Master Thesis

Challenge accepted – Why some entrepreneurs succeed where others do not

An exploratory study on context and challenge perception and the choice of strategic activities of entrepreneurs in Dutch high-technology and clean-technology start-ups

by

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Executive Summary

Wealth, prosperity and sustainable economic growth for future generations are topics which today's policy makers and society have to deal with on an everyday basis. Radical technologies, disrupting incumbent technological and societal regimes play an important role in realizing these advances. Entrepreneurial innovation has been identified as the main vehicle in bringing these technologies to the market. Entrepreneurs in start-ups do so by searching for repeatable and scalable business models in markets with high growth potential and under extreme uncertainty. However, the complex environment of a start-up confronts them with a wide variety of challenges which they have to overcome by choosing suitable strategic activities in order to be successful. The entrepreneurs are the decision makers who select these strategic activities dependent on how they perceive this environment which is ever-changing over the life-cycle of the start-up. The decisions of the entrepreneur directly influence the performance of the new venture and lead to path dependencies in its further development.

The exploratory research conducted in this thesis aims to draw a picture of this environment – the context of a start-up. It investigates what the context of high-technology and particularly clean-technology start-ups looks like, what challenges entrepreneurs in these start-ups face and perceive and whether or not these challenges are similar across different sectors and kinds of start-ups. Understanding and identifying critical shared perceptions of challenges in different start-ups makes it easier for policy makers and incubators to provide suitable support measures to entrepreneurs in order to make their start-ups more successful and contribute to a sustainable future. Two research questions are the focus of the thesis:

> ***Q1:*** *What are common challenges that entrepreneurs in high-technology and clean-technology start-ups face?*
>
> ***Q2:*** *Is there a difference in perception and prioritization of challenges between entrepreneurs in different high-technology start-ups and specifically clean-technology start-ups?*

By employing Q-methodology, the research conducted in this thesis reveals shared viewpoints of 30 Dutch high-technology and clean-technology entrepreneurs on how they perceive certain challenges. 43 statements describing challenges of technology start-ups were derived from literature and exploratory interviews. The respondents were asked to rank these statements according to their subjective opinions and personal perceptions, resulting in a holistic picture of how their context moderates the challenges they face and the decisions they take.

Two common challenges entrepreneurs in all start-ups shared were identified*: 'High pressure from incumbent industry'* makes it important for start-ups to carefully choose a market niche in which they can communicate their value proposition with the biggest effect. *'Long sales cycles'* lead to problems in cash-flow as access to working capital is limited. Additionally, clean-technology start-ups were often found to suffer from a dependence on commodity prices and regulatory frameworks.

Contextual elements influencing challenge perceptions were observed to be more complex than only on an industry level. Thus, no significant differences in challenge perception and prioritization were

found between entrepreneurs in hardware, software and service start-ups. However, four distinct profiles, describing shared viewpoints of entrepreneurs in four groups of start-ups emerged.

1. Profile one, *'clean technology behemoths'* describes entrepreneurs in start-ups relying on complex clean-technologies. They successfully developed a minimal viable product, sold it to launching customers in a strategically chosen niche and are currently aiming to enter mainstream markets. Their main challenge is to scale up their capacities in a sustainable way and they need capital to do so.

2. Entrepreneurs in start-ups associated with profile two, *'raw diamonds'* were identified to being in a phase in which they iterate between product development and analyzing market feedback. This group of young entrepreneurs is, even though inexperienced, well aware of their lack of commercial skills and market knowledge. They acknowledge that they need to acquire this knowledge before being able to move forward.

3. Profile three, *'innovators eager to grow'* describes young entrepreneurs in start-ups which rapidly developed a first minimal viable product and now aim to grow aggressively. However, by focusing too much on entering the market, they overlook an offset between actual market needs and their value propositions which hampers their diffusion and ability to expand.

4. Entrepreneurs in start-ups associated with profile four, start-ups *'in the valley of death'* did not acknowledge the need to adapt their value proposition to their customers' needs by constantly asking for and implementing market feedback. A lack of communication with the market place leads to long product development cycles and a lack of launching customers, manifested in perceived difficulties to convince investors and to raise funding.

The results found in this thesis contribute to academia by acknowledging the thus far commonly neglected link between process and environment and go one step further towards the contextualisation of entrepreneurship. It was found that not only perceived challenges lead to the choice of certain strategic activities but also previously chosen activities might introduce new challenges by influencing the context of the firm. The four identified profiles describe start-ups on different levels of maturity and showcase that decisions on strategic activities the entrepreneurs took in the past are linked to their present position and induce path dependencies. The findings of this exploratory research provide a base for further research. By identifying specific challenges and shortcomings entrepreneurs in high-technology and clean-technology start-ups face, a foundation is laid from which causal relations between perceived and actual challenges and specific strategic activities can be investigated in the future. Moreover, the observed path dependencies in entrepreneurial decision making represent a new perspective on strategic decision making theory and a basis for further research.

The findings also allow for practical application and give implications on how to overcome the identified challenges. Policy makers are able to tackle challenges like funding gaps or coherence of innovation networks and practice transition management on a policy level. Incubators are able to analyze their start-ups following the identified characteristics and provide suitable support measures. Entrepreneurs are able to critically assess their current situation to prevent misinterpretation of challenges and missing out on valuable opportunities.

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Introduction

This research focuses on how entrepreneurs in high-technology start-ups perceive and prioritize challenges posed by the context and environment the start-up operates in. It is investigated if perceived challenges differ between entrepreneurs in different types of high-technology start-ups and how the context of a start-up moderates the perceived challenges. Special emphasis is laid on the field of clean-technology start-ups which were identified to be one of the main vehicles to bringing sustainable technologies to the market. Furthermore the thesis aims to throw light on moderating factors influencing the context of the start-ups and challenge perception of high-technology entrepreneurs. The direct connection between a start-up's environment or context and its challenges and success has thus far been underrepresented in academic research. Understanding how entrepreneurs in high-technology start-ups perceive challenges enables incubators and policy makers to evaluate and improve their support measures. Furthermore it allows the entrepreneurs to take a more active role in shaping the context of their firms and making their endeavours more successful. Figure 1 shows the structure of the thesis.

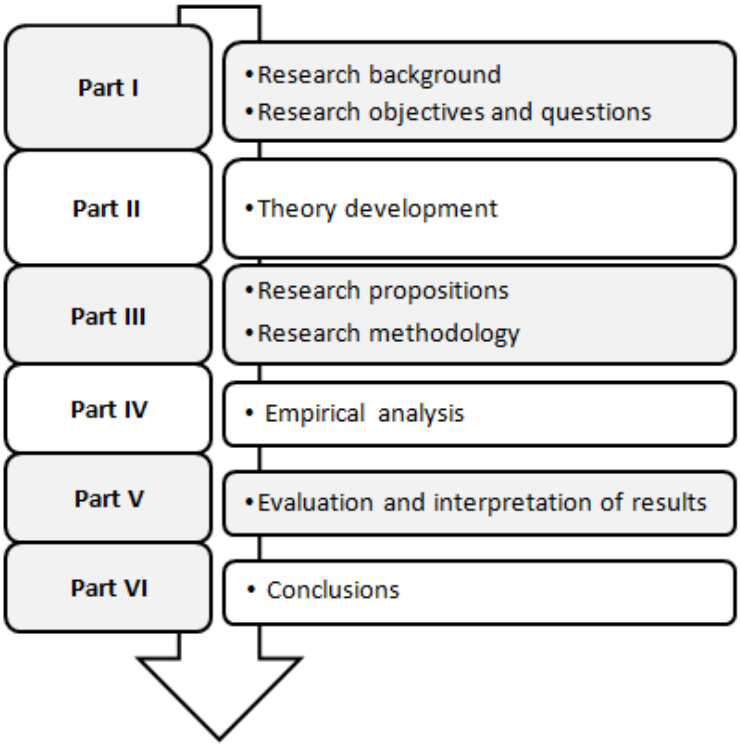


Figure 1: Thesis structure

The thesis is divided into six consecutive parts. In part one **(part I)** the problem is defined from both a scientific and a practical point of view. Following from the problem definition, research objectives and questions are formulated. The second part **(part II)** introduces a conceptual model of the role of the context of start-ups and focuses on the link between challenges, challenge perceptions and strategic decision making in high-technology start-ups. A list of typical barriers to success of high-technology start-ups is derived from literature. The model that the perceived challenges of the entrepreneur in a start-up are dependent on the start-up's context is introduced. Part two opens with a theoretical overview on how the context of a start-up influences the entrepreneur's perception of challenges and introduces fundamental key concepts which build the basis of this

thesis. Furthermore, the nature of entrepreneurial decision making and the role of strategic activities in overcoming challenges and barriers to success are discussed.

In the third part **(part III)**, Q-methodology is introduced as suitable methodology to answer the research questions and test the theoretical model established in part two. On the basis of the literature, several propositions are introduced and investigated. Research design and research methods are elaborated on and the process how the research was conducted is made explicit. It is elaborated on the application of Q-methodology and the Q-set and P-set are developed and introduced.

In the fourth part **(part IV)**, factor analysis is conducted to compare subjective viewpoints of the respondents. Four factors are extracted using centroid factor extraction and rotated by employing varimax rotation to form factor arrays. The four emerged factors represent groups of start-ups in which the entrepreneurs perceive similar challenges. In the fifth part **(part V)**, the factors are interpreted and four distinct profiles emerge, each with a different set of challenges. In the sixth and last part **(part VI)**, the results are discussed and conclusions are made. Furthermore, their connection to the formulated propositions is elaborated on. Scientific and practical results are presented. Subsequently, recommendations for incubators and start-ups are formulated. It is elaborated on limitations of the research and implications on potential further research in the field are given.

1. Research context and problem definition

Part one of this thesis establishes the background of the thesis and elaborates on the scientific and practical relevance of the topic. After giving an insight into the context of the research, the main research objective is formulated on the basis of the problem definition. Subsequently, two research questions are formulated.

1.1. Research context

Sustainable development, a sustainable future, resources for the generations to come and growth of wealth are terms with which one is confronted day after day when opening the newspapers or turning on the TV. Scholars as well as policy makers are well aware of these issues (Adams, 2006; Binswanger, 2001; Commission of the European Communities, 2006; Mulder, van Lente, & Ferrer, 2011; Obama, 2013; Schramm & Hackstock, 1998; A. Smith, Stirling, & Berkhout, 2005; United Nations World Commission on Environment and Development, 1987) . Even though it is often brought forward that technology alone will not be able to solve them (Huesemann, 2003), it is argued that radical technological innovation is a key instrument to balance the impact of growing population and wealth (Chertow, 2001; Ehrlich and Holdren, 1971). Christensen (1997) argues that start-ups perform especially well in bringing these disruptive technological innovations to the market, in the end leading to replacement or shifts of technological regimes following Schumpeter`s concept of '*creative destruction*' (Schumpeter, 1934). In the same line, other scholars argue that entrepreneurial innovation was the main vehicle to give answers to challenges posed by environmental trends (Garnsey, Dee, & Ford, 2006) and societal issues (Austin, Stevenson, & Wei-Skillern, 2006) in the past.

In this thesis the role of high-technology start-ups bringing these radical and disruptive technological innovations to the market is discussed and the process of new venture development is investigated.

Special emphasis is laid on the role of start-ups developing technologies contributing to a sustainable future, often referred to as *'clean technologies'* which Clift (1995, p.1) describes as *"...a means of providing a human benefit which, overall, uses less resources and causes less environmental damage than alternative means with which it is economically competitive".* In times of resource depletion and continuing growth of population and wealth, adoption of clean-technologies are in the focus of policy makers (Obama, 2013) as well as corporations (Shrivastava, 1995; Esty & Andrew, 2009) and scholars (Coenen & Avdeitchikova, 2011; Kemp & Volpi, 2008; Schot, 1992). However, many aspects on how to innovate in a sustainable way are yet unexplored.

It was observed that start-ups perform particularly well in creating diversity and game changing technologies – disruptive innovations. Other than sustaining innovations which enforce existing innovation systems, disruptive innovations are usually innovations *"that result in worse product performance, at least in the near term"* and are on medium or long term generally *"cheaper, simpler, smaller, and frequently, more convenient to use"* (Christensen, 1997). Thus, disruptive innovations eventually make incumbent societal and technological regimes obsolete. The process of developing disruptive innovations usually happens in environments requiring flexibility and continuous pivoting. Entrepreneurial innovation was found to be a process of problem solving under resource constraints, trying to give answers to problems in ever changing contexts (Garnsey et al., 2006). This pivoting takes place in close proximity to the market place and circles between searching and technology development (Van Vrede, 2012; Ries, 2011) by constantly adjusting the value proposition to the changing contexts and markets needs.

Garnsey et al. (2006) argue that this pivoting and adapting is less likely to take place in larger firms in which adjustments to new circumstances happen slow and are often only marginal. This observation is in one line with Wennekers' and Thurik`s (1999) general notion of entrepreneurship (corporate as well as individual entrepreneurship) being a major driver of economic growth. Hence, successful start-ups are important drivers of technological innovation and economic growth and play a significant role in creating a more sustainable future for the generations to come.

However, whether or not these start-ups are *'successful'* is, after all, dependent on how well they are using available (but scarce) resources, how much value they are able to create and how well they perform in communicating that value to their customers. Gartner (1985) argues that a new venture is to be seen in the context of its environment and forced to *"seek out resources to compete in the marketplace".* Similarly, Aldrich and Martinez (2001) argue that like in evolutionary theory, process and context (in terms of *"strategy and environment"*) determine whether a company is successful and survives or not. Being able to adapt the process to the changing context in order to overcome barriers to success (referred to as *'challenges'* in this thesis) is of utmost importance. Aldrich & Martinez (2001) concluded that integrating these two determents, strategy and environment, into research designs is still one of the major challenges in entrepreneurial research. The same was observed by other scholars. While the contextualisation of entrepreneurship gained more attention in the last decade (Welter, 2011; Zahra, 2007), it is still underrepresented in academic literature (Wiklund, Davidsson, Audretsch, & Karlsson, 2011).

