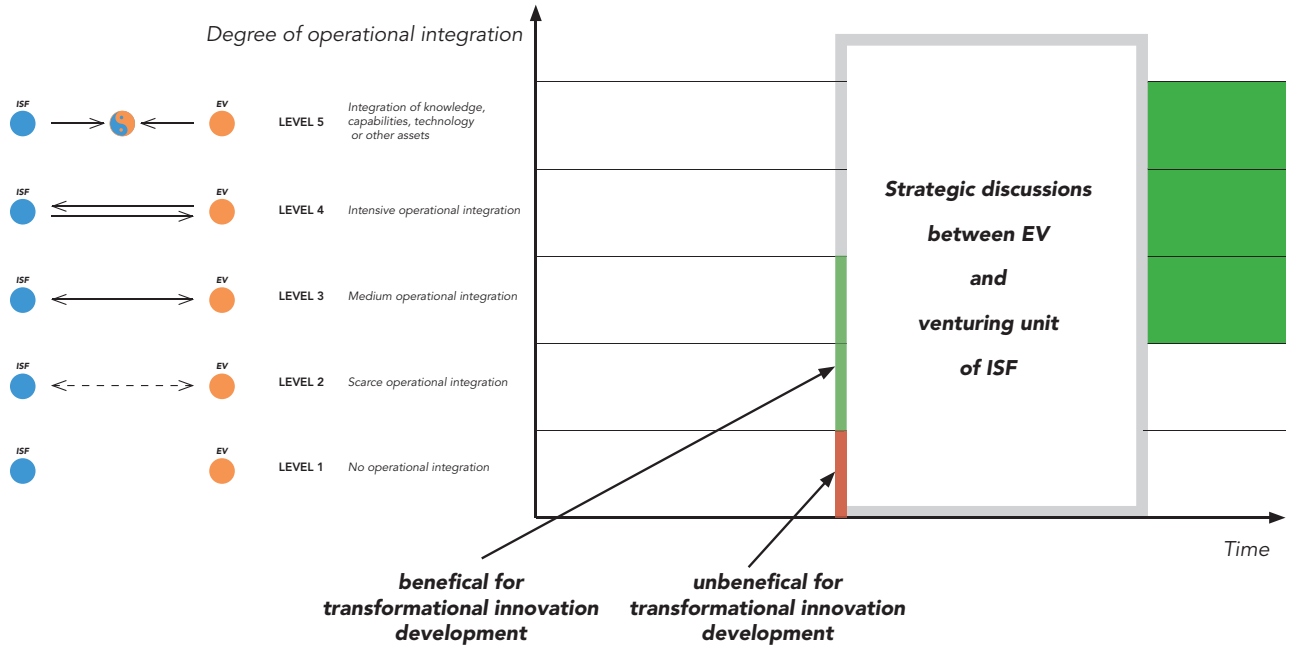


Figure 16 – Strategic discussions, started with moderate (level 2 or 3) operational integration, seems beneficial for innovation development and an impulse for high degrees of operational integration (Own ill.)

In the failure case Company 5 – Company 6, Company 6 (EV) had no operational integration (level 1) with Company 5 (ISF), at the moment that strategic venturing discussions started between Company 6 and the venturing unit of the Company 5. Company 5 directly created these venturing discussions (with discussing equity exchange) before there was yet any form of operational integration between Company 5 and Company 6. The lack of operational integration at the moment that the strategic discussions started is mentioned by Company 6 as a cause of the failure of the innovation development. They preferred a situation of first working together and subsequently discussing the strategy.

In all (two) successful transformational cases the strategic venturing discussions between the EV and the venturing unit of the ISF started after a moderate (scarce to medium) degree of operational integration was developed. The strategic venturing discussions in these success cases had an enhancing and positive effect on turning the already existing scarce to medium degree of operational integration into joint developments and collaborations with high degrees of operational integration which in turn had a positive effect on the innovation development.
In the only transformational case without moderate operational integration during the strategic discussions turned out in a venturing failure. See table 5 below.

It should be recognized that in two cases without moderate operational integration between ISF and EV the discussion about strategic matters have nevertheless been successful. However, these two cases (Company 5 – Company 9 and Company 11 – Company 12) do not lay on the domain of transformational innovation development.

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 – Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 – Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 – Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 – Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 – Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 – Company 10	+	+	+	LVL 2&4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 – Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 5 – Case results overview table highlighting relevant aspects for cross-case finding 3 (Own ill.)

4.3.4 Cross-case finding 4: High strategic autonomy of the external venture, given by the innovation seeking firm, seems required

It seems beneficial for innovation development between an innovation seeking firm and external venture when the innovation seeking firm gives much strategic autonomy towards the external venture. The external venture seems to understand better what is good for the joint innovation development. Besides the autonomy seems to enable the transformative effect of the external venture on the innovation seeking firm.

In innovation failure case Company 5 – Company 6, Company 6 wanted to serve big clients with large offices. Nevertheless, Company 5 steered Company 6 in the direction of serving small clients as schools. In this way Company 5 hampered the strategic autonomy of Company 6. Furthermore, Company 5 steered Company 6 explicitly towards a different 'way of working'. Company 5 demanded Company 6 to work according the Company 5 planning standard. This is a second example of how Company 5 hampered the strategic autonomy of Company 6. The lack of strategic autonomy is mentioned by Company 6 as a cause of the failure of the innovation development.

Both Company 3 and Company 1 explain that strategic autonomy is especially important for developing transformational innovation because in these cases the external venture has to have a changing (transformational) effect on the innovation seeking firm instead of the other way around. A low degree of strategic autonomy hampers the external venture of having a 'changing' effect on the innovation seeking firm.

The case results show that an innovation seeking firm giving an external venture much strategic autonomy can result in both success and failure of a venturing relation. From the six cases in which the EV is given autonomy, five cases were a success. In only one out of the six cases with autonomy of the EV, the venturing relation failed. Furthermore, there was one case in which the EV was given no autonomy (the Company 5 – Company 6 case) and this case was not successful. Lastly, all successful venturing cases have in common that the external venture is given much autonomy. Giving autonomy towards an external venture as an innovation seeking firms is therefore no guarantee for success, but seems to be a precondition. See table 6 below.

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 – Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 – Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 – Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 – Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 – Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 – Company 10	+	+	+	LVL 2&4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 – Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 6 – Case results overview table highlighting relevant aspects for cross-case finding 4 (Own ill.)

4.3.5 Cross-case finding 5: Development of indirect relations between an innovation seeking firm and external venture after the venturing relation started seems beneficial

It seems beneficial for transformational innovation development between an innovation seeking firm and external venture to develop a set of indirect relations between these firms, after the venturing relation stated. To developing these indirect relations is also referred as creating cluster integration.

All success cases did develop indirect relations after their venturing relation started. All transformational failure cases (Company 5 – Company 6 and Company 7 – Company 8) did not build these indirect relations after their venturing relation emerged. However, the Company 7 – Company 8 case was already stopped before it had a chance to develop indirect relations so the lack of indirect relations in this innovation failure case should not be taken to serious. See table 7 below.

Indifferent of whether cases showed the emergence of indirect relations after the ISF-EV relation started, almost all firms valued building these indirect relations. They explained that they believe that indirect relations between an innovation seeking firm and an external venture can complement and enhance the innovation development. However, also mentioned frequently is that building indirect relations should not be a goal in itself. Especially Company 7 explained that each relation should be focused and should never emerge from an ambition to have indirect relations. Company 1, Company 3 and Company 4, three companies of the transformational success cases, explained that they think that especially transformational innovation benefits from indirect relations between an innovation seeking firm and external venture. They recognise that transformational innovation in many cases seems to have total solution characteristics. And as they have the impression that total solutions benefit from closed 'ecosystem networks' with many indirect relations, they think that transformational innovation development flourishes in such a context as well.

	Topic 1: Degree of goal complementarity between the ISF and EV	Topic 2: Degree of resource complementarity between the ISF and EV	Topic 3: Degree of strategic autonomy of EV given by the ISF	Topic 4: Eventual degree of operational integration between the ISF and EV	Topic 5: Degree of operational relatedness between the ISF and EV	Topic 6: Degree of strategic importance of the relation with the EV for the ISF	Topic 7: Degree of exploration or exploitation venturing goal of the ISF	Topic 8: Order in which, the focused contact betw. the EV and a ISF-BU and the focused contact betw. the EV and a ISF-VU, emerged	Topic 9: Degree in which the EV was in the network of the ISF, before the ISF - EV relation started	Topic 10: Degree in which cluster integration emerged in the period after the ISF - EV relation started	Topic 11: Degree of success of the venturing relation for the ISF in respect to dev. the aimed for innovation	Topic 12: Type of innovation the ISF aims for in the venturing relation	Degree in which the ISF was already active in domain of the EV, before the ISF-EV relation started	Degree of operational integration between the ISF and EV, at the moment that the strategic discussions between the EV and the venturing unit of the ISF started
Case Company 1 – Company 2	+	+	+	LVL 5	–	++	R/I	BU VU BU	4 ir	3 ir	+	TR	+	LVL 3
Case Company 3 – Company 4	+	+	+	LVL 4	–	++	R	BU VU BU	1 ir	2 ir	+	TR	+	LVL 2
Case Company 5 – Company 6	–	–	–	LVL 2	–	+	R	BU VU BU	2 ir	0 ir	–	TR	–	LVL 1
Case Company 7 – Company 8	+	+	+	LVL 3	–	+	R	VU	0 ir	0 ir	–	TR	–	...
Case Company 5 – Company 9	+	+	+/–	LVL 3	–	+/–	I	VU BU	2 ir	2 ir	+	A D J	+	LVL 1
Case Company 3 – Company 10	+	+	+	LVL 2&4	–	+	R/I	RD VU	0 ir	7 ir	+	IN CR	+	LVL 2
Case Company 11 – Company 12	+	+	+	LVL 2	–	+/–	I	VU	11 ir	2 ir	+	IN CR	+	LVL 1

Table 7 – Case results overview table highlighting relevant aspects for cross-case finding 5 (Own ill.)

4.4 Learnings from innovation developments at firms outside the construction sector

The case highlights described in paragraph 4.2 and the cross-case findings described in paragraph 4.3 enable an answer on sub question 2 that is formulated as:

"What can be learned from (transformational) innovation developments at firms outside the construction sector?"

The research on innovation developments at firms outside the construction sector resulted in the following seven aspects that seem beneficial for transformational innovation. At first, it seems beneficial if the innovation seeking firm has activities already on the domain of the external venture before the contact between these parties starts. Secondly, the goals and resources brought into the venturing relation should be aligned. Thirdly, it seems beneficial if strategic discussions between the external venture and innovation seeking firms are started when there is a moderate degree of operational integration. Fourth, following-up the strategic discussions by a high degree of operational integration seems beneficial for the actual exploitation of the innovation potential of the collaboration. Fifth, for innovation seeking firms it seems beneficial to give much strategic autonomy to the external venture during the intense collaboration. Sixth, building indirect relations between the innovation seeking firm and the external venture seems to be beneficial for the venturing relation. Finally, 'network orchestration venturing' seems promising for transformational innovation development.

4.5 Expert evaluation findings

The expert evaluation findings are a result of an expert evaluation session. In this session, the learnings from (transformational) innovation developments at firms outside the construction sector are presented to a panel of three innovation experts of three different engineering firms: Royal HaskoningDHV, Arcadis and Witteveen&Bos. These learnings are presented in the form of three different strategies. Each strategy focuses on a different aspect that, resulting from innovation developments at firms outside the construction sector, seems beneficial for (transformational) innovation development. Subsequently, the experts is asked to give feedback on these strategies. They are asked to reflect on what they like and dislike in each strategy, and how in their opinion the strategy would be better suited for the construction sector. This feedback, forms the expert evaluation findings, which describe how construction sector experts evaluate the learnings from (transformational) innovation developments at firms outside the construction sector. The expert evaluation findings also answer sub question 3 which is formulated as:

"How do construction sector experts evaluate the learnings from (transformational) innovation developments at firms outside the construction sector?"

The expert evaluation findings which answer sub question 3 are described in the following paragraphs.

Construction sector experts evaluate it as beneficial for transformational innovation development when an engineering firm and external venture have business on the same domain, before starting any collaboration. They agree that both parties need viable business on the same domain in order to make any form of collaboration possible. The experts explain that having some insight in what the other party does, by sharing a business domain, enables a fruitful start of innovation collaboration.

Construction sector experts evaluate it as beneficial for transformational innovation development when an engineering firm and external venture start strategic discussions after having a moderate degree of operational integration.
The experts recognise as the most difficult part of venturing relations to get employees of an operational business unit of an engineering firm operationally integrated with employees of an external venture. Therefore, they recon it only useful to start strategic discussions after a moderate degree of operational integration is achieved. Furthermore, the experts recognise that a moderate degree of operational integration, for example in the form of pilot projects, creates insight in each other's operational situation which is beneficial for fruitful strategic discussions.

Construction sector experts evaluate a high degree of operational integration between an engineering firm and external venture, after the strategic discussions, as beneficial for transformational innovation development. This is recognised as the actual moment that both parties can build upon each other and exploit the innovation potential. The experts recon that the strategic discussions enable this high degree of operational integration. Especially the joint development agreements, in most cases part of strategic discussions, are recognised as instrumental for this enabling power.