The research in this thesis aims to close that gap and pay more detailed attention to the concept of *'the context'* by acknowledging and investigating its role in entrepreneurial value creation. Following this thought, it is argued that start-ups are subject to a continuous development process and have to

adapt to the dynamic context they are in. That said, challenges of start-ups transform throughout its lifecycle (Van Weele, 2012) as the context of the start-ups shifts as well. The context of a start-up for this purpose can be understood as the environment a start-up is in. Dimensions determining the context can for instance be *'external'* domains like the industry, the market, a policy framework, the general state of the economy or availability of resources the start-up has to adapt to (Aldrich & Pfeffer, 1976; Hannan & Freeman, 1977; Aldrich, 1979 as cited by Gartner, 1985). Scholars indicate that there are also various *'internal'* elements like experiences of the founding team which moderate the environment the entrepreneurs perceive as *'reality'* and build the basis of strategic choices (Child, 1972; Starbuck, 1976; Weick, 1979 as cited by Gartner, 1985). Overcoming challenges in an analytical and efficient way by choosing certain strategic activities is necessary for the start-up to be successful.

Based on the proposition that the challenges of a start-up shift during its life cycle as the context itself transforms, it is argued that there must be certain factors moderating the context. Incubation programs for instance aim to affect and moderate the environment and context of a start-up in the most beneficial way in order to maximise its performance. This is done by providing coaching, network and infrastructure (Peters, Rice, & Sundararajan, 2004) and thus shaping the environment a start-up evolves in. Following Aldrich's and Martinez's notion (2001) of start-up success being a function of process and context, it becomes clear that entrepreneurs also choose their strategic activities in dependence of the environment provided and influenced by various moderating factors. Hence, to be successful, it is of crucial to understand the challenges entrepreneur perceives and thus also the context the start-up is in. Being able to identify and understand moderating factors and critical success criteria enables entrepreneurs and policy makers to actively take part in shaping the context of a start-up in the most favourable way.

1.2. Problem definition

The problem definition is divided in a scientific and a practical part. While the given answers to the scientific problem aim to contribute to our understanding of underlying mechanisms in entrepreneurial value creation, the thesis also aims to provide useful practical implications for entrepreneurs and incubators.

1.2.1. Scientific problem definition

It was argued that high-technology start-ups have an essential function in bringing disruptive technological innovations to the market. Particularly clean-technology innovations as a subgroup of high-technologies were argued to be necessary to provide a sustainable future. To be successful, it was argued that entrepreneurs must take the *'right'* strategic decisions to overcome challenges posed by the start-up's context. Hence in order to understand why entrepreneurs choose certain strategic activities it is important to first determine how the context their start-up is in actually looks like and how the entrepreneurs in their function as decision makers perceive the challenges they face.

This question has scientific relevance from two different aspects. First it is important to understand how exactly the context of a start-up influences the entrepreneur's perception of challenges, resulting in the choice of strategic activities. Even though a lot of research has been done to investigate what factors influence the success of a start-up, the role of the entrepreneur as decision maker who chooses certain strategic activities based on his perception of the situation his start-up is

in, has thus far been underrepresented. Viewpoints and perceptions of the entrepreneurs on this matter are therefore of considerable importance when trying to understand why some start-ups are successful while others are not. The research conducted in this thesis aims to fill up this empty space and to provide insights into these mechanisms.

The second aspect focuses on the field of high and clean-technologies. Research has been done on innovation systems of various high and clean-technologies (e.g. Kamp, 2008; Kamp, Negro, Vasseur, & Prent, 2009; Kemp & Volpi, 2008; Negro, Hekkert, & Smits, 2007; Sark & Hekkert, 2007). However, their research mainly focused on *'macro'* challenges on a regime and landscape level rather than on actual challenges entrepreneurs face in everyday life like prototyping, fundraising, strategic sales or leading a team. Hence, the research conducted in this thesis is expected to add an important *'micro'* aspect to existing research on innovations systems theory and aims to explain why on the first look very different start-ups suffer from similar challenges.

1.2.2. Practical problem definition

Incubators and policy makers aim to optimize the performance of start-ups by providing a fertile environment for the start-up, thus shape the context the start-up. Not only for the sake of society it is tried to maximise survival rate and start-up success, but also to maximise the return on investment on the resources invested in the start-up. However, challenges remain. How for instance can incubators tackle problems of entrepreneurs and create a fertile environment without first understanding their actual challenges and needs? Achieving greater understanding in this field and the underlying mechanisms would enable incubators and policy makers to evaluate and improve their efforts and value propositions and to help entrepreneurs to actively participate in identifying, choosing, shaping and creating the context of their start-ups in order to optimize their performance.

Yet, various aspects remain unclear. Do all high-technology entrepreneurs, and in particular clean-technology entrepreneurs, encounter similar challenges? Are there differences in how entrepreneurs in clean-technology start-ups prioritize challenges compared to entrepreneurs in other technology start-ups? Is there a difference in challenge perception between hardware, software and service start-ups? How do factors like being part of an incubation program moderate the context of a start-up and perception of challenges? This thesis tries to answer at least some of these questions and aims to go one step further in explaining the role of a firm's context in moderating the perception of challenges.

1.3. Research objective

Following from the practical and theoretical problem definition, it becomes clear that the field of challenges in high-tech start-up is thus far underrepresented in academic research and often only dealt with in a rather intuitive way. The research conducted in this thesis serves one main objective as shown in table 1 and attempts to solve the theoretical and practical problems introduced in chapter 1.2.

Table 1: Research objective of the thesis

Research objective
O1: The research aims lead to an overview of what the context of high-technology and particularly clean-technology start-ups looks like, what challenges entrepreneurs in these start-ups face and whether or not these challenges are similar across different sectors and kinds of start-ups.

Objective one (O1) aims to provide a clear picture of which challenges entrepreneurs in high-technology and in particular clean-technology start-ups perceive in the light of their context. Even though literature implies that the context of clean-technology start-ups differs from the context of other technology start-ups, challenges within this context have not been made explicit yet. Also, it is argued that hardware, software and service start-ups encounter different challenges as they operate in different contexts. It is compared and analyzed if entrepreneurs in different high-technology start-ups face similar challenges despite the diverse contexts they are in and how these differences in challenges can be explained. These insights build on and extend existing research and represent a basis for further investigations on whether or not a *"one size fits all"'* approach for start-up support can be applied for various high-technology start-ups or not (Van Weele, 2012). Furthermore, objective one aims to unravel if and how factors (e.g. like being part of an incubation program) have a moderating effect on the start-up's context and the entrepreneur's perception of challenges. Achieving thorough understanding of a start-up's challenges and problems is a fundamental first step when trying to solve them. Understanding influencing factors on challenge perceptions would help for instance incubation programs to tailor support to specific start-ups. If certain start-ups share challenges due to the similarity of context it would be easier for incubators and policy makers to anticipate and subsequently tackle these challenges specifically.

1.4. Research questions

Based on the research objectives two research questions emerge as shown in table 2.

Table 2: Research questions of the thesis

Research questions
Q1: What are common challenges that entrepreneurs in high-technology and clean-technology start-ups face? **Q2:** Is there a difference in perception and prioritization of challenges between entrepreneurs in different high-technology start-ups and specifically clean-technology start-ups?

Question one (Q1) aims to explore what challenges entrepreneurs in high-technology, clean-technology and other technology start-ups generally face. Making the challenges entrepreneurs face explicit enables incubation managers and policy makers to tackle specific issues in order to increase new venture performance (NVP) and helps entrepreneurs to anticipate potential future challenges before they occur. A literature review and exploratory interviews result in a list of typical challenges entrepreneurs in these start-ups usually face which represent the basis for further investigations using Q-methodology. Shared fields of interest representing common perceptions of challenges are shown and made explicit.

Question two (Q2) aims to draw a picture on how these challenges are perceived and prioritized by different kinds of high-technology and clean-technology entrepreneurs. Furthermore the challenges are analyzed and conclusions of their cause are drawn. Understanding how challenge perception differs between entrepreneurs in different kinds of high-technology and clean-technology start-ups gives important implications whether or not it is important to offer specific support measures for different start-ups. If certain groups of start-ups, with their entrepreneurs sharing viewpoints on

specific challenges, emerge it would be easier for incubators to choose suitable start-ups for their program and to provide tailored support to the entrepreneurs.

2. Challenges in high-tech start-ups – A literature review

In part two of this thesis, relevant key concepts are introduced and a conceptual model to answer the proposed research questions is provided.

First, the term *'start-up'* will be defined and narrowed down. Subsequently the definition of *'high-technology'* is introduced and the term *'clean-technology'* is made explicit. Differences and attributes of *'hardware, software and service start-ups'* and their connection to high-technology will be elaborated on. It will be shown that the environments these start-ups operate in are fundamentally different. Furthermore emphasis is laid on different perspectives on the term *'sustainability'* and implications of the term sustainability on the process of *'sustainable development'* will be given. The concept of *'new venture performance'* is introduced and a link between the success of a start-up and its strategy is made. Doing so, a theoretical overview on different start-up success frameworks and entrepreneurial decision making is given. The entrepreneur as rational decision maker who systematically overcomes challenges by choosing certain strategic activities is introduced. A picture of the environment in which these decisions are taken – the *'context'* of a start-up – is drawn and the subjective nature of perceived challenges within this environment is made explicit. Furthermore it is elaborated on the role of incubation programs in entrepreneurial value creation. Part two closes with a summary of the introduced theory, building the backbone and theoretical model which is followed in the research conducted in this thesis.

2.1. Start-ups

Decades ago, Schumpeter introduced his theories on Schumpeter mark I and mark II firms (Schumpeter, 1934, 1962). While the latter focused on the role of large firms in the innovation process, his earlier work concentrated on the entrepreneur as innovator. Consequently, fundamental differences in terms of resources constraints, strategies and decision making were observed between new ventures and established firms (e.g. Aldrich & Fiol, 1994; Shrader & Simon, 1997, Garnsey et al., 2006). Start-ups were argued to be a main driver of disruptive innovation (e.g. H.E Aldrich & Martinez, 2001; Austin et al., 2006; Garnsey et al., 2006) and are therefore also in the focus of this thesis. However, the terms start-up or new venture needs some further refinement as they are commonly misinterpreted.

Often the term *'start-up'* is associated with an SME (small or medium sized enterprise) at the beginning of its lifecycle. The term SME follows the definition of the European Commission, based on headcount and turnover or balance sheet total (European Commision, 2005). The enterprise or firm as Penrose calls it, is *"a collection of productive resources (human and non-human) under administrative coordination and authoritative communication that produces goods and services for a sale in a market for a profit"* (Penrose, 2009, p. xii). The Strategic Planning Institute (Strategic Planning Institute, 1978 as cited by Gartner, 1985) extends this definition and argues a start-up to be a new business venture (or a new firm following Penrose's definition) with the attributes presented in table 3.

Table 3: New business ventures (Strategic Planning Institute, 1978 as cited by Gartner, 1985)

New business ventures
1. *An independent entity*
2. *A new profit center within a company which has other established businesses, or*
3. *A joint venture which satisfies the following criteria:*
a) *Its founders must acquire expertise in products, process, market and/or technology.*
b) *Results are expected beyond the year in which the investment is made.*
c) *It is considered a new market entrant by its competitors.*
d) *It is regarded as a new source of supply by its potential customers.*

In practice however this academic definition is further refined. A start-up is often referred to as a firm which is short before or was already founded in a market with high growth potential under extreme uncertainty (e.g. Graham, 2012; Ries, 2010). The start-up as it is looked upon by popular science and academic literature is a firm in its early stage of existence in which the entrepreneur is moving from exploring towards exploiting (Choi, 2004). Furthermore Blank (2010) defines a start-up as "[...] *an organization formed to search for a repeatable and scalable business model*". This view is in line with Penrose's definition of *'the firm'* (Penrose, 2009), focusing on the early stage of its growth.

Hence the definition that a start-up is *'an organization in the first period of its existence, searching for repeatable and scalable business models in markets with high growth potential and under extreme uncertainty'* will be followed in this thesis. Start-ups can generally provide technical or non technical products or services.

2.1.1. High technology and high-technology start-ups

There are several different definitions of high-technology, generally based on government classifications, industry characteristics or the type of innovation (Mohr, Slater, & Sengupta, 2009). The public often characterizes high technologies as such which are perceived as complex and difficult for them to understand. However, this definition introduces a bias. What seems to be complex for one individual is not necessary complex for another person. Furthermore, *'complexity'* of a product or service not necessarily results from technological complexity but also from complexity and a sense of unpredictability in other dimensions. Hence, the definition of high-technology needs to follow a more generalizable approach. Scholars argued that high-technology are technologies brought to markets suffering from *"market uncertainty"*, *"technological uncertainty"* and *"competitive volatility"* as shown in figure 2 (Mohr et al., 2009).

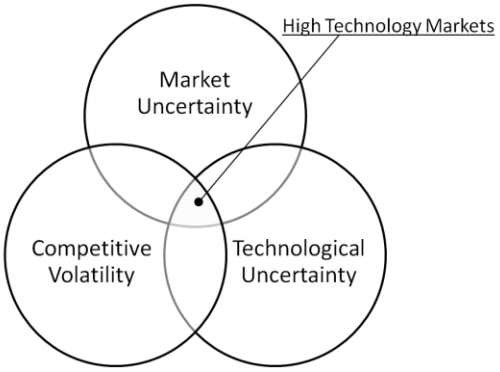


Figure 2: High Technology Markets – Definition (Mohr et al., 2009)

Hence high-technology is rather defined by these shared characteristics than by input or output based approaches or subjective perceptions of technological complexity. They reflect the complexity of high-technology products by acknowledging their uncertainty in several dimensions. Characteristics of high-technologies and high-technology markets within these dimensions are for instance *'high unit-one costs'*, *'tradability problems'*, *'knowledge spillovers'* and *'network externalities'* (Mohr et al., 2009). Will the complex technology work out as expected? Will the market accept the product or service? How will competitors react? These factors occur in the light of resource and time constraints, thus characterize a highly complex environment.

2.1.2. Hardware, software and service start-ups

High-technologies can take various forms and their commercialisation can be based on different business models. Generally, it is distinguished between hardware, software and service start-ups. Even though not paid substantial attention to in academic literature yet, differences between hardware, software and service start-ups are regular subject to discussions in popular science blogs, in classrooms and amongst entrepreneurs. Industry experts, popular scientists and the start-up community hypothesize and suggest that due to the different natures of the products and customers, these start-ups also encounter different challenges (e.g Bishof, 2012, Dixon, 2013, Stangel, 2013). While hardware start-ups sell physical products and software start-ups usually focus on selling ownership over programs, service start-ups usually market a physical or virtual product via a service contract. Hence, service start-ups do not sell ownership over the product itself, but apply their product or offer access to their product to offer a specific outcome. Aspects of hardware, software and service start-ups are often combined in successful business models which aim to capture the benefits of each.