Construction sector experts evaluate it as essential for transformational innovation development that an engineering firm gives an external venture much autonomy during the phase of intense collaboration. Nevertheless, they recon that this is not easy. The construction sector experts explain how they can have a specific strong image about how a certain collaboration should look like. However, they recognise that they have to be able to let go this specific image and give the external venture some space in determining the strategic direction of a collaboration. They explain that in the end, engineering firms have to learn from external ventures and the external venture needs to be able to have a changing effect on the engineering firm, which only can be ensured by giving it strategic autonomy.

Construction sector experts evaluate the creation of indirect relations between an engineering firm and external venture as beneficial for transformational innovation development. They recognise that a set of multiple indirect relations between an engineering firm and an external venture can form a valuable 'ecosystem' with a high degree of complementary relations. However, they also have a fear that networks like this diminishes their broker position. Engineering firms, for long times, flourished by exploiting broker positions. Therefore, they are not so eager to give up their broker positions. Nevertheless, in general they believe that in the end building a network of indirect closed network configurations relations between them and external ventures will be beneficial for transformational innovation development of engineering firms. Furthermore, the experts see these closed network configurations already emerging on a project level, however according to them the real challenge is to create them on a structural level. Besides, they stress that having their role clear as an engineering firm in any closed network configuration is essential to make the closed indirect relations beneficial on a structural level.

Lastly, engineering firms evaluate the 'network orchestration venturing' strategy as promising for transformational innovation development of engineering firms. But at this juncture, they recognize it as 'just pie in the sky' for engineering firms. The construction sector experts explain that venturing is not yet matured at engineering firms, and they do not have the scale and budgets to perform venturing activities extensive as this. Nevertheless, they see Autodesk, a large construction sector party, currently exploiting a kind of 'network orchestration venturing' strategy. The experts have the impression that this strategy is rather successful for Autodesk. So, they see opportunities for 'network orchestration venturing' in the construction sector and they think that eventually it may be powerful for engineering firms as well. But at the moment, engineering firms lack the resources for this type of venturing.

5 CONCLUSION

5.1 Introduction

This chapter describes the conclusion of this research, by answering the main research question which is formulated as:

"For engineering firms, what order of steps is beneficial for developing transformational innovation through relations with external parties?"

5.2 Conclusion

This research results in an order of steps beneficial for engineering firms in developing transformational innovation through relations with external parties. The order of steps is described in the following four paragraphs and is illustrated in figure 17.

Activities on the same domain before collaboration

This research indicates that it seems beneficial when an engineering firm and an external venture have activities on the same domain before they start collaborating with a moderate degree of operational integration. It seems to be that by being exposed to the same context, technology, challenges, stakeholder etc. both parties develop insight in each other's operational situation. This seems to have a beneficial effect on establishing a first moderate degree of operational integration. In turn, this moderate operational integration seems to have an enhancing effect on the insight in each other's operational situation.

Moderate operational integration before strategic planning

The research indicates that it seems beneficial when an engineering and external venture start strategic discussions after a moderate degree of operational integration is developed. This may be different from what might be expect. Having strategic discussions at first in a strategic venturing relation does not sound strange at first sight. Nevertheless, this research shows that an engineering firm and an external venture seem to need sufficient insight in each other's operational situation, developed by a moderate degree of operational integration, before strategic discussions can become fruitful.

Intensive collaboration, strategic autonomy and building indirect relations after strategic planning

After the strategic discussions between the external venture and the venturing unit of the engineering firm, a high degree of operational integration seems beneficial for the actual exploitation of the innovation potential of the venturing relation. This high degree of operational integration seems to be enabled by the strategic discussions, and especially by the joint development agreements which in most cases are part of it.

While working together with high operational integration, it seems beneficial when the external venture receives much strategic autonomy from the engineering firm. Especially for transformational innovation development this seems beneficial. It seems to enable room for the required transformative changing effect of the external venture on the engineering firm.

Furthermore, while working together with high operational integration, it seems beneficial when indirect relations are built between the engineering firm and the external venture that form closed network configurations around the venturing relation. The research indicates that these closed network configurations have a relatively high degree of complementary relations. A high degree of complementary relations is recognised as a network in which many relations can complement each other. Two relations for example can complement each other when the technology of relation A can complement the business model of relation B. The high degree of complementary relations in the closed network configurations around venturing relations seems beneficial for the development of innovation and transformational innovation especially.