Hardware start-ups

As the name suggests, hardware start-ups naturally focus on hardware products which are sold business to business (B2B) or business to customer (B2C). Hardware start-ups have arguably been underappreciated by investors throughout the last two decades in which society saw the rise of software. However new technologies and trends like rapid prototyping and increased access to cheap manufacturing facilities are expected to lead to a renaissance of hardware start-ups (Stangel, 2013, Graham, 2012b, Mitroff, 2012). Hardware refers to a *'physical product'* and introduces a few limitations compared to software of service start-ups.

As hardware start-ups rely on physical products rather than on easily replicable code, manufacturing is an essential function of success (Dixon, 2013). Especially the transition from prototypes to large scale manufacturing with all its pitfalls like capital intensity, maintaining quality or supply chain issues represents a major point of interest. While the "*build, measure, learn"* philosophy introduced in '*The Lean Start-up'* (Blank, 2013; Ries, 2011) works well for software-start-ups, one has to be aware that these methods become significantly more challenging when applied on hardware products with complex supply chains and cost intensive manufacturing. The lean start-up theory relies on a minimum viable product satisfying the basic needs of launching customers and is based on iterative learning steps. Van Vrede (2012) investigated project management practices in hardware start-ups and found parallels in the sense that their activities can be categorized in a *"searching",* a "*developing technology"* and an *"entering market"* phase.

Relying on a physical product with substantial marginal costs introduces the issue of *'defensibility'* in terms of competition from lower cost manufacturers. Dixon (2013) argues that the lack of network effects of hardware start-ups weakens their competitive position. These points lead to a higher perceived risk when investing in high-tech start-ups, often making them less appealing to investors (Breeze, 2012).

On the upside, hardware start-ups bear several significant advantages. Amongst other points, Fleshman (2013) argues that hardware start-ups *"enable software"* and are therefore often an essential platform for software products. Additionally he states that hardware products usually yield a higher perceived value for their customers. These advantages in combination with new manufacturing and prototyping technologies, reducing the risk of investment by minimizing iteration cycles and times, make hardware start-ups increasingly interesting for investment (Breeze, 2012).

Software start-ups

Software, especially in combination with hardware (Dixon, 2013), has the advantage of being able to exploit great network effects (Katz & Shapiro, 1994) and positive feedback loops, for instance due to cheap incremental production (Arthur, 1990). Software start-ups often rely on *'co-creation'* through its users adding functionality and value, thus creating a very unique user experience (O'Reilly, 2005). Similarly, Bouwman, Bejar, & Nikou (2012) used Q-methodology to investigate the usage context of mobile service applications and dimensions of user experience. They found that *"context"* is an important dimension in adoption and use of mobile services. Elements like innovativeness and effort to use are important factors in determining how and if mobile apps or software products are adopted and used.

After initial capital investment for the development of the software, marginal production costs are close to zero which yields significant advantages compared to hardware start-ups. Software start-ups experienced a boom as they don't suffer from constraints like a large required infrastructure to manufacture physical objects. Furthermore software start-ups usually have lower insurance costs, a shorter period of time from design to start of sales and a less rigorous bug-testing prior to product releases as software products can easily be updated (Breeze, 2012).

However, the advantages of software start-ups are at the same time its Achilles heel. Low initial required capital and low times to market mean relatively low barriers to entry for competitors. Also, intellectual property is an issue for many software start-ups and even though they are theoretically able to generate large network effects, compatibility between different software products often makes it hard to remain unique and irreplaceable. Speed to market and an even closer proximity to the market place by introducing minimal viable products (MVP) to the market and continuously iterating the value proposition is crucial (Ries, 2011). Hence, while barriers to entry are low, barriers to success are rising (D. Miller, 2012). Also in academic literature a trend a shift in challenges within the software sector from products towards services was observed, resulting in a changing context and different challenges (Cusumano, 2008).

Service start-ups

Service start-ups sell an outcome of an activity rather than ownership over a product. While non-high technology services include for instance activities based on manpower like cleaning, service start-ups in the high-tech sector usually rely on using their own unique hardware or software solutions or

grant temporary access to them in order to create a sustainable business model and a competitive advantage. High-technology service start-ups are often combinations of service with hardware or software start-ups which chose to not sell ownership over their products but deliberately decided to base their business model on offering them as a service. For instance SAAS (software as a service) refers to *'on demand software'* which can be accessed as a service when needed. Again, service start-ups may offer their service B2B or B2C.

Mixed start-ups

Firms combining elements of hardware, software and service start-ups and different elements of their business models are able to mitigate risks and downsides of each individual type and to build on their strengths. By combining hard and software for instance, start-ups often aim to overcome the respective downsides (e.g. lack of network effects) by partially combining the positive sides of both (Dixon, 2013). An example for this kind of firm is Apple which locks its customers in by providing them with superior hardware products combined with a unique user experience and software support. Hardware products are argued to add to software and service products by providing a better user experience and often acting as an enabling platform (Fleshman, 2013).

2.1.3. The clean-technology innovation system and clean-technology start-ups

Clean-technologies generally share the characteristics of high technologies. Therefore they are seen as a subgroup of high technologies. Clean-technology start-ups can be hardware, software or service start-ups. Similar to high technologies, they are often developed under various aspects of uncertainty and aim to diffuse into existing regimes by making incumbent standards obsolete. Clift (1995, p.1) describes a clean-technology as *"...a means of providing a human benefit which, overall, uses less resources and causes less environmental damage than alternative means with which it is economically competitive".* Markusson (2011) outlines the difference between *"end-of-pipe technologies"* which only filter pollution and reduce its impact on the environment versus *"clean-technologies"* which reduce the production of pollutions.

Garnsey et al (2006) argues that, even though large corporations would have the resources to push radical innovations in the renewable and clean technology market place, they often do not do so. According to Garnsey, large firms are often hesitant as they are locked into regimes, bound to satisfy their shareholders expectations of return on investment. They try to do this without taking high risks or making their own, already existing, solutions obsolete by cannibalizing sales. This makes clean-technologies especially interesting for entrepreneurs. They pursue opportunities by re-arranging existing but also creating resources to potentially triggering major shifts in technological and societal regimes by *"turning resources of little or negative utility into a source of value"* (Garnsey et al., 2006, p.6).

For the purpose of this thesis, when using the term clean-technology it is referred to '*technologies of different sectors like renewable energies, recycling, IT, transportation or chemistry which use innovative ways to cause less environmental damage than alternative means, compete with them on the market place and aim to diffuse into and ultimately replace existing regimes and innovation systems'.*

Diffusion of clean-technologies

Even though the definitions of *'clean-technology'* and *'high-technology'* have a lot of common attributes, their diffusion and exploitation is in many aspects fundamentally different. Johnson &

Suskewicz, (2009) argued that clean-technology describes a new innovation system rather than an industry or a set of technologies. Kemp & Volpi (2008) add that little is known on the diffusion of clean technologies and stress the differences between end-of-pipe solutions and disruptive clean-technologies in terms of technology diffusion and adoption.

Innovation system theory establishes the notion that technology diffusion takes place as both an individual and collective act (Nelson & Nelson, 2002 as cited by Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). The innovation system is made up of institutions, stakeholders and economic structures and moderates and determines the diffusion of an innovation into society through technological change (Hekkert et al., 2007). Scholars introduced and elaborated on a multi level approach to describe innovation systems as shown in figure 3 (Geels, 2002; Rotmans & Asselt, 2001).

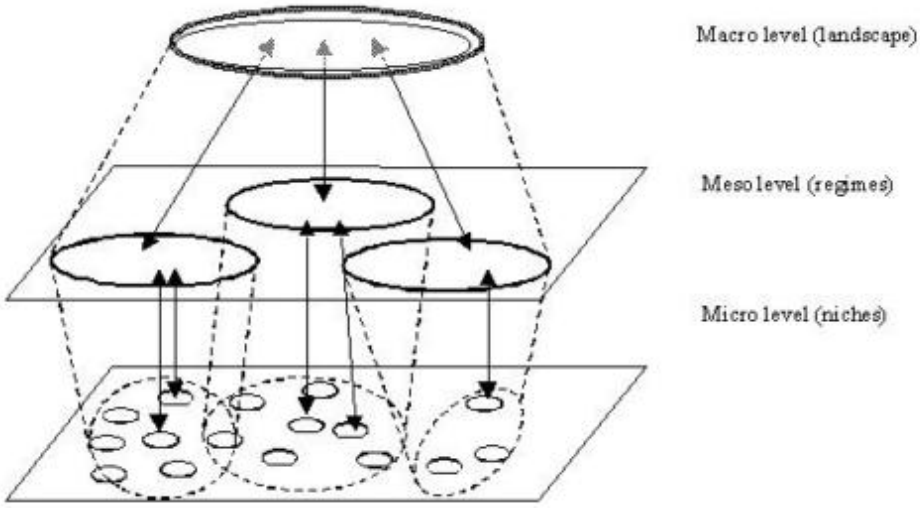


Figure 3: Multi level approach of innovation systems (Rotmans & Asselt, 2001)

The macro level, the *'landscape'*, consists of exogenous factors like economic growth, wars or oil prices and provides *"gradients for technological trajectories".* It only changes slowly and can hardly be influenced by individuals. The incumbent innovation system is labelled as *'regime'* – a *"rule-set"* of common practices with established technologies, infrastructures, firms and usage patterns. Firms are *'locked-in'* and constrained by these incumbent regimes. New innovations have room to diffuse into these regimes via niches which act as incubation rooms for emerging technologies. A large variety of technologies exists in these niches and whether or not they manage to emerge and change the existing regime is dependent on different factors on a societal as well as technological level. Scholars argue for a promotion of clean technologies on a policy level to create protected niches allowing them to diffuse (Cramer, Schot, Van Den Akker, & Maas, 1990; Schot, 1992).

Hence clean-technologies do not only compete with incumbent technologies but on a higher level with incumbent innovation systems and existing regimes. Clean-technologies are *"less an industry and more a theme"* (Parker & Youngman, 2009 as cited by Kshetri, 2012) which has the purpose of *"re-engineering an economy that has run on fossil fuels since the industrial age"* (Kshetri, 2012).

Thus it is argued that rather than simply promoting the replacement of a single technology by another one which is *"cheaper, simpler, smaller or more convenient to use"* (Christensen, Raynor, & Anthony, 2003), a whole innovation system needs to be in place for clean-technologies to disrupt

these existing regimes. Clean-technologies have to diffuse into, disrupt and finally replace existing regimes and energy systems which are characterized by three main attributes. They are large **(1)**, have large capital costs and long lifecycles **(2)** and are heavily regulated **(3)** (Hargadon et al., 2011).

1

Size

Being large means that these innovation systems are deeply entrenched in everyday life. Fossil fuels are used by every single individual on every single day. Hargadon et al. (2011) argues that the scale of technological change and investment needed to enable a socio-technological shift of such an enormous magnitude is simply too big for emerging ventures to address.

2

Capital costs and long life cycles

The existing regimes bind an unbelievably large amount of resources. Hargadon et al., (2011) estimates the global energy supply system to have a value of approximately $12 trillion. An even larger sum is argued to be bound in the global energy demand system which heavily relies on incumbent energy regimes (Hargadon et al., 2011). Transportation systems, consumer goods, manufacturing plants, residential buildings etc. are widely based on existing sources of energy. These "sunk costs" are already invested capital which somehow needs to be recovered for the investors within a certain time frame. Typical asset turnover times for these investments are as long as up to 80 years for buildings and usually 30-40 years for the energy supply system like refineries, mines etc. (Hargadon et al., 2011). A lock-in situation emerges as disrupting these systems would lead to massive losses of investment and thus faces large pressure from existing regimes. Kemp & Volpi (2008) stress that sunk costs favour end-of pipe solutions and adaption of processes rather than disruptive innovations.

3

Heavy regulations

Hargadon et al. (2011) argues that markets in which clean-technologies aim to diffuse in are usually heavily regulated. Especially in the European Union, the energy sector also show a high level of public ownership (Conway & Nicoletti, 2006). Subsidizing incumbent standards poses a heavy constraint to new technologies and ventures.

Following the definition of a *'start-up'* introduced earlier and the attributes of *'clean-technologies'* and *'high-technologies'*, it is argued that both clean-technology start-ups and other high-technology start-ups have the purpose to find repeatable and scalable business models under high uncertainty.

However, clean-technology start-ups additionally suffer from pressure of competitors in large incumbent innovation systems, high costs of capital and heavily regulated markets. While these factors may also apply to other high-technology start-ups, they inevitably play an important role in the context of clean-technology start-ups. Hence, clean-technology start-ups are expected to encounter additional barriers to success compared to other high-technology start-ups. Therefore, different strategic activities are argued to be necessary and additional support measures should be provided to make clean-technology start-ups successful. Within the boundaries of the mentioned factors, clean-technology start-ups often appear to be hardware start-ups bringing high-value physical products to the market.

2.2. Sustainability

In the first chapter of this thesis, the research context, the role of *'sustainable development'* towards a *'sustainable future'* was underlined. However, *'sustainability'* as a concept itself has multiple layers and can be interpreted from various perspectives. The Oxford dictionary defines the adjective '*sustainable'* as *"able to be maintained at a certain rate or level"*. This can refer to economic growth, level of natural resources or any other use of resources (Oxford Dictionary, 2013). In line with this definition, it was argued, that clean-technologies are technologies which enable sustainable development in means of providing *a 'human benefit'* by using less resources and causing less environmental damage than alternative, economically competitive means (Clift, 1995).

The general public often reduces the term sustainability to one dimension and usually associates it with environmental responsibility. However, this simplification is biased and it is important to make a distinction in the choice of the viewpoint and to define clear boundaries of the term '*human benefit'.* It is argued that different stakeholders naturally have different points of view (Adams, 2006). Hence, what is sustainable for an individual might not be sustainable at all for a group of people, a firm, an industry or society. While clean-technologies might be sustainable from the viewpoint of humanity as a whole, certain industries and countries would certainly disagree with that notion, fearing to lose their base of existence. A refinery as an example would most likely not agree that a ban of fossil fuels would be sustainable for its business operations or its employees. Porter (1980) for instance uses the term sustainability in the context of *"sustainable competitive advantage"* and therefore from the perspective of the firm. Hence the definition of sustainability for the purpose of this thesis needs further refinement.