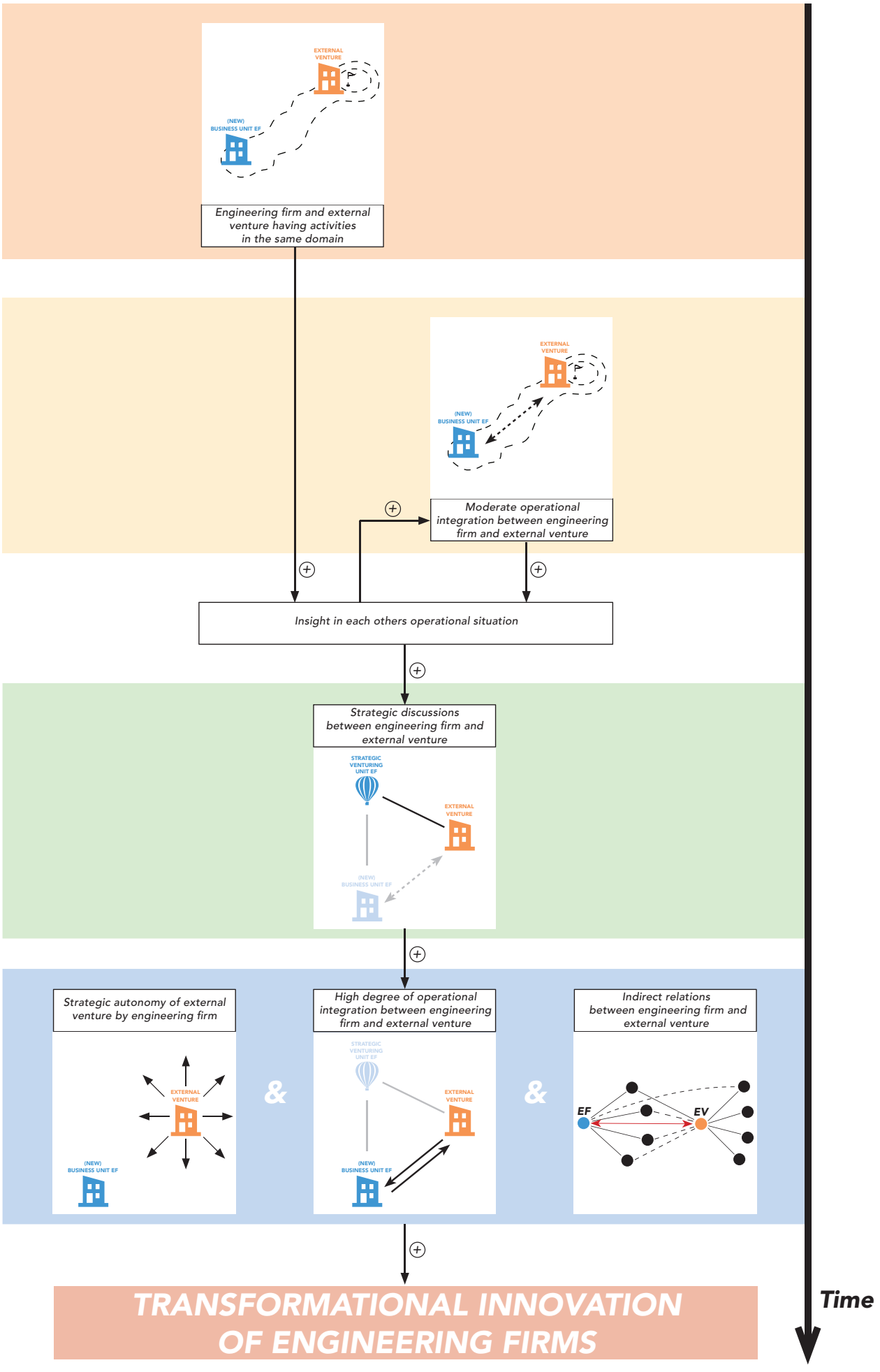


Figure 17 – For engineering firms, the order of steps beneficial for developing transformational innovation through relations with external parties (Own ill.)

6 DISCUSSION AND LIMITATIONS

6.1 Discussion

Reflection on Burgelman

Burgelman (1984) described that for a beneficial innovation development, the 'degree of strategic importance of the venture for the innovation seeking firm' gives the appropriate 'degree of strategic autonomy of the venture given by the innovation seeking firm'. However, this research says that the appropriate degree of strategic autonomy of the external venture is indifferent of how strategic important the venture is for an innovation seeking firm. This research indicates that an innovation seeking firm should always give the venture much strategic autonomy.

Furthermore, Burgelman (1984) described that for a beneficial innovation development, the appropriate 'degree of operational integration between a venture and innovation seeking firm' is given by the 'degree of operational relatedness between both parties'. However, this research does not support this reasoning. It concludes that the degree of operational integration should be moderate at first and can be enhanced to high degrees after strategic discussions took place.

It has to be considered that the research of Burgelman (1984) took place in the context of an innovation seeking firm and internal ventures. This research is about innovation seeking firms and external ventures, which may explain the difference in findings.

Reflection on network characteristics influencing innovation

This research indicates that a high degree of degree of complementary relations is available in closed networks and is especially beneficial for transformational innovation development. A possible explanation for the positive effect of the high degree of complementary relations on the development of transformational innovation may lay in that a high degree of complementary relations could be instrumental in binding partial solutions towards a total solution. If furthermore most transformational innovations have 'total solution' characteristics, this could explain the positive effect.

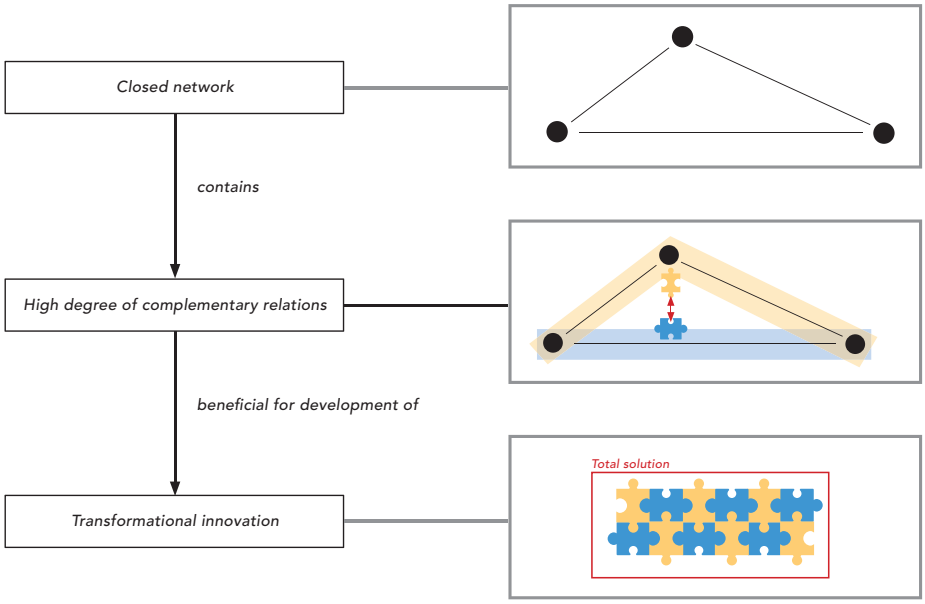


Figure 18 – What explains the positive effect of the high degree of complementary relations on the development of transformational innovation? (Own ill.)

In literature, the only network-characteristics described as having influence on innovation development are the 'degree of diversity of information' and the 'degree of efficiency in communication'. These network characteristics influencing innovation are described by author as McEvily & Zaheer (1999) and Ahuja (2000). However, this research indicates that a high of degree of complementary relations in a network positively influences innovation development.
Therefore, this research suggests to recognise the network characteristic 'degree of complementary relations' as an network characteristics influencing innovation as well.

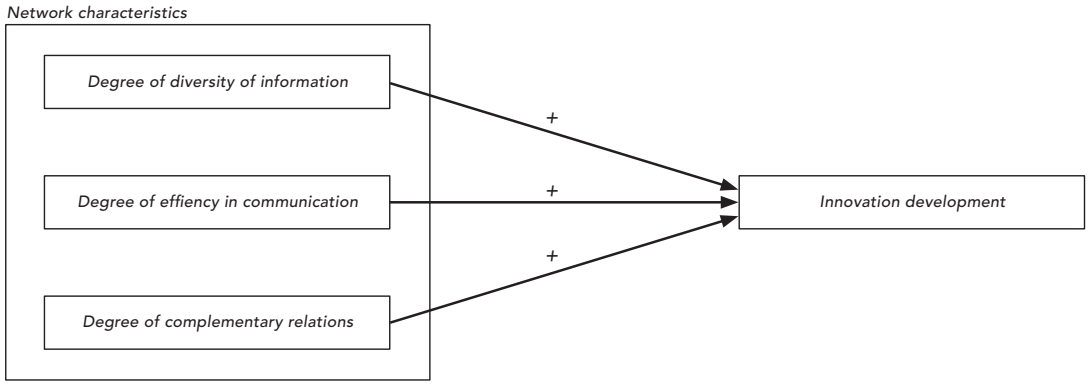


Figure 19 - Three network characteristics influencing innovation development (Own ill.)