The United Nations World Commission on Environment and Development (1987, p.37) defines sustainable development as a *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* in their proceedings *'Our common future',* often called the '*Brundtland report'.* The report introduces two main concepts.

1. *"The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given."* (United Nations World Commission on Environment and Development, 1987)

2. *"The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."* (United Nations World Commission on Environment and Development, 1987)

Following the definition of the report, sustainability therefore refers to the needs of the world and its society as a whole rather than the interests of individuals.

While the Brundtland report mainly focused on social and environmental issues, the 2005 World Summit extended the definition of sustainability by a third pillar. The *'World Summit Outcome Document'*, defines three *"interdependent and mutually reinforcing pillars"* sustainable development is based on. It is argued that sustainable development consists of an environmental, an economic and a social component from the perspective of humanity as a whole (United Nations, 2005). Similarly, the *'Club of Rome'* defines sustainable development in its program *'A New Path for World*

Development' as a system of *"Environment and Resources"*, *"Globalisation", "International Development", "Social Transformation"* and *"Peace and Security"* which is fundamental for *"humanity to surmount the challenges ahead"* (Club of Rome, 2012).

Following these argumentations, the use of the term '*sustainability'* in this thesis refers to *"the ability to meet the needs of the present without compromising the ability of future generations and humanity as a whole to meet their own needs from an environmental, social and economical perspective"*. Hence the perspective taken in the thesis is from the position of society as a whole rather than from an individual viewpoint.

2.3. Start-up success, new venture performance and strategy

2.3.1. Start-up success

Whether a new venture performs well or not and which metrics are used to measure its success and performance is highly subjective and subject to discussion. Gartner, Starr, & Bhatt (1998) analyzed predictors of new venture success commonly used by reporters, journalists and venture capitalists to predict success of new ventures. They found that expert perceptions of certain factors and circumstances, determining the success of a start-up, are highly subjective and often not generalizable. They often depend on subjective definitions of what success means in the first place and merely represent rules of thumb or general rules. Academic and popular literature therefore identified a large amount of success factors of start-ups (e.g. Bantel, 1998; Chrisman & Hofer, 1998; Duchesneau & Gartner, 1990; Hitt & Bierman, 2001; Hormiga, Batista-Canino, & Sánchez-Medina, 2010; Roure & Keeley, 1990; Sandberg & Hofer, 1987; Simpson, Tuck, & Bellamy, 2004; Song, Podoynitsyna, Van Der Bij, & Halman, 2008; Stein, 2012; Stuart & Abetti, 1987; Unger, Rauch, Frese, & Rosenbusch, 2011). Four different theoretical frameworks to explain the performance of new ventures by taking the sum of these factors into account have emerged in literature (Cleyn, 2011).

1 ***Resource based theory***

The *'resource based theory'* (RBT) states that a firm can only achieve a sustainable competitive advantage (and a high new venture performance) if its resources are valuable, rare, inimitable and non-substitutable (e.g. Peteraf, 1993, Barney, 1991).

2 ***Human capital theory***

The *'human capital theory'* (HCT) poses that the performance and success of a new venture is a function of firms' knowledge, skills and experiences. These are bound in its human capital - the entrepreneur and the people who work there. Human capital, following this definition, can be changed by adding specific knowledge or skills through education and training or by changing the team.(e.g. Bosma, van Praag, Thurik, & de Wit, 2004, Unger et al., 2011). It was argued that human capital is, after all, another resource with the attributed defined in the resource based theory (Hitt & Bierman, 2001).

3 ***Social capital theory***

The third theoretical framework is the *'social capital theory'* (SCT), arguing that a firm's performance is dependent on a firm's network surrounding it (e.g. Adler & Kwon, 2002, Davidsson & Honig, 2003). Cleyn (2011) argues that the difference between RBT, HCT and SCT is that while RBT and HCT are focusing on firm internal factors, SCT looks at the actor

network surrounding the firm. Social capital theory plays an important role in incubator research as it is one of the three main functions an incubator provides.

Life cycle model

4 The forth and last theoretical framework around venture performance is the *'life cycle model'* (LCM), which argues that the needs of a firm change throughout its lifetime (Cleyn, 2011).

In academic literature *'survival'* is argued to be the main success criteria of a start-up (Sandberg & Hofer, 1987; Duchesneau & Gartner, 1990; Chrisman & Hofer, 1998, Gartner et al., 1998). Furthermore start-up success is also associated with *'return on equity'* (ROE) and *'profitability'* (Sandberg & Hofer, 1987), *'growth'* (Duchesneau & Gartner, 1990) and closely related to *'graduation rates from incubation programs'* (Peters et al., 2004). All definitions have in common that the success of a start-up is directly dependent on the performance of a start-up, in this thesis defined as *'new venture performance'* (NVP).

2.3.2. New venture performance

A start-up's performance on bringing technologies to the market and, after all, whether it is able to contribute to a sustainable future, is measured by *'new venture performance'* (NVP) (Sandberg & Hofer, 1987). Sandberg and Hofer argue that NVP is the result of an entrepreneur with specific traits, skills experiences and hence unique behaviour and decisions who strategically positions technology in a market within an industry of a certain structure. Hence, Sandberg and Hofer introduce the notion that NVP is a function of '*industry structure'* **(1),** *'the entrepreneur'* **(2)**, and *'strategy'* **(3)**. They observed that when interacting with each other, the three factors had a far greater impact as when in isolation. They also found *'industry structure'* to be the single most influencing factor when looked upon exclusively. Similarly, *'strategy'* was observed to have a significantly higher conditional than non-conditional impact and therefore to a large extend dependent on the other factors. Other scholars introduced two additional aspects influencing NVP. The *'organizational structure'* **(4)** and *'resources'* **(5)** in terms of tangible and intangible resources were introduced, yet not tested, as factors on NVP by Chrisman and Hofer (1998). Chrisman and Hofer also suggest that these factors are heavily dependent on each other.

Industry structure

1 Industry structure, following Sandberg and Hofer's definition, pictured the evolution stage and the equilibrium conditions of an industry, the sector of economy, barriers to entry into an industry (including economies of scale, product differentiation, network effects, availability of distribution channels, and size independent cost advantages) and product and firm heterogeneity within and industry (Sandberg & Hofer, 1987).

Entrepreneur

2 Sandberg and Hofer define *'the entrepreneur'* not as a person, but as a set of *'entrepreneurial characteristics'* consisting of prior entrepreneurial and start-up experience, managerial experience in related industries, age and education (Sandberg & Hofer, 1987). Chrisman et al. (1998) extended that picture by adding unique behaviours, values and decision making by an entrepreneur to this dimension. This, adding up to a part of the personality of an entrepreneur, is argued to have a direct and indirect influence on

NVP (Chrisman & Hofer, 1998).

Strategy

3 The term *'strategy'* in Sandberg and Hofer's work refers to means to achieve a competitive advantage over firms' competitors, rather than being explicitly defined by listing a set of specific activities leading to a higher NVP (Vesper, 1980; Porter, 1980 as cited by Sandberg & Hofer, 1987). They distinguish between *'focused strategies', 'differentiated strategies'* and *'undifferentiated strategies'* and observed strategy to be a function of the circumstances around a venture and the entrepreneur in terms of NVP. They state that *"it [strategy] all depends on the circumstances"* (Sandberg & Hofer, 1987).

Organizational structure

4 In the term '*organizational structure',* Chrisman and Hofer (1998) refer to the hierarchy of a venture, how it is controlled and owned and how flexible it is on terms of hiring, compensation and implementation of new structures and processes.

Resources

5 In general, it is to be distinguished between tangible and intangible resources. While tangible resources usually refer to capital or infrastructure, intangible resources are human capital, entrepreneurial skills and experiences and networks (Chrisman & Hofer, 1998).

The model introduced by Sandberg, Chrisman and Hofer shows parallels to the four theories of new venture success as introduced in chapter 2.3.1. While resources can be associated with RBV and HCT in terms of tangible and intangible resources, strategy is acknowledged to transform throughout the life cycle of the start-up (LCM). The Entrepreneur, organizational structure, industry structure are covered by the human and social capital theories (HCT, SCT). As shown in figure 4, resources, industry structure, strategy, organizational structure and the entrepreneur were observed to have both a conditional and direct effect on NVP. The five factors represent the context of a new venture – the dimensions of the space which determines the performance of a new venture. The dependence of the factors on each other implies the complexity of forecasting NVP.

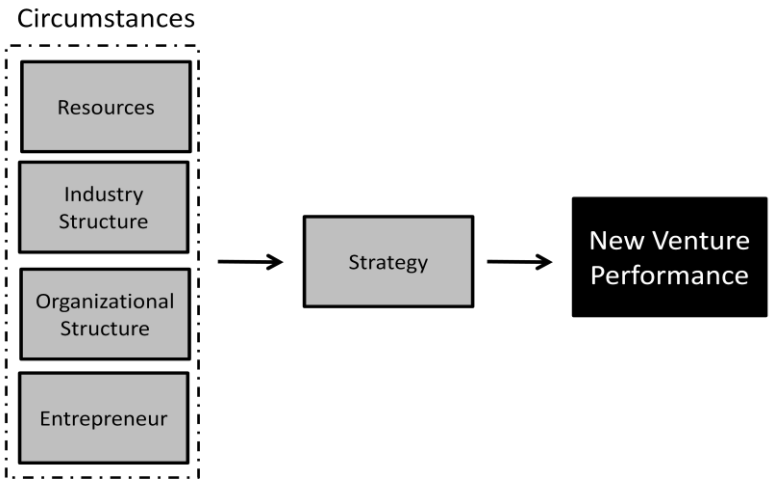


Figure 4: Conceptual framework of new venture performance (derived from Chrisman & Hofer (1998))

2.3.3. Start-ups and strategy

Sandberg & Hofer (1987) rely on the definitions of Porter (1980) and Vesper (1980) in their use of the term *'strategy'*. Strategy in that sense refers to means to achieve a competitive advantage over a firm's competitors. Porter argues that choosing a *'strategy'* means to choose a unique set of activities and execute them in a different way than competition does in order to deliver a unique set of values. He induces that the choice of activities depends on the (unique) circumstances a firm is in, representing its *'context'*, as shown in figure 5. This argument is in accordance with the earlier introduced direct and indirect relation between the context of a start-up and NVP.

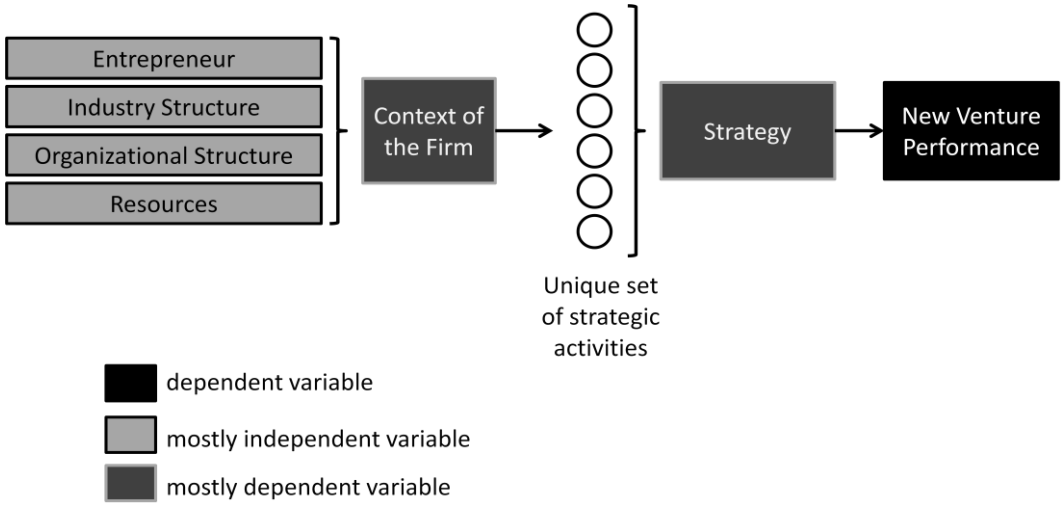


Figure 5: Causal relation between start-up context, strategy and NVP

A unique choice and execution of strategic activities, fitting the context of the venture, enables firms to take a unique and competitive position in the market (Porter, 1996). Indeed, also Sandberg and Hofer (1987) observe strategy to be a function of the *'circumstances'* around a venture and the entrepreneur in terms of NVP as argued earlier. Scholars like Moore (1991) tried to define these '*circumstances*' in more detail, thus shaped concepts like *'the valley of death'* or *'the chasm'* describing explicit contextual scenarios with specific challenges and barriers to success. Moore (1991) argues that, even though strategic activities have to be unique, specific groups of activities have to be paid special attention to in order to being able to meet the challenges posed in these contexts. Furthermore, Porter (1996) argues that *"strategic positions can be based on customers' needs, accessibility or the variety of a company's products or services".* Similarly, most of the strategic activities defined by Moore and others are based on understanding the customer and, based on that, creating a set of products or services offering unique value to satisfy the customer needs. Following the argumentation above, choosing the *'right'* strategic elements leads to a competitive advantage and ultimately to success.

2.4. New venture context and strategic decision making in start-ups

2.4.1. Start-ups and the entrepreneur

Following the definition of a firm (Penrose, 2009) and a start-up (Blank, 2010; Graham, 2012a; Strategic Planning Institute, 1978) as introduced earlier in this thesis, the start-up as an entity is the legal and organizational vehicle the entrepreneur uses to explore and exploit opportunities. The start-up as an organisation faces challenges due to elements in its context (Sandberg & Hofer, 1987; Chrisman & Hofer, 1998) but the entrepreneur is the one who perceives them as such and chooses

certain strategic activities to overcome them (Porter, 1996). Even though the main interest of this thesis is the success of the start-up itself, it becomes clear that the entrepreneur as decision maker determines the process of growth of a start-up. The decisions of the entrepreneur are dependent on how he perceives the context of the start-up and he acts according to his ability to interpret the set of contextual elements. Therefore, in order to understand how start-ups are successful, it is important to pay special attention to the subjective perceptions and actions of the entrepreneur who consequently becomes the unit of observation.

2.4.2. New venture context

In the previous sections it was argued that NVP determines whether or not a start-up is successful and that NVP is dependent on the interactions between different factors. The sum of the factors introduced in chapter 2.3 is argued to make up the *'context'* of a start-up for the purpose of this thesis. As introduced earlier, academic literature often labels *'context'* as *"circumstances"* (Porter, 1996; Sandberg & Hofer, 1987) or environment (Aldrich & Pfeffer, 1976; Aldrich, 1979; Aldrich & Martinez, 2001; Gartner, 1985) The four factors build the cornerstones of this space and contain a large variety of different elements moderating the context of a start-up and the strategic decisions of the entrepreneur as exemplarily shown in figure 6. Even though the combination of these factors is essentially unique for every start-up, correlations of patterns amongst start-ups are a sign of similar contexts and explain shared success barriers, constraints or challenges. An analogy to the transition of innovation systems can be observed. While some of the factors determining the context of a start-up, hence moderating NVP, are on a regime or landscape level and can therefore hardly be changed (Rotmans & Asselt, 2001) others can easily be influenced.

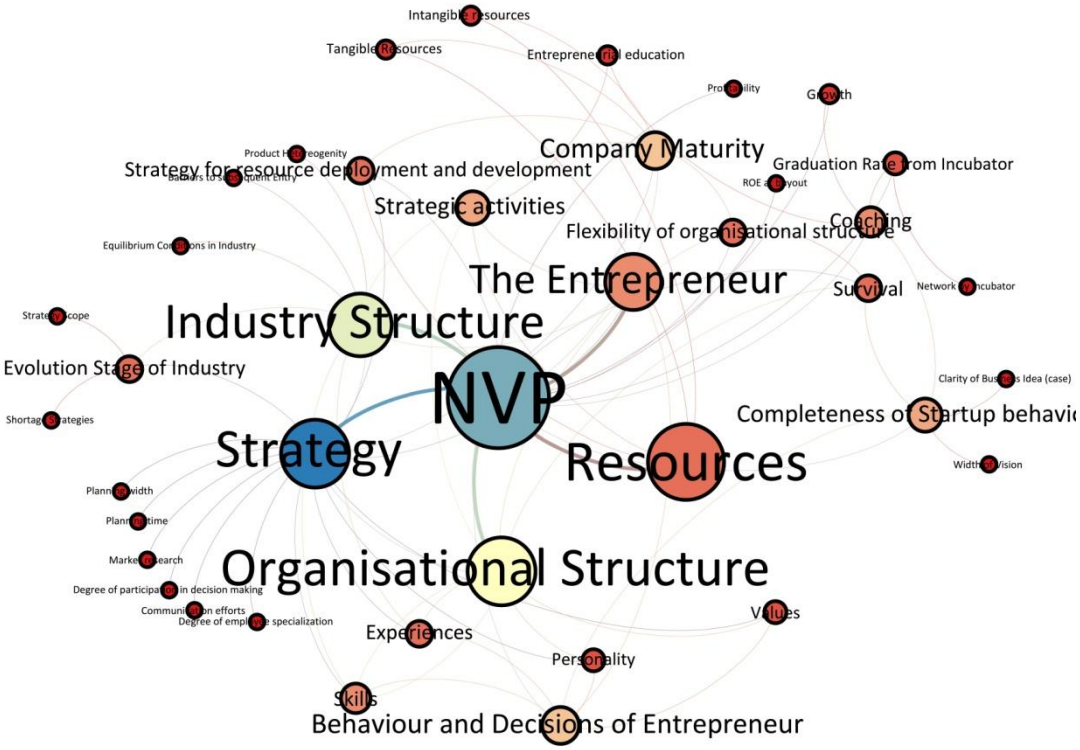


Figure 6: Complexity of factors in the context of a start-up – exemplarily network

The first refer to factors which are exogenously given. Examples for these exogenous factors are for instance market and industry dynamics like commodity prices as well as most demographics and traits of the founders. These factors play a crucial role in moderating the context of a start-up. While

they can hardly be influenced, it is still possible to anticipate their moderating effect on the outcome and take this into account when taking strategic decisions.

The latter refer to factors which can easily be influenced by the entrepreneur or other stakeholders. Policy makers can enhance the development of innovation systems or a stronger network between important stakeholders can positively influence collaboration between start-ups. Tailored education can be provided and target the specific needs of entrepreneurs in niches or team members can be added to bring important skill sets on board. Funding for specific industries can be stimulated on a policy level as well as by creating a stronger network of investors for specific industries etc..

Hence, the context of a new venture is defined as the sum of factors influencing perceptions, behaviour and environment of the firm. Following the argument that start-up success is dependent on NVP as a function of the context of a start-up, complete control over all factors in the context would allow for control over the success itself. Obviously complete control is merely a theoretical game of thought. However, it becomes clear that even having control over a few important sub-elements of the context of start-ups may already have a significant impact on their success.

Based on the notion that firms might share elements in their context and therefore also encounter similar challenges, it is argued that when comparing perceived challenges of entrepreneurs certain groups of start-ups should emerge.

2.4.3. Strategic decision making in the context of a start-up

It is widely argued that decisions are taken under the aspect of value maximisation (e.g. Simon, 1959). However, subjective perceptions of '*value'* play an important role in taking complex decisions. The *'economic man',* always taking rational decisions in the light of full information (as for instance noted by Edwards (1954)) is a generalization rather than a realistic scenario. Following from this argument it is concluded that decisions are rational but taken based upon available information, values and preferences and in the light of the context of the decision maker. Decisions are dependent on how the context in which they are taken is perceived, thus being subject to the concept of *'bounded rationality'* and *'subjective choice'* and limited by the cognitive abilities of human beings (March, 1978).

Same accounts for strategic decision making – decisions made upon the choice of strategic activities (Papadakis, Lioukas, & Chambers, 1998) taken under the aspect of value maximisation. Thus the entrepreneur's perception of the context - or circumstances and environment - of a firm has a moderating effect on how he takes strategic decisions. Choosing certain strategic activities is influenced by available information and the context provided by the start-ups environment and how information and context are perceived by the entrepreneur. If for instance an entrepreneur encountered a specific challenge and made the experience that a certain strategic activity allowed him to successfully overcome it, he tends to use similar measures again when he believes to encounter a comparable challenge. However, this approach is subjectively influenced by the experiences the entrepreneur made in the past (Smith, 1998) and applying the same activity again might not be suitable anymore when looking at the context of the start-up and the challenge as a whole.

2.5. Challenges and challenge perception in high-technology start-ups

Challenges, often referred to as constraints, are barriers in the context of a start-up which hinder the entrepreneur and his start-up from being successful (Sandberg & Hofer, 1987, p. 9). Constraints can arise in different dimensions, usually related to tangible and intangible resources like financial capital, human and social capital or knowledge and change throughout the life cycle of a start-up (Cleyn, 2011; Van Weele, 2012).

2.5.1. Common challenges in high-technology start-ups

A literature review on different success barriers and common challenges in the context of high-technology start-ups was conducted. The goal of the literature review was to identify a wide range of potential success barriers and constraints and to establish a list of challenges high-technology start-ups potentially face. It was tried to cover as much of the spectrum of challenges as possible to make sure that all potential viewpoints were accounted for following the mutually exclusive – collectively exhaustive (MECE) approach. From the conducted literature review, a list of challenges was derived. The challenges were aggregated and disaggregated using different sources which gave similar implications on specific factors and challenges. The identified statements were subsequently paraphrased into sentences to make them easier to understand and to reduce ambiguity. Appendix A1 shows the identified factors from the literature review.

The extracted challenges can be attributed to five identified dimensions. These were constituted by the different theoretical frameworks of start-up success (Cleyn, 2011) and NVP (Chrisman & Hofer, 1998; Sandberg & Hofer, 1987) and the attributes of high-tech products (Mohr et al., 2009) as introduced in chapter two of this thesis. Affiliation to each group was based on implicit information in the literature and several exploratory interviews conducted with industry experts, entrepreneurs and scholars. The dimensions represent groups of viewpoints which are supported by several different perceived challenges.

1 ***Technological uncertainty***

"Technical uncertainty" refers to challenges associated with technological development and validation, product development and technological knowhow and knowledge.

2 ***Market uncertainty***

The dimension *"market uncertainty"* contains challenges posed by uncertainty in customer preferences and concentration, market dynamics, regulatory frameworks and market attributes.

3 ***Lack of financial resources***

Lack of financial resources summarizes challenges in cash flow, fundraising, investor concentration and legitimacy to investors.

4 ***Lack of human capital***

Lack of human capital refers to firm internal challenges posed by lack of skills and experience in the team, organizational legitimacy, difficulties in hiring employees and conflicts in the team.

Lack of social capital

5 Lack of social capital refers to firm external challenges in the firm's network like lack of entrepreneurial peers, access to training and coaching and access to labour markets.

2.5.2. Challenges versus challenge perception

As introduced in chapter 2.4.3, strategic decisions taken by entrepreneurs in order to overcome challenges are rational but based upon the entrepreneurs' perception of his context. Decisions are therefore subject to the concepts of bounded rationality and subjective choice (March, 1978). Hence the entrepreneur's perception of challenges does not necessarily reflect the actual challenges and vice versa. However, the entrepreneur will only deal with challenges he perceives as such as he as a human is by definition limited by his cognitive abilities (March, 1978).

While some challenges, the ones with a lower potential impact on the success of a start-up, often allow to be neglected, other challenges pose a significant risk to the firm when not met appropriately. Overcoming these challenges requires problem solving skills which differ from situation to situation, are applied systematically and can be learnt (Jonassen, 2000). Efficient and effective problem solving combines an analytical approach with creative thinking. Different problems and challenges require different measures to overcome them. Jonassen (2000, p. 82) argues that *"articulating a set of strategies to support problem space construction is the focus of future research"*. Following this argument, defining and understanding the problem space is a precondition to systematically overcome challenges. Understanding moderating effects on constraints of start-ups and learning on how to anticipate and overcome them represents a great challenge on its own.

It is widely argued that different types of high-technology and clean-technology start-ups suffer from different barriers compared to each other and to other start-ups (e.g Bishof, 2012, Dixon, 2013, Stangel, 2013) as important elements in their respective contexts are fundamentally different. Furthermore, it was brought forward that the field clean-technology confronts the entrepreneur with a specific set of elements, thus making up a context by itself (Coenen & Avdeitchikova, 2011). Hence, it is hypothesised that challenges clean-tech entrepreneurs face are similar as the contextual elements are similar as well. Following this argumentation, similar mechanisms are also expected to be in place between different other subgroups of start-ups which share contextual elements. If that is the case, *'challenge profiles'* of start-ups sharing these elements should emerge. However, how exactly high and clean-technology entrepreneurs perceive their context, how exactly the challenges they face look like and whether or not they also prioritize challenges differently than entrepreneurs in other start-ups is yet to be investigated. Furthermore no research has been done whether or not factors like being part of an incubation program have a moderating effect on these perceptions as shown in figure 7.

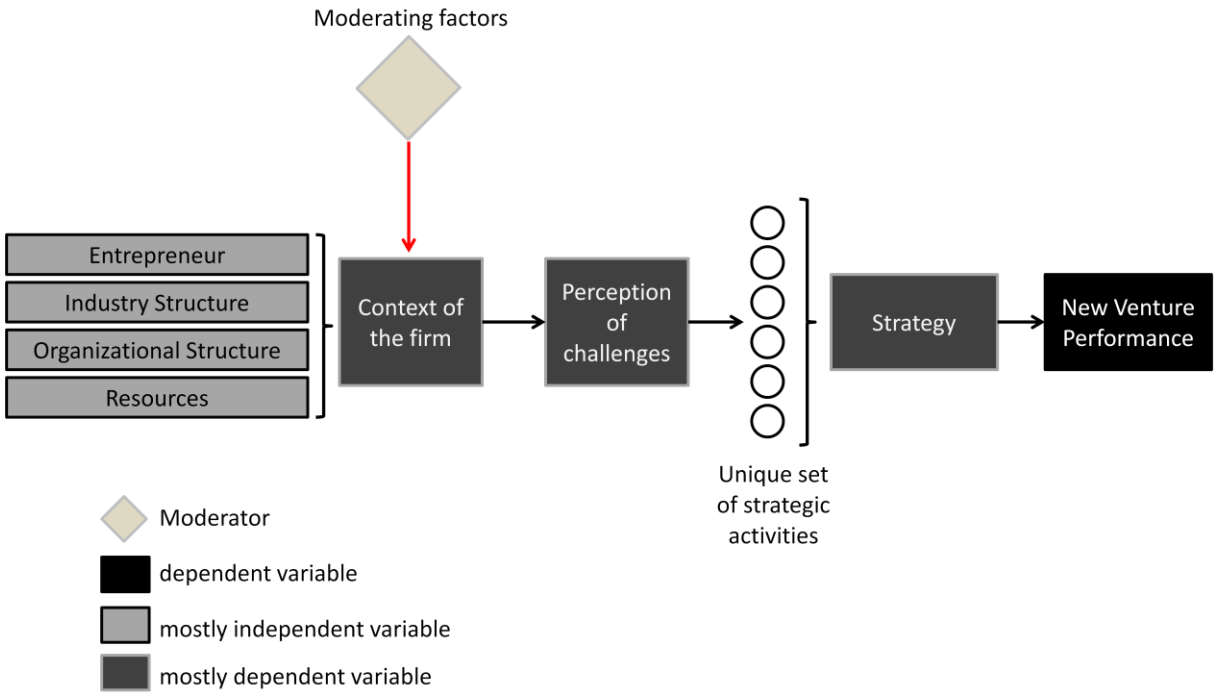


Figure 7: Influence of moderating factors on perception of a firm's context – conceptual model

Following Sandberg & Hofer's notion that "*strategy is dependent on circumstances*", it is unclear how specifically challenges posed by the context of the start-ups are perceived by entrepreneurs in different parts of the high-technology and clean-technology sector. Furthermore a relation between factors like incubation programs influencing the perception of challenges for high-technology start-ups has not been established thus far.

2.6. Incubation programs

Incubation programs have the aim to support the entrepreneur in the entrepreneurial process from idea generation and opportunity recognition all the way to building a successful business and realizing the rewards (Peters et al., 2004). Incubators exist in different forms, shapes and can be found under names like accelerators, innovation facilitators, pressure cookers etc. Incubators can be part of large corporations to serve the firms innovation pipeline or act independently. They can be for-profit, not for-profit and university based (Peters et al., 2004). However, all these constructs serve the purpose to increase the success rate of start-ups end enhance the innovation capacity of its firms. While incubators were originally often referred to being merely more than a shared office building, nowadays they influence start-ups in several dimensions. Incubators support the development of technology based start-ups by providing technological, business and social input (R. Miller & Marcel, 1987). Peters describes the functions of an incubator as providing *"infrastructure, coaching and network"* to the entrepreneurs to accelerate the growth of the firm by *"effectively linking talent, technology, capital and know-how"* (Peters et al., 2004), thus providing the entrepreneur with different resources. These tangible or intangible resources are used to overcome constraints or challenges the entrepreneur encounters. Thus, incubation programs are an example for an element which considerably moderates the context of a start-up. The role of incubation programs is to guide the entrepreneur through the first phase of venture creation and to position and equip him with the right knowledge to successfully control this process.