6.2 Limitations

The first limitation of this research is that only 7 cases are investigated. An increased number of cases would have increased the reliability of the conclusions. Furthermore, only two persons per case are interviewed in order to get insight in the research topics. These persons have their own background and opinions, possibly leading to biased results retrieved from the interviews. During these interviews the researcher could only ask a limited number of questions; this may result in a limited picture of each case limiting the reliability of the research. Maybe the factors, really beneficial for transformational innovation development, lay outside the scope of the investigated topics.
Lastly, this research is affected by cross industry bias. The findings of (transformational) innovation development outside the construction sector, are projected on the construction sector. Although an expert evaluation session is used to limit this cross-industry bias, some factors may be only relevant outside the construction sector. In the end, the construction sector is much different from the sectors analysed, enlarging the risk of the cross-industry bias.

7 RECOMMENDATIONS

7.1 Recommendations for engineering firms

The future of engineering firms is unsure and challenging. At the moment, conventional engineering firms exploit an outdated core business consisting of calculating, drawing and managing built assets in relation to an hour based consultancy business model. The question arises whether, despite of their lack of digital data capabilities, engineering firms will be able to make a successful transformation towards selling total solutions related to service business models. In these transformations, engineering firms are threatened by players new in the construction domain, with much digital data capabilities. It will be exciting to see whether engineering firms are able to handle their lack of digital data capabilities or whether these new players are able to handle their lack of construction sector domain knowledge.

For engineering firms, the following steps are recommended in developing transformational innovation through relations with external parties. This process is visualized in figure 20.

Step 1 - Develop activities in transformational innovation domain

As a first step, engineering firms are advised to develop activities on a transformational new domain. For example, the domain of total solutions with digital data elements related to service business models.

Step 2 - Identify potential external venture

As step two, engineering firms are recommended to identify an external venture active on the transformational domain they just developed activities on and seems to have the potential to contribute to transformational innovation development through a partnership.

Step 3 - Create moderate operational integration

As step three, engineering firms are recommended to start a moderate degree of operational integration with the external venture. It is advised to do a pilot project together.

Step 4 - Start strategic discussions

As step four, after moderate operational integration has been achieved the engineering firm is recommended to start strategic discussions between its strategic venturing unit and the external venture. These discussions are the perfect moment to set-up joint development agreements which bring the operational integration to high levels.

Step 5 – Create intensive collaboration, give strategic autonomy and build indirect relations

As step five, after the strategic discussions, the engineering firms are recommended to create high levels of operational integration between the engineering firm and the external venture. During this phase of high operational integration, it is essential that the engineering firm respects the strategic autonomy of the external venture. Hence, during this phase of high operational integration the engineering firm is advised to develop indirect relations between its firm and the external venture. In this context, the engineering firm is recommended to try to create relations with main partners of the external venture. Furthermore, engineering firms can initiate relations between their main partners and the external venture.

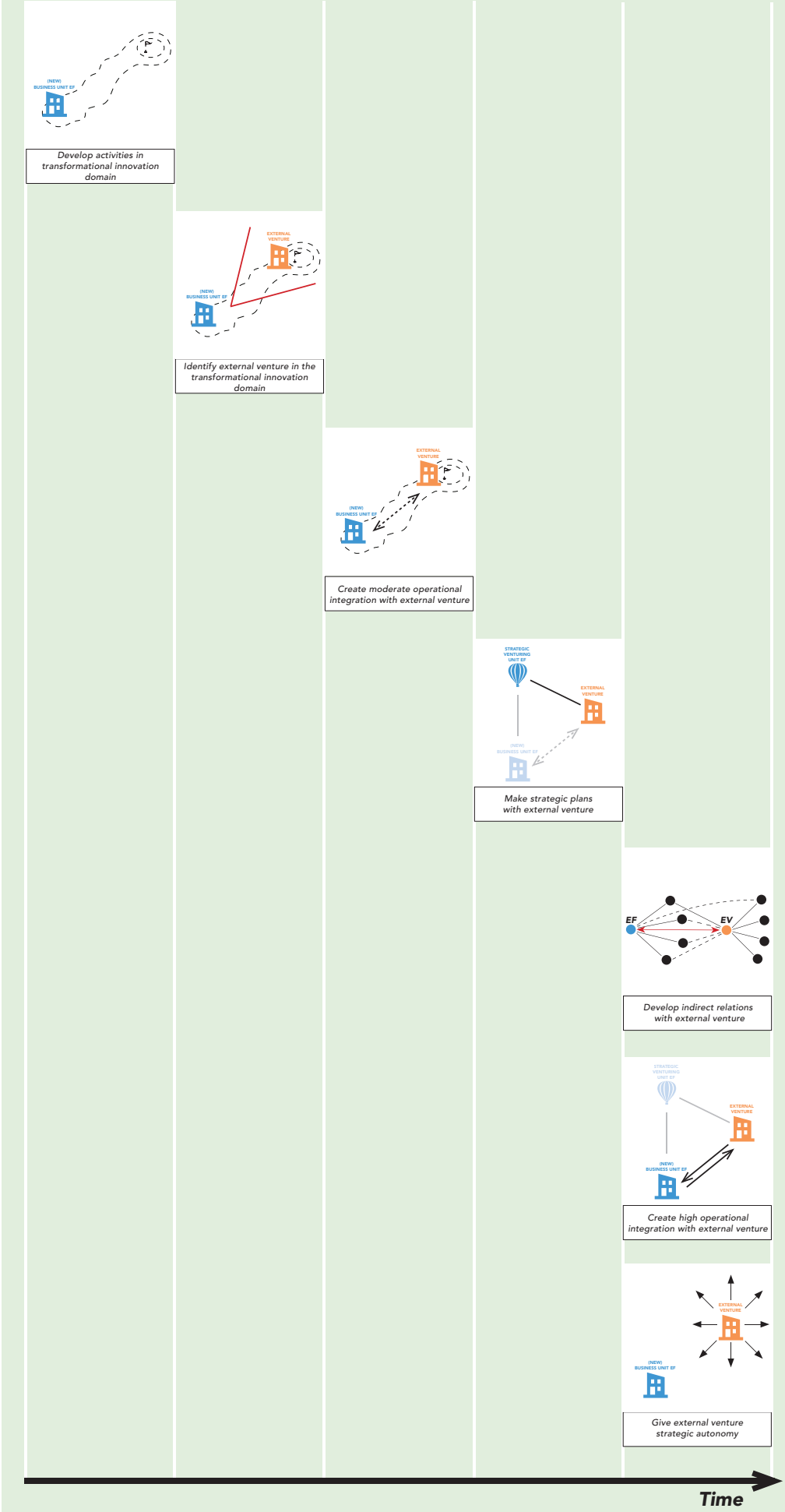


Figure 20 - Recommended process for engineering firms for developing transformational innovations through relations with external parties (Own ill.)