Van Weele (2012) found that the needs and perceived constraints of incubated entrepreneurs shift from being focused on tangible resources (e.g. physical or financial resources) towards intangible resources like human and social capital during a start-ups life-cycle. According to van Weele, incubator strategies focus on providing these intangible assets in order to help the start-ups to realize a competitive advantage. He found that the strategies of an incubator cannot follow *a "one size fits all approach"* as they are subject to, and strongly influenced by, the different natures of the start-up's contexts. He argues that the factors surrounding the resource constraints of entrepreneurs are of utmost importance as "*the rational boundaries of entrepreneurs impedes them from developing and acquiring those resources that are crucial for gaining a competitive advantage"*. According to Van Weele, solely looking at resource constraints perceived by the entrepreneurs only provides a static picture, neglecting influencing factors and dynamics around the resources. Hence, he suggests that incubation managers should not follow a demand driven approach when trying to satisfy the entrepreneurs' needs but rather to guide them through the early stages (Van Weele, 2012).

However, this suggestion is based on the hypothesis that incubation managers do exactly know what the needs of the incubated start-ups and entrepreneurs are. To satisfy this condition, it is required to understand the surrounding factors and how they influence potential resource constraints. Trott, Scholten, & Hartmann (2008) even go as far to argue that incubators can hamper the success of start-ups (in the case of their study university spin-offs) if they focus too much on certain aspects of support. When suggesting measures to incubators on how to support their start-ups, advice has therefore to be communicated in a sensible way.

2.7. Summary and conceptual model

In part two of this document several important key points were made. Based on academic literature, a high-technology start-up was defined as *"an organization in the first period of its existence, searching for repeatable and scalable business models in markets with high growth potential"* operating in an environment which is subject to *"technological and market uncertainty and competitive volatility".* A distinction has been made between hardware, software and service start-ups and the hypothesis that they are fundamentally different and suffer from different barriers to success due to their dissimilar context was introduced. While hardware start-ups rely on physical products and usually suffer from high marginal unit costs and long product development cycles, software start-ups often manage to capture network effects and positive feedback loops in their value creation. Service start-ups provide their products or services on a flexible, usually per-use or on a temporary basis. It was pointed out that firms with business models relying on combinations of hardware, software and services often manage to mitigate the downsides of each and achieve a strong competitive position.

The concept of clean-technology start-ups, a subgroup of technology and high-technology start-ups often being high-value hardware start-ups, was introduced. Clean-technologies are referred to as *"technologies of different sectors like renewable energies, recycling, IT, transportation or chemistry which use innovative ways to cause less environmental damage than alternative means, compete with them on the market place and aim to diffuse into and ultimately replace existing regimes and innovation systems"* for the purpose of this thesis. Clean-technology start-ups suffer from similar issues as high-technology start-ups and usually face and compete in large innovation systems with high capital investment which are heavily regulated.

The success of a new venture was found to be dependent on new venture performance and thus on how effectively the entrepreneur overcomes challenges in the context of the start-up by choosing certain strategic activities. The entrepreneur as decision maker in these start-ups was argued to trying to choose the *'right'* strategic activities to successfully overcome these challenge. However, it was argued that challenges need to be explicitly perceived as such before being overcome. An offset between actual challenges and perceived challenges was argued to be present. As the context of a start-up was found to moderate the perception of challenges it is also argued to moderate the choice of strategic activities. Awareness of one's challenges is therefore a prerequisite of choosing the appropriate strategic response.

This context was argued to *'depend on the circumstances'* and defined as the sum of factors influencing perceptions, behaviour and environment of the firm. Factors in the context of a start-up were identified as being moderators on which challenges entrepreneurs face and how they perceive them. Different demographic parameters of the start-up and the entrepreneurs, industry characteristics and dynamics and economic factors were introduced as exemplary factors. The role of incubators as being institutions which play an important role in shaping these factors has been further elaborated on. It was argued that start-ups with similar contextual elements also face similar challenges. Figure 8 shows two firms which have similar elements in their context and therefore share similar challenges. As they suffer from similar challenges, certain strategic activities will be beneficial for both of them. Identifying which start-ups are similar to each other and why they face similar challenges enables entrepreneurs to anticipate challenges and certain strategic activities and to choose appropriate support measures.

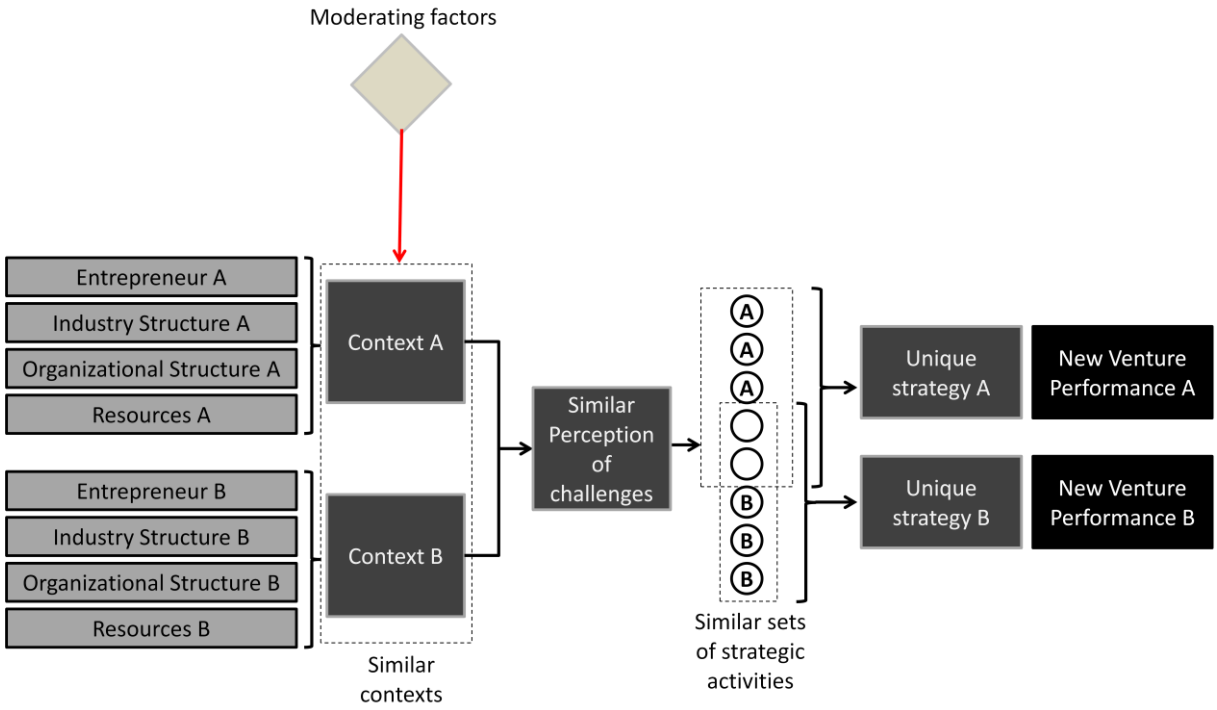


Figure 8: Similar challenges of start-ups with similar context

3. Propositions, research methodology and research design

On the basis of the research questions introduced in chapter one and the literature review of chapter two, Q-methodology was identified as suitable methodology. After elaborating on the suitability of Q-methodology to answer the research questions, several propositions and presumptions are formulated based on the research questions and the presented theoretical model. The steps followed during the research are laid down by introducing the chosen research framework and the design of the research. Subsequently it is further elaborated on the research methodology by introducing the chosen research methods.

Special emphasis is laid on the application of Q-methodology and the theoretical background, the development and the practical application for the purpose of this thesis. After a theoretical overview over Q-methodology, it is elaborated on the development of P-set, concourse, Q-set and the Q-sorting process itself.

3.1. Connecting research questions and research methodology

Based on the presented literature and theoretical background on start-up success, challenge and context perception and entrepreneurial decision making, it is argued that the key to supporting start-ups is to explore and understand what challenges entrepreneurs encounter and how they deal with them. To do so, it is crucial to pay attention to the subjective opinions of the entrepreneur. It was shown that entrepreneurs take their strategic decisions based on their personal perceptions of the challenges they aim to overcome rather on objective factors presented by academic literature. Hence, to understand what challenges high-technology and clean-technology start-ups generally encounter it is required to explore if shared subjective viewpoints - common challenges - in the perceptions of challenges emerge from the population of high-technology and clean-technology entrepreneurs.

Q-methodology satisfies these requirements as it aims to explore shared opinions on a topic by correlating arrays of statements. Factor analysis is applied and reveals shared views of subgroups of the sample, thus providing initially independent viewpoints a quantitative foundation. Following the argument that start-ups with similar contextual elements also share certain challenges, different common challenge profiles of start-ups are expected to emerge. Subsequently interpretation of the factors aims to find objective reasons why these shared viewpoints emerged which gives the statements an objective meaning. From initially subjective opinions, shared viewpoints based on objective facts emerge, allowing the researcher to draw conclusions on what challenges high-technology and clean-technology entrepreneurs face.

3.1.1. Propositions

Based on the research context, several research objectives and questions emerged. The theoretical background on start-up success, challenges and the context of start-ups aimed to introduce a conceptual model to explain why different types of start-ups encounter different challenges. The theory that challenges, and how they are perceived, are dependent on elements in the context of a start-up was introduced. As argued in chapter two, there are countless elements making up the context of a start-up, moderating challenges and challenge perceptions of start-ups. However, some are expected to be of larger importance and some can be steered and influenced easier than others.

In chapter 2.4 it was argued that belonging to a specific industry has an impact on the elements influencing the success of start-ups as the context of these start-ups is similar. Hence, entrepreneurs in hardware, software and service start-ups are expected to encounter different challenges due to their contextual differences. As introduced in chapter one, research question one **(Q1)** aims to identify general challenges of high-technology and clean-technology start-ups. Research question two **(Q2)** aims to throw light on differences between different industries and types of start-ups and tries to identify certain elements in the context of a start-up which lead to a certain challenge profile. Following from research question two and the theoretical background of clean-technology and high-technology start-ups, proposition one **(P1)** and two **(P2)** are introduced:

P1: There is a difference in challenge perception and prioritization between entrepreneurs in clean-technology start-ups and other high-technology start-ups.

P2: There are differences in challenge perceptions between entrepreneurs in hardware, software, service start-ups due to their different contexts.

Based on the theoretical model introduced in chapter 2.7, proposition three **(P3)** is introduced:

P3: Entrepreneurs in start-ups with similar context perceive similar challenges.

If P3 is valid, it is expected that groups of start-ups emerge from the Q-sorting and that these groups share certain contextual elements. While the groups may suffer from different challenges, the challenges within the groups are homogeneous and occur due to similar reasons.

3.2. Research design and research planning

3.2.1. Research Design

Based on the introduced model shown in figure 8, the perceived context of start-ups was investigated and subjective perceptions on challenges were to be explicit. Subsequently, perceptions of entrepreneurs in different high-technology and clean-technology start-ups were compared, analyzed and interpreted. The research strategy chosen for this thesis is shown in figure 9.

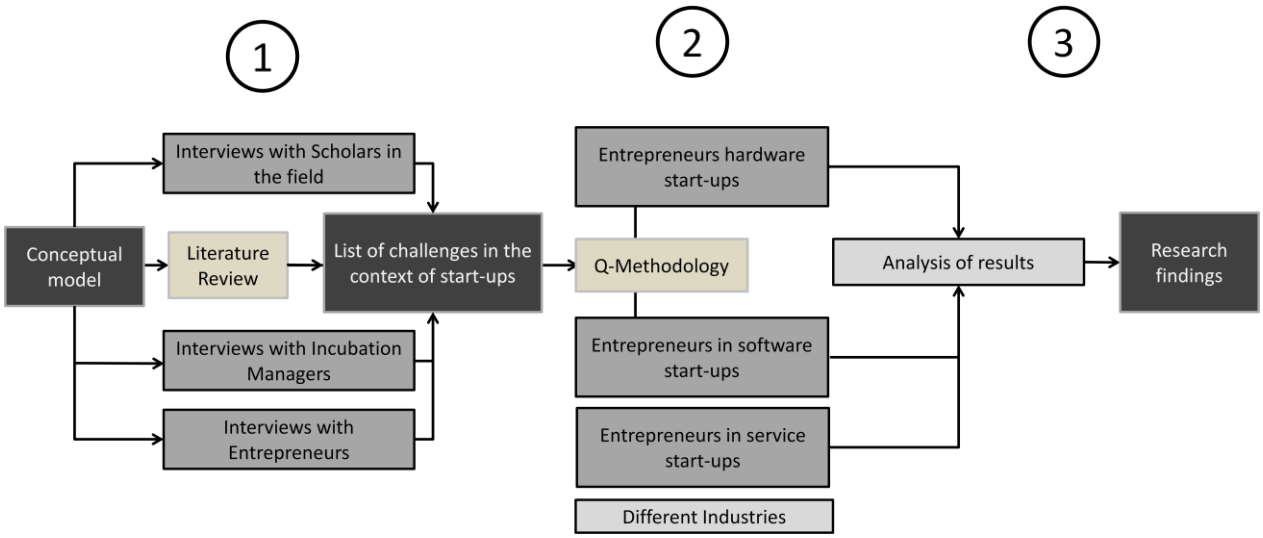


Figure 9: Research strategy

The research strategy consisted of three subsequent steps. First, a set of exploratory interviews was conducted to together with an in-depth literature review develop a representative set of statements **(1)**. This set was made up of statements concerning challenges in the context of the start-ups and can be found in appendix A1. The statements were subsequently iteratively tested with entrepreneurs in high-technology hardware, software and service start-ups in different industries inside and outside of incubation programs. Special emphasis was laid on clean-technology start-ups as argued in the introduction of this thesis. Looking at high-technology start-ups from different industries and with different products and business models was expected to reveal whether or not there are significant differences in challenges imposed by their respective contexts **(2)**. The results were analyzed, thus drawing a picture of the perceived challenges posed by the start-ups' context **(3)**.