7.2 Recommendations for further research

Role of clients

Generally, the role of clients in the built environment is large. Therefore, in some way they will probably influence the development of transformational innovation of engineering firms as well. How should engineering firms deal with clients when they desire to develop transformational innovation? Do they need to search for specific types of clients? Do they have to influence the commissioning of existing clients? Further research in the role and influence of clients on the development of transformational innovation of engineering firm seems prudent.

Role of people

Innovation management is people management. And people have the tendency to dislike change, especially engineers. They tend to do what they did. However, if an engineering firm keeps doing what they did, transformational innovation is impossible. Therefore, engineering firms need a large understanding of the behavioural dynamics of their engineers, in order to let them develop transformational innovation. How can engineering firms inspire engineers to let go conservative behaviour and develop visionary new products and services? Research into the conservative behaviour of engineers would be interesting.

Network orchestration venturing

The research showed that a 'network orchestration venturing' strategy seems to have potential for engineering firms. Nevertheless, at the moment it is considered as too costly for engineering firms. Research should be carried out in what form this type of venturing may be possible at engineering firms.

8 REFLECTION

Just from the start of my graduation research I had plenty of idea's that I wanted to integrate. As the research process proceeded the number of idea's even increased more and more. I recognised these ideas as valuable for my research question but it was difficult for me to formulate exactly its relation to the research topic. Exploring and gathering new 'idea chunks' was an associative process that developed naturally and sparked me joy.

After having developed a large amount of idea chunks, the challenge emerged to integrate these chunks into a thesis. I had to converge. I had to determine the exact relation between the idea chunks and my research. And even more challenging, I had to kill my darlings. I experienced as the most difficult issue during the research process to stop diverging and to start converging. Problems with discovering a line towards an end product in the collection of my ideas was an important aspect of this difficulty. Furthermore, I had no appetite in converging. I enjoyed diverging and developing new ideas. During the entire research period I preferred to enrich my thesis with more elements rather than working out existing elements towards an end-product.

Eventually I stepped out of my comfort zone and I endeavoured in converging towards an end-product. This converging period was short but intensive. In more or less two weeks I wrote the core of this research report.
I experienced this converging period as tough because I found it difficult to turn the rich collection of ideas into a satisfying end-product. Moreover, it was burdensome because it pushed me towards the boundaries of my 'logical thinking' capacity.

Eventually, my ambition to graduate drove me to finalise the graduation process. I recon, this process gave me much insights into myself. It reinforced my self-knowledge about how I like diverging, and how converging is challenging to me. I look forward to play with these traits in the rest of my life.

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ATTACHMENT 1

INTERVIEW PROTOCOL WHICH GUIDED THE INTERVIEWS RELATED TO CHAPTER 1 'CONTEXT OF INNOVATION DEVELOPMENT AT ENGINEERING FIRMS'

Deel 1 - VRAGEN GERELATEERD AAN CONTEXT VAN RESPONDENT

"Wie bent u? "

"Wat is uw studie achtergrond? "

"Wat is uw functie bij uw ingenieursbureau?"

"Wat is uw drijfveer in uw werk?"

"Wat is uw drijfveer in uw leven als geheel?"

"Op welke manier bent u betrokken bij innovatie ontwikkeling?"

Deel 2 - VRAGEN GERELATEERD AAN INNOVATION ONTWIKKELING BINNEN INGENIEURSBUREAUS

2.1 Stand van zaken

"Hoe vindt u dat er momenteel in de constructie sector aan innovaties gewerkt wordt?"

"Hoe vindt u dat er momenteel specifiek bij ingenieursbureaus aan (service)innovaties gewerkt wordt?"

"Heeft u de indruk dat hierbij goed gebruik wordt gemaakt van kansen die externe partijen / alliantie samenwerkingen biedt?"

2.2 Strategie

"Welke mechanismen zijn er nu bij uw ingenieursbureau om innovatie ontwikkeling te stimuleren?"

"Welke mechanismen zijn er specifiek om transformationele innovaties te stimuleren?"

"Wat voor een rol spelen externe partijen in deze (transformationele) innovatie ontwikkeling mechanismen?"

"Welke profijt hoopt uw ingeneiursbureau van externe ventures te hebben?"

"Zoekt uw ingeneiursbureau naar externe ventures met bepaalde netwerk eigenschappen?"

"Welke uitdagingen liggen er momenteel in het betrekken van externe 'start-ups/scale ups' bij innovatie ontwikkeling van een ingenieurs bureau?"

"Welke trends en innovatie ontwikkelingen in de bouwwereld hebben uw grootste interesse cq invloed op uw strategie?" (Sidewalk labs, OVG techn)

Deel 3 - VRAGEN GERELATEERD AAN KARAKTERISTIEKEN VAN DE BOUWSECTOR CQ INGENIEURSBUREAUS EN HOE DIT INNOVATIEONTWIKKELING BEINVLOED

"Welke karakteristieken beschrijven volgens u de bouwsector?"

"Welke karakteristieken beschrijven volgens u een ingenieursbureau in de bouwsector?"

"Met welke karakteristieken onderscheidt de bouwwereld zich van andere sectoren? "

"Welke karakteristieken van de bouwwereld hebben volgens u de meeste (negatieve) invloed op innovatie ontwikkeling in de algehele bouwsector? "

"Heeft u daarbij een praktijk voorbeeld? "

"Welke karakteristieken van de bouwwereld cq ingenieursbureau hebben volgens u de meeste (negatieve) invloed op innovatie ontwikkeling bij ingenieursbureau's? "

"Heeft u hiervan praktijk voorbeelden? "

"Kunt u ook karakteristieken van de bouwwereld noemen die volgens u een positieve invloed hebben op innovatie ontwikkeling in de bouw cq ingenieursbureau's. "

ATTACHMENT 2

DATA COLLECTION PROTOCOL WICH GUIDED THE EMERGENCE OF THE CASE STUDY EVIDENTIARY DATA BASE

Deel 1 – VRAGEN MET BETREKKING TOT VENTURING STRATEGIE

1.1 Venturing strategie (algemeen)

"Wat is de algemene strategie van uw venturing afdeling?"

1.2 Venturing strategie voor transformationele innovaties

"Welke specifieke venturing strategie hanteert ubij het ontwikkelen van innovaties die transformationeel kunnen zijn voor uw bedrijf?"

Deel 2 – VRAGEN MET BETREKKING TOT EEN ISF-EV CASUS

"Kunt u iets vertellen over een relatie met een externe partij, gericht op de ontwikkeling van innovatie, die heeft geleid tot een succesvolle innovatie, een minder succesvolle innovatie of het geheel uitblijven van een innovatie?"

2.1 Detectie

"Hoe is de externe partij bij u in beeld gekomen?"

2.2 Relation goal

"Wat was het doel van de relatie voor jullie?"

"Wat was het doel van de relatie voor het externe bedrijf?"

"Hoe complementair zijn deze relatie doelen?"

2.3 Input-resources

"Welke bronnen (vaardigheden, kennis of assets, pilotprojecten, geld) brengen jullie in?"

"Welke bronnen bracht de andere partij in?"

"Hoe complementair zijn deze ingebrachte bronnen"

2.4 Relatie in de praktijk

"Hoe ziet de relatie er in de praktijk precies uit?"

2.5 Positieve elementen in relatie

"Wat gaat er goed in de relatie?"

2.6 Negatieve elementen in relatie

"Wat gaat er minder goed en waar liggen de uitdagingen in de relatie?"

2.7 Mate van succes van de ISF-EV relatie

"Hoe succesvol, is de (venturing) relatie met de EV, voor de ISF in de ontwikkeling van een type X innovatie?"

Of:

"Hoe succesvol is de relatie met de ISF voor de ontwikkeling van uw bedrijf (de EV)?"

2.8 Mate van transformationele innovatie

"Wat is de mate waarin de innovatie als transformationeel gekenmerkt kan worden (zie tabel)?"

2.9 Mate van autonomie van EV

"Mag de externe venture zomaar van sector wisselen?"

"Is er een directe verantwoordings structuur?"

"Is er directe invloed in planning en bugetering?"

"Bemoeit uw bedrijf zich met de strategische richting van de externe partij?"

"Heeft uw bedrijf een bestuurszetel in de externe partij?

Zoja, wordt deze gebruikt om de strategische richting beinvloeden?"

2.10 Speelt 'mate van strategische autonomie' dilemma een rol?

"In hoeverre speelde de overweging dat het geven van weinig autonomie aan de EV (veel controle van ISF) er toe kan leiden dat EV te veel gestuurd wordt door ISF (met negatief effect voor ISF en EV), en dat te veel autonomie er voor kan zorgen dat de EV zich buiten de voor ISF gewenste scope ontwikkelt, een rol?"

2.11 Mate van operationele integratie tussen ISF en EV

"Wat is de mate van operationele integratie tussen de vaardigheden / assets van ISF en EV?"

"Mate van afstemming van elkanders bronnen?"

"Mate waarin er op operationeel nivo door mensen samen wordt gewerkt?"

"Mate van vrije stroom van expertise tussen de twee bedrijven?"

"Heeft een operationele bussiness unit contact met de EV, of alleen de Venturing unit?"

2.12 Organisatorische positie van EV ten opzichte van ISF

"Heeft de EV contact met:

- **Ventunring Unit van ISF?**
- **New Business unit van ISF (non-core)?**
- **Core business unit van ISF?"**

2.13 Speelt 'mate van operationele integratie' dilemma een rol?

"In hoeverre speelde de overweging dat te veel integratie tussen EV en ISF kan leiden tot negatieve beïnvloeding (besmetting van conservatieve kennis) van de EV en dat te weinig integratie tussen EV en ISF de exploitatie van een positief effect van de EV op de ISF kan bemoeilijken, een rol? "

2.14 Operationele gerelateerdheid

"Wat is de afstand tussen de operationele karakteristieken (vaardigheden, kennis, assets) van uw bedrijf en de ISF?

2.15 Mate van strategisch belang

"Wat is het strategische belang van de EV voor de ISF"

"Is de EV belangrijk in een specifieke ontwikkeling die het bedrijf voor ogen heeft?"

"Is de EV uniek of is de EV inwisselbaar?"

"Hoog of laag?"

Deel 3 – VRAGEN MET BETREKKING TOT NETWERK ONTWIKKELINGEN EN OVERWEGINGEN IN EN BUITEN DE ISF-EV CASUS

3.1 Partner identificatie

"Wat zijn de 5 belangrijkste partners in het uitvoeren van uw core business?"

3.2 Open/geslotenheid van cluster

"Welke van die partners zijn naar uw weten met elkaar verbonden?"

3.3 Cluster positionering EV (EV binnen of buiten cluster van ISF?) – Identificatie van al aanwezige indirecte relaties

"Met welke partners van EV (niet partijen die inmiddels partner van EV zijn, maar partijen die partner van de EV waren op het moment dat ISF met hen een relatie aanging) ontwikkelde de ISF een relatie, nog voordat EV en ISF een relatie kregen?"

"Zo ja, welke partijen waren dit?"

"Wat was het effect/betekenis van deze al bestaande indirecte relatie op de ISF – EV relatie?"

3.4 Cluster positionering EV (EV binnen of buiten cluster van ISF?) – Identificatie van al aanwezige indirecte relaties.

"Met welke partners van ISF (niet partijen die inmiddels partner van ISF zijn, maar partijen die partner van de ISF waren op het moment dat EV met hen een relatie aanging) ontwikkelde de EV een relatie, nog voordat EV en ISF een relatie kregen?"

"Zo ja, welke partijen waren dit?"

"Wat was het effect/betekenis van deze al bestaande indirecte relatie op de ISF – EV relatie?"

3.5 Indirecte relatie ontwikkeld? Relaties van ISF naar partners van EV ontwikkelt?

"Heeft de ISF contact gelegd met partners van de EV (niet partijen die inmiddels partner van EV zijn, maar partijen die partner van de EV waren op het moment dat ISF met hen een relatie aanging) op het moment dat ISF en EV al een relatie hadden?"

"Zo ja, welke partijen waren dit?"

"Wat was hier het effect van?"

"Wat was hiervan het effect op de relatie tussen ISF en EV?"

3.6 Indirecte relatie ontwikkeld? Relaties van EV naar partners van ISF ontwikkelt?

"Heeft de EV contact gelegd met partners van de ISF (niet partijen die inmiddels partner van ISF zijn, maar partijen die partner van de ISF waren op het moment dat EV met hen een relatie aanging) op het moment dat de ISF en EV al een relatie hadden?"

"Zo ja, welke partijen waren dit?"

"Wat was hier het effect van?"

"Wat was hiervan het effect op de relatie tussen ISF en EV?"

3.7 Waarde van situatie met indirecte relaties (clusterintegratie) tussen ISF en EV

"Ziet u waarde in het creëren van indirecte relaties tussen EV en ISF?