3.2.2. Research planning

The activities which were to be performed to achieve the research objectives were laid out and deliverables for each step were defined. Following Verschuren & Doorewaard (2010), an iterative-parallel research approach was chosen, meaning different activities were to be carried out simultaneously. This for examples refers to immediate evaluation and analysis of interviews and an ongoing documentation process for the final report throughout the whole thesis project. It was expected that this process, containing several feedback loops, will enable the author to optimize his learning curve and utilize the time in the best way possible by using idle times to work on the documentation. A continuous and detailed documentation process conducted from the beginning forced the author to make lines of thought explicit and was expected to help in evaluating and reassessing obtained information. Figure 10, following Verschuren & Doorewaard (2010), shows the sequence of the planned activities needed to satisfy the research objectives of the thesis.

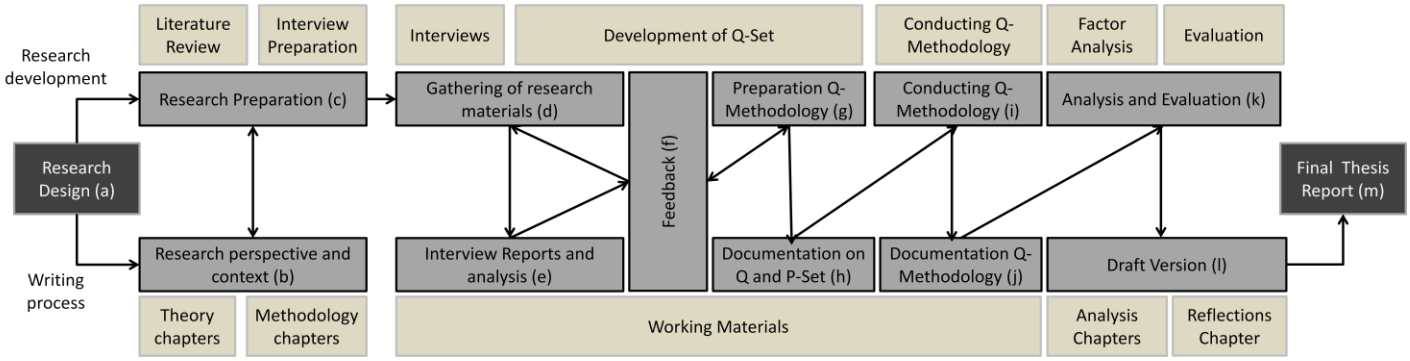


Figure 10: Research activities

Phase **(a)** reassessed the draft research design from the research proposal. This step was conducted in collaboration with the supervisors and is concluded with milestone M1, the kick-off meeting, resulting in deliverable D1 the final thesis proposal. Subsequently it is distinguished between documentation activities (the writing process) and research activities (research development).

Phase **(b)** and **(c)** were conducted simultaneously. They included an extension of the research context of the thesis proposal, conducting a literature review and resulted in an interview methodology. In this phase it was also worked on the theory and methodology chapters for the final report. In phase **(d)**, a number of interviews with entrepreneurs, scholars and incubation managers were conducted. These had an exploratory nature, aiming to reveal perceived context and challenges. Based on the interviews and the literature review the Q-set was developed iteratively in phase **(g)** and explicitly documented in phase **(h)**, constituting deliverable **D2**, the Q-set and the P-set. Phase **(h)** ended with milestone **M2**, an intermediate progress meeting between the author and the supervisors. Subsequently Q-methodology was conducted in phase **(i)**, documented in phase **(j)** and analyzed in phase **(k)**. Phase **(l)** provided deliverable **D3**, the draft report and ended with milestone **M3**, the green light meeting. After the green light meeting the draft report was revised, finally delivering the final thesis report, deliverable **D4**. The thesis defence constituted milestone **M5**.

3.3. Research methodology – Q-methodology

The research methodology used in the thesis is a combination of an in-depth literature review, exploratory interviews and Q-methodology. In this part of the thesis the choice of this methodology is justified and elaborated on, a short introduction into the methods is given and the research population and sample are defined. Emphasis will be laid on the application and practicability of Q-methodology for the purpose of the thesis. The application of the literature review and the exploratory interviews to establish a set of statements (Q-set) for Q-methodology will be justified and elaborated on.

Q-Methodology gives insights in subjective viewpoints, opinions, believes and values of people and is therefore *"the systematic study of subjectivity"* (Brown, 1993). It gives the respondents, the P-set, a number of subjective statements to be ranked according to their personal preference or judgement. Doing so, it is argued that they give subjective meaning to the statements and share their viewpoints and opinions (Van Exel & de Graaf, 2005). Rather than imposing an opinion on the respondents, Q-methodology lets the participants themselves determine what is meaningful and valuable from their personal, subjective perspective (Ward, 2009). Q-methodology is based on the argument that only a

limited number of distinct viewpoints exist on a specific topic and is not used to estimate population statistics but to identify viewpoints which would otherwise be overlooked (Brown, 1993)

This is achieved by introducing a set of statements, the Q-set, to the respondents, the P-set, which are to be ranked relative to each other following the respondents' subjective preferences and perceptions. The statements are ranked between two *'distribution ankers'* which represent extremes of opinions on the statements like *'strongly disagree'* or *'strongly agree'* (Thomas & Watson, 2002). These extremes are assigned values to. For instance the introduced scale could be between -4 (strongly disagree) and +4 (strongly agree). The respondents are forced into a quasi-normal distribution as this requires them to take clear decisions (Thomas & Watson, 2002). By forcing the respondents to rank the statements following the quasi-normal distribution, Thomas & Watson (2002) argue that the Q-sorts around the centre of the distribution, usually the ones between the values -2, 0 and +2, represent statements which are neutral or leftovers with little value. Looked upon independently, they are therefore considered to contain only little information and are paid less attention during the analysis. However, in combination with other statements they often reveal interesting relations which would otherwise have been overlooked (Watts & Stenner, 2012). Other scholars observed that the kurtosis of the curve is depended on the polarity of the opinions and should therefore be chosen accordingly. Brown (1993) argued that topics with are subject to strong and polar opinions use a flatter distribution where as for less distinct viewpoints usually a rather steep distribution is used.

For the size of the Q-set the *"mutually exclusive – collectively exhaustive"* approach applies. The number of statements in an optimal Q-set should be large enough to cover the whole spectrum of subjective opinions. At the same time the number of statements should be small enough to not create ambiguity. That means statements should be clearly distinct and not overlap in their meaning. Furthermore it is of advantage to choose an amount of factors which allow for normal distribution. Even though the statements represent subjective viewpoints, they can be subject to factor analysis, thus revealing shared viewpoints of the P-set. Correlation of profiles may indicate similar viewpoints or differences of opinions by different subgroups (Van Exel & de Graaf, 2005). Risdon et al argues that the results of a Q-methodological study describes a population of viewpoints and not, like in R, a population of people (Risdon, Eccleston, & Crombez, 2003 as cited by Van Exel & De Graaf, 2005). Contrary to R-methodologies, only a small set of sample is required as *"it can reveal a characteristic independently of the distribution of that characteristic relative to other characteristics"* (Smith, 2001 as cited by Van Exel & De Graaf, 2005).

Hence Q methodology represents a combination of qualitative and quantitative research, drawing on the advantages and values of both. Brown (1993) suggested a set of steps to follow when conducting Q-methodology which will be interpreted for the course of this thesis and subsequently be used as shown in figure 11

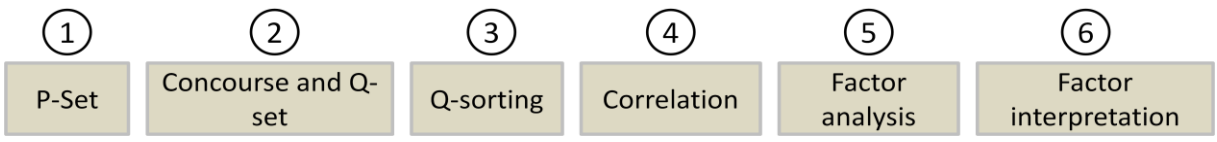


Figure 11: Steps in Q-methodology (Brown, 1993)

3.3.1. P-Set development

Brown & Ungs as well as Ward argue that rather than randomly selecting participants, thus aiming to grasp a picture of the whole population, the participants in Q-sorting are to be carefully selected to make sure that certain viewpoints are included based upon the research questions (Brown & Ungs, 1970; Ward, 2009). Durning & Brown (2007, p. 544 as cited by Ward, 2009) state that *"the categories may be somewhat imprecise, but this is of little concern in Q methodology because these categories, unlike the demographics in conventional research, are not typically used for testing purposes"*. Davis & Michelle (2011) argue that participants in Q-studies are usually not randomly selected but in fact consciously chosen, using purposive sampling. This is due to the fact that Q-methodology seeks to identify and analyze subjective viewpoints and extremes, in that case challenges for high-tech start-ups, rather than generalizable attributes of a whole population. Q-methodology therefore serves the purpose to explore and reveal viewpoints and hypotheses for further, detailed research rather than to test and generalize them (Watts & Stenner, 2012).

The research population in this thesis are all high-technology start-ups inside and outside incubation programs in different states of evolution in the Netherlands. The research focuses on hardware, software and service start-ups as it is expected that these suffer from significantly different barriers. Clean-technology is of special interest as, following the arguments in chapter one and two, sustainability is an issue becoming of more and more importance for society. Thus survival of clean-tech start-ups is a topic which is, or should be, paid more attention to.

Regarding the size of the sample, it has been shown that a relatively small amount of observations already lead to the stabilization of major relationships which only change marginally when additional observations are included in the study (Steven R Brown & Ungs, 1970). Brown (1996) argued that *"Q avoids the 'numbers games' in a certain sense because it studies qualitative differences, on which quantity has no effect."* He introduces the analogy that *"if you wish to examine the differences in colour between a tub full of green and a tub full of red paint, for instance, a thimble of each will do and buckets full from the same tubs will only provide redundant information. Similarly, in Q: If you are interested in examining the differences between the thinking of factor A vs. factor B, three or four of each will do and buckets full will not advance understanding markedly."* (Brown, 1996, p. 563, as cited by Ward, 2009)

Q-methodology generally does not require a large set of participants as replicability is of larger concern than statistical reliability or the ability to generalize results to the whole population. Hence the results of Q-methodology are not to be interpreted as percentages of the sample or the general population (Nicholas, 2011).

P-set

According to Watts & Stenner (2012), in Q-methodology systematic sampling has the aim to include cases which are expected to add interesting viewpoints to the holistic picture. The P-set contains 30 observations, strategically selected to reveal a wide array of possible viewpoints. It is constituted of 30 Dutch high-technology start-ups with a special focus on clean-technology start-ups. Hardware, software and service start-ups from several Dutch incubation programs as well as start-ups not affiliated with any incubators were included. The ages of the start-ups varied between 0 and 7 years. While some start-ups from different university projects, others have no affiliation with academia. The founders of the start-ups have different educational backgrounds.

Table 3 summarizes the demographics of all cases in the P-set. **ID** refers to the anonymized ID of the start-up. **INC** indicates whether or not the start-up is formally part of incubation, acceleration program or participates in any other formal or informal innovation cluster. The start-ups in the sample were part of different programs to foster entrepreneurship. Closer attention to the nature of the programs is paid to in the analysis. As argued in the theoretical model, it is expected that being part of such a program significantly influences the context of a start-up as it usually facilitates networks and/or even provides resources and coaching.

For matter of confidentiality, the names of the start-ups are not disclosed and the results are anonymized. The number and ID of a case are random and do not allow to trace back the start-up.

SPIN describes whether or not the start-up is the result of a university project. Some start-ups were direct spin-offs of research groups or resulted from entrepreneurs commercializing their graduation projects. **CT** states if the start-up shares the attributes of a clean-technology start-up as introduced in chapter two. It has to be noted that the distinction between clean-technology/not clean-technology is a rather difficult one and this factor introduces an element of subjectivity as it is based on the judgement of the author. Similarly, **HW/SW/SE** indicates if the start-up is a hardware, software or service start-up or a mix the different categories. Again, distinction between the categories is often blurry as business models merge and continuously change. The author had to rely on the judgement of the respondents themselves and subjective application of the criteria of hardware, software and service start-ups introduced in chapter two. Hardware start-ups outweigh as clean-technology start-ups were observed to be predominantly hardware start-up and their viewpoints compared to other high-technology start-ups was of special relevance for the purpose of this research.

EXP shows whether or not the founders had any entrepreneurial experience before starting up. EXP is based on the replies of the respondents and can hardly be checked. Types of experiences of the entrepreneurs in the P-set range from serial entrepreneurs to application of entrepreneurial elements (e.g. fundraising) in student unions.

EDU indicates if the founding team had any entrepreneurial education before, at the time of or in the early phase of starting up. Types of education range from following whole university programs based on entrepreneurship and marketing, entrepreneurial minors to university courses on business planning and master classes offered by different programs like incubators or innovation networks. **YR** refers to the founding year of the company and **EMP** to the amount of employees. EMP includes the founding team, legally employed and paid FTE staff as well as unpaid volunteers, graduate students and interns which are part of the team.