"Ziet u waarde in een situatie met indirecte relaties tussen EV en ISF?

"Waar kan die waarde precies uit bestaan?"

"Denkt u dat indirecte relaties een positief effect (kunnen) hebben op de innovatie ontwikkeling / exploitatie tussen ISF en EV?"

"Denkt u dat indirecte relaties steeds belangrijker worden gedurende de ontwikkeling naar exploitatie en tijdens de exploitatie van de innovatie tussen ISF en EV?"

ATTACHMENT 3

CODES USED IN CODING THE QUOTATIONS IN THE TRANSCRIPTS WHICH ARE USED FOR WRITING CHAPTER 1

Contours of transformational innovations (1)

- TIEF - Contours of an 'innovative' construction sector and contours of transformational innovations at engineering firms.

Current degree of innovation development (2)

- IEF - Current degree of innovation development at engineering firms in the construction sector
- IEFC - Current degree of innovation development in the construction sector

Developments in the construction sector and at engineering firms specifically which are influencing (transformational) innovation development at engineering firms (17)

- ATS - Market demand for engineering firms selling 'total solution' (via service / license) in stead of selling 'advice' (per hour)
- CMI - Construction sector is moving towards more innovation
- CPD - Conventional construction parties will dissapear in the near future (because thinking in end product)
- DCS - Digitalisation of construction sector and engineering firms is happening now
- DFA - Market demand for flexible and adaptive construction assets
- EDPP - Engineering firms developing new (core) business which consists of products or services (with recurring fees - in the form of a lisence) i.s.o. projects (one-off)
- FOQ - Focus on quality i.s.o. time and budget
- IEF - Innovations has to come from the engineering firms and the project developpers
- KPT - Knowledge (broker) position of engineering firm in the value chain is threatend
- LDMD - Low degree of innovation remains possible due to the high market demand of construction assets. This high demand makes selling non innovative products possible.
- NEE - New ecosystems are explored
- NTPE - New (tech) players entering construction sector - forming competition for conventional engineering firms
- SAD - New players start from the question: "How to create maximum added value for the end-user?"
- SC - The concept of 'smart city'
- TCR - Technological possibilities for recycling - decomposition
- TIM - innovation forming a 'innovative sector' will emerge if some big players will build a platform around their data which monaterise this data
- TSS - Market demand for (engineering firms selling) 'total solutions' offered in relation with a 'service' / 'licence' business model. In stead of owning the assets.

Innovation chances (3)

- DGTL - Digitalisation
- ICEF - Innovation chances for engineering firms in the construction sector
- ICEFC - Innovation chances for the construction sector

Innovation hampering factors (21)

- AM - Contracting method (aanbestedings methodiek)
- ANX - Anxiety and lack of trust in each other
- CECB - Construction sector is enabling core business of other businesses / sectors in stead of being directly related the core business of others
- CRA - Clients shifting their responsibility away
- EFU - Engineer feels uncomfortable with seeking a client answer, the engineer wants to know it directly.
- EFUP - Engineer is uncomfortable with prototyping and testing with non-perfect ideas (experimenting, trial and error) - engineer wants to have it perfect in once
- IHF 1 - Project based character of construction sector (and engineering firms)
- IHF 2 - Value creation dependent on an efficient network collaboration
- IHF 3 - Fragmentation in sector: disconnections between stakeholders
- IHF 4 - Temporary colation of partners
- IHF 5 - Long term economic nature of construction assets
- IHF 6 - Actors are responsive to derived demand - No upfront investments
- IHF 7 - Short term return vision
- IHF 8 - Conservative culture - tendency to stay with the existing
- IHF 9 - Closed culture - not open for collaboration, not transparant - internal orientation
- IHF 10 - No communication in culture
- IIE - Innovation is expensive
- INDP - Engineering firm has independent role in the value chain
- RA - Risk averse
- RNPT - Resistance against 'Non-proven' technology
- SA - Engineering firms used to selling advice (per hour) in projects (iso selling products in the form of a service)

Meta level strategies for developing innovation at an engineering firm (22)

- AF - Allow faillures, only then some succesfull innovations will emerge
- CEC - Creating entrepreneurial culture
- CO - Contract with 'innovatie-partnerschap'
- CTP - Construction actors have to become techplayers combining domain knowledge with tech
- DDEO - Development of digital products and services require (new)external partnerships, impossible to develop 100% internal
- DEE - Develop extrovert engineer who tests prototypes (experiments)
- DEEWB - Experimentation (prototyping and testing) skills for engineers is not a primairy strategy for developing innovation. Creating the right partnerships is a primary strate
- DP - Digital program - capability building
- DPIP - Develop in partnerships pragmatic and integral solutions from theoretical R&D core (from universities)
- IBU - Delopment of an seperate and dedicated innovation business unit - RHDHV: Smart Solutions
- IICE - Engineers must go from 'individual and implicit' towards 'collective and explicit'
- LPP - Allow long payback period for tranformational innovations
- MUI - Making upfront (innovation) investments
- NC - TI requires new capabilities
- OS - Get involved with people from other sectors
- PP - Think in products / service (1 development, recurring fees) i.s.o. projects (one-off)
- SDP - Top level support - Senior management with decision power related to innovation development
- SPL - Seperate profit and loss of business unit incl transformational innovation from P&L of core business units
- SU - Keep incremental innovations in core business unit
- SUS - Put transformational innovations in seperate unit (seperated from core business)
- TDKDC - Centralising the combination of 'technological domain knowledge' with 'digital capabilities'
- TOS - Technologie toe passen uit een andere sector

Need for transformational innovation (2)

- TIC - TI required to become truly competitive
- TIREF - Why engineering firms are in need for transformational innovation

Promising innovation developments (2)

- IDEF - Promising innovation developments at engineering firms
- IDEFC - Promising innovation developments outside engineering firms

Strategies for developing innovation at an engineering firm (5)

- AC - Acquisitions
- BE - Building ecosystems
- DT - Design thinking (in labs..)
- IF - Innovation funnel (program)
- SPA - Strategic partnering (Joint Ventures, venturing) - external relations

Thoughts related to partnering (for innovation) (10)

- BR - Buying other ventures is not the same as making a relation with other ventures
- CBCI - Creating bridging tie to other clusters (and subseuently cohesive ties (clusterintegration))
- CPP - Current partnering problem
- CR - Complementarity required in partnering - do not become to much the same
- DBP - Develop a big pie with much partners i.s.o. a small pie with low number of partners - netto resulting in a bigger part of pie
- ICWT - Importance of cultural aspects in succesfully working together
- MNR - Make new relations in a existing cluster (inside a entity a different contact)
- NS - Network structure (structural holes, bridging ties etc.)
- PC - Partnering criteria
- PWC - Partnering with competitor