Table 4: Constitution P-set

#	ID	INC	SPIN	CT	HW/SW/SE	EXP	EDU	YR	EMP
1	AQ	Yes	No	Yes	HW	No	Yes	2012	3
2	BI	No	Yes	Yes	HW	Yes	Yes	2012	5
3	BR	Yes	Yes	Yes	HW	Yes	Yes	2010	8
4	DI	Yes	Yes	Yes	HW	Yes	No	2012	4
5	EL	Yes	No	Yes	HW	No	Yes	2009	6

6	ES	Yes	Yes	Yes	HW	Yes	Yes	2011	8
7	GS	Yes	No	Yes	HW	Yes	Yes	2010	3
8	OF	Yes	No	Yes	HW	No	Yes	2008	4
9	PE	Yes	No	Yes	HW	Yes	Yes	2012	3
10	PB	No	No	Yes	HW	Yes	No	2009	7
11	SG	Yes	No	Yes	HW	Yes	Yes	2009	56
12	SC	Yes	No	Yes	SW/SE	Yes	Yes	2011	12
13	SO	Yes	No	Yes	SE	No	Yes	2011	3
14	SU	Yes	Yes	Yes	HW	No	Yes	2012	4
15	VF	Yes	Yes	Yes	HW	Yes	Yes	2010	5
16	WC	Yes	Yes	Yes	HW	No	Yes	2010	8
17	AC	Yes	Yes	No	SW/SE	Yes	Yes	2012	2
18	DI	Yes	Yes	No	SW/SE	No	Yes	2012	3
19	GM	Yes	Yes	No	SE	Yes	Yes	2010	3
20	JS	No	No	No	HW	Yes	Yes	2013	4
21	SA	Yes	Yes	No	HW	No	Yes	2009	4
22	SS	Yes	Yes	No	SW/SE	Yes	Yes	2013	8
23	TM	Yes	Yes	No	HW	No	Yes	2011	3
24	DP	Yes	Yes	Yes	HW	Yes	Yes	2013	3
25	IS	Yes	Yes	No	HW	No	No	2007	40
26	TK	Yes	No	Yes	HW	No	Yes	2011	1
27	GP	No	No	No	HW/SW	Yes	No	2005	65
28	VV	No	No	No	SW/SE	Yes	Yes	2008	3
29	MO	Yes	Yes	Yes	HW	No	Yes	2012	7
30	EW	Yes	Yes	Yes	HW	Yes	Yes	2012	8

3.3.2. Concourse and Q-Set development

As introduced in chapter 3.2.2 of this thesis, the statements of the Q-set were designed to follow the '*MECE'* approach – thus being *'mutually exclusive and collectively exhaustive'.* This is important because to explore existing viewpoints on a specific topic, all potential viewpoints have to be covered to create a concise image of reality. Overlap between the statements has to be avoided as it creates ambiguity and leads to misperceptions of the statements. The statements were derived from the findings of a literature review **(1)** and exploratory interviews with entrepreneurs, scholars and incubation managers **(2),** generally referred to as the *"concourse*" (Brown, 1993). These findings were paraphrased into clear statements derived from the raw material of the concourse with the goal to make them easier to understand for the respondents and to minimize potential misinterpretations. Subsequently, the Q-set was presented to a set of individuals in open interviews, who analyzed it on clarity of the statements. Statements which were perceived as ambiguous, unclear or overlapping with other statements were re-formulated, aggregated or disaggregated. This process constituted the exploratory interviews as introduced in chapter 3.2.1. The interviews were conducted as an iterative process with each interview partly building on the findings of the previous ones and going deeper into identified points of conflict and ambiguity. The statements were subsequently divided into five distinct dimensions, representing general fields of perceived challenges.

As argued in chapter 3.2.2, the respondents are asked to rank the statements following a quasi normal distribution. Doing so, the respondents are forced to decide which of the statements are

more or less relevant to them and to make the extremes in their perceptions explicit. The kurtosis of the quasi-normal distribution is chosen by the researcher and dependent on whether or not the researcher expects the opinions of the respondents to be rather strong and polarised or less distinct. For the purpose of this thesis a relatively flat distribution was chosen as the exploratory interviews held before the Q-sorting revealed rather polar perceptions on challenges. Figure 12 shows the chosen quasi-normal distribution of the array. For the analysis the statements close to the anker points, the ones with the values +4/-4 and +3/-3, were paid special attention to.

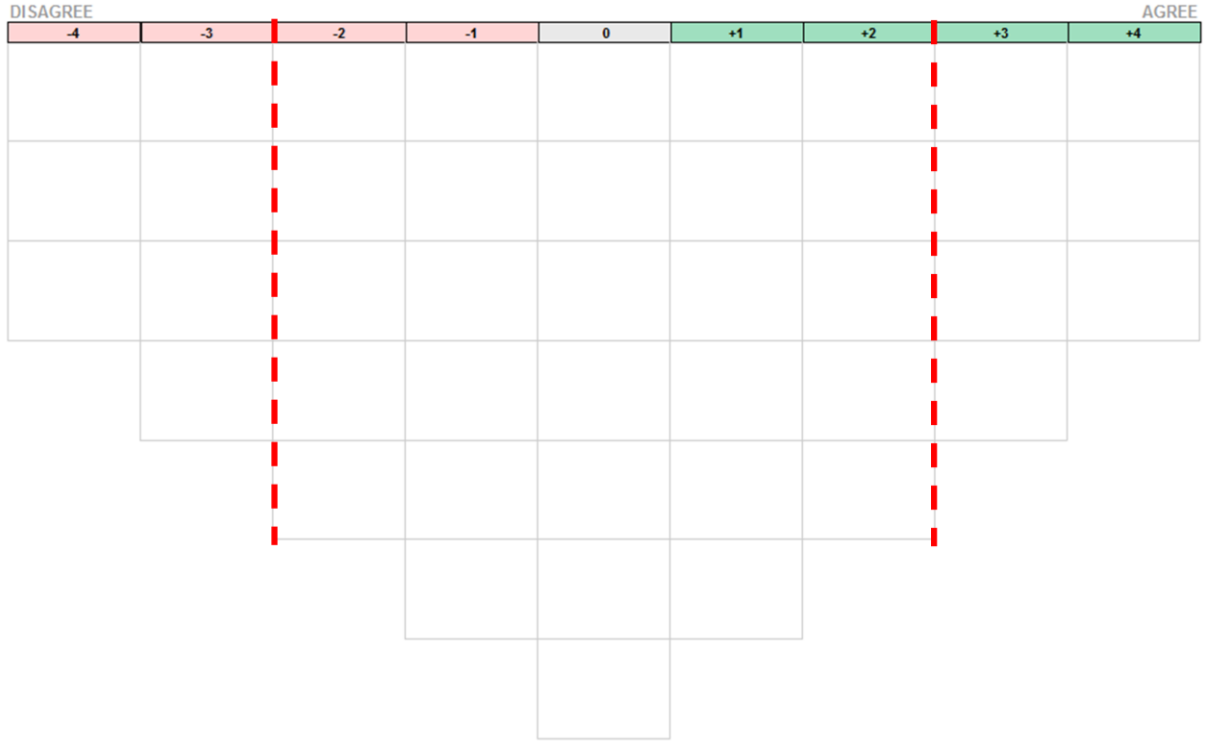


Figure 12: Quasi-normal distribution used in the thesis with extremes

Following Thomas & Watson's (2002) argumentation, the statements in the middle, the ones with values between +2 and -2 were paid less attention to during the interpretation as they were expected contain less relevant information. Following the concept of q-methodology, the statements in the middle of the quasi-normal distribution are merely leftovers and represent statements which are not value loaded or not relevant for the respondent. As the statements are often neutral to the respondent, it is argued that the interpreted value of the statements between +2 and -2 is too similar. However, the ranking in Q-methodology is not to be understood as expressing clear positive or negative viewpoints but as ranking the statements compared to each other. Statements which are ranked on 0 for instance are perceived as less negatively loaded than statements ranked at -3. When interpreted in relation to and combination with other items, they can therefore often mean cautious agreement rather than neutrality (Watts & Stenner, 2012)

Literature review

As elaborated on in section 2.5, a literature review was conducted to extract common challenges of high-tech start-ups identified in academic literature. The keywords were chosen based on the key topics identified previous to conducting the research. Hence, the terms *'innovation barriers'*, *'success factors'*, *'challenges'* and *'performance'* were in the centre of the search. These terms were used in connection with *'new venture'*, *'start-up'*, *'technology'*, *'clean-technology'* and *'high-technology'*. Additionally, synonyms of these terms were used to cover as much content as possible.

Scopus, Web of Science and Google Scholar were used as main databases. These databases cover a large part of existing literature as they combine two of the largest publishers (Elsevier and Reuters) and are backed up with an open platform (Google scholar). Papers were chosen upon their fit to the keywords, the number of citations and to the content presented in the abstract. The methodology utilized for the literature review is shown in table 5. A complete list of the identified statements can be found in appendix A1.

Table 5: Methodology literature review – Q-set development

Literature Review – Q-set development	
Keywords	• Innovation barriers • Success barriers • Success factors • Challenges • Performance • New venture • Start-up • Technology • Clean-technology • High-technology
Databases	• Scopus • Web of Science • Google Scholar
Decision criteria	• Number of citations • Fit to key words • Fit to content

Exploratory Interviews

Interviews with entrepreneurs, scholars and incubation managers contributed a substantial part to developing understanding how they perceive the context of high-technology start-ups and start-ups in general. The interviews with entrepreneurs served the purpose to collect as many subjective statements as possible to subsequently be combined with the statements from the literature review (appendix A1). As the statements are purely subjective, their origin is of no significance in terms of being formulated by entrepreneurs themselves or other affiliated individuals. Interviewing scholars was expected to contribute with statements from a scientific basis. Interviewing incubation managers contributed by giving insights in how incubators perceive the context and challenges their start-ups are in.

A set of unstructured, exploratory interviews were conducted to conclude the development of the Q-set. The interviews served two purposes: First, they were used to identify if any perceived challenges were not covered by the literature review. Additional challenges were added to the list of statements. Second, the interviews were used to eliminate ambiguity of the statements. To do so, the interviewees were asked to express their understanding of the challenges and their interpretation was compared with the paraphrased statements in several iterative steps. In total ten

interviews were conducted with persons from different backgrounds. The interviews were conducted in person or on the phone. Table 6 shows the methodology used for the exploratory interviews.

Table 6: Methodology exploratory interviews - Q-set development

Exploratory interviews – Q-set development	
Interviewees	• Entrepreneurs • Start-up employees • Incubator employees • Scholars • Students
Number of Interviews	• 10

The exploratory interviews were unstructured, lasted between 15 and 30 minutes and were conducted in three consecutive steps. First, the respondents understanding of the term *'challenges'* was openly discussed for a few minutes **(1)**. Subsequently the interviewer walked the interviewee through the list of statements from literature. During this step every statement was briefly discussed. If a statement was unclear for the respondent, it was paraphrased accordingly. Furthermore, it was tried to eliminate statements for which an overlap in their meaning was perceived by the respondents **(2)**. In the last step, the interviewees were asked to again reflect on their understanding of *'challenges'* and to come up with additional challenges which were missed in their opinion.

The interviews were iterative. That said, the results of the first interviews were subsequently used in the following ones. This approach allowed a stepwise reduction of ambiguity as the interviews built on each other. The additional statements which were identified through the interviews can be found in appendix A1.

Q-set

The challenges were paraphrased in 43 statements to reduce ambiguity. Throughout several iterative steps in the interviewing process, the statements were formulated in a way that they were clear to all interviewees. During the exploratory interviews, it was found that the statements are perceived as clearer if certain key-points are highlighted and marked in bold. The paraphrased statements can be found in appendix A1.

3.3.3. Q-sorting - Application of Q-methodology in this thesis

Following the argument that Q-methodology gives insights in subjective viewpoints, Q-methodology served as an instrument to reveal differences in perceptions of challenges for the purpose of the thesis. Scholars argue that no significant differences were observed between Q-sorting conducted in a person to person setting and online (Van Exel & de Graaf, 2005). While using online tools has the advantage of easier administration and gives the opportunity to utilize a larger P-set, it was observed that additional qualitative information can be gained by conducting the Q-sorting under direct supervision of the researcher. Also the requirement of communicating the subjective character of Q-methodology to the respondent (Van Exel & de Graaf, 2005) is easier to satisfy in this setting. To combine the benefits of both approaches, Q-sorting was conducted using a software tool in person, via VOIP (Skype) or the phone. The Q-sorting took place in form of an informal interview in which the respondents were allowed to ask questions and invited to express their thoughts and opinions

throughout the whole process. For the interpretation, several short, unstructured follow-up interviews were conducted with conveniently chosen respondents to better understand specific viewpoints.

Software

FlashQ, a flash based Q-sorting software developed by Christian Hackert and Gernot Braehler in 2007, was used to conduct the Q-sorting. The software allows for a high degree of customization in terms of choosing the kurtosis of the quasi-normal distribution, amount of statements and additional questions. The program was either sent to the respondents via e-mail and required them to open an application or directly opened on the authors laptop if conducted in person. The identity of the respondents was only known by the author of this thesis and kept confidential. The respondents were asked to go through five steps. An overview over the program and how the participants were asked to use it can be found in appendix A2. After going through the five steps, a button allowed the respondents to send the results directly to the author.

4. Empirical analysis

Part four of this thesis deals with the empirical analysis of the collected data. Factor analysis was used to extract common viewpoints of the Q-set. According to Tinsley & Tinsley (1987, pp 414), *"Factor analysis is an analytic technique that permits the reduction of a large number of interrelated variables to a smaller number of latent or hidden dimensions. The goal of factor analysis is to achieve parsimony by using the smallest number of explanatory concepts to explain the maximum amount of common variance in a correlation matrix."* First a brief theoretical introduction on factor analysis is given. Subsequently factor analysis is conducted and the results are presented and empirically interpreted. Throughout the chapter, choices made between different factor extraction and rotation methods are justified.

4.1. Factor analysis

30 Q-sorts (cases) were inter-correlated and factor analysed using the computer package PQMethod (Schmolck, 2012) as well as SPSS. Four factors were extracted and emerged as subject of study. After being rotated, they explained 39% of the studies total variance. Of the 30 Q-sorts, 23 loaded significantly (factor loading of $>\pm 0.36$ at the $p<0.05$ level) on one of the four factors. This chapter is largely based on Watts & Stenner's (2012) great book on Q-methodological research which, apart from containing other useful resources, elaborately explains different analysis and interpretation methods. Watts & Stenner extensively build on the work of Brown (Brown, 1980, 1993, 1996; Brown & Ungs, 1970; Durning & Brown, 2007) who pioneered Q-methodology in social sciences.

For each factor, a single *'typical'* factor array emerged based on the method of weighted average. Stenner, Cooper, & Skevington (2003, pp 2164-5 as cited by Watts & Stenner, 2012) state that *"higher loading exemplars are given more weight in the averaging process since they better exemplify the factor. Being a merged average the factor array looks like a single complete Q-sort".* The weighted average method thus satisfies Thomas & Watson (2002) notion that the Q-sorts with values between -2 and +2 contain only little or no information by assigning less weight to them. Q-sorts loading significantly on the same factor, thus also on the exemplified Q-sort of the factor, share common perceptions on their challenges based on their individual ranking of the statements in the

factor array. In the following chapters, emphasis will be laid on the three consecutive steps in Q analysis– correlation, factor extraction and rotation and computation of factor scores.

4.1.1. Correlation

In the first step of the empirical analysis, a correlation matrix of all respondents to the study was generated. The full correlation matrix can be found in appendix A3 and reflects the nature and extend of the relationships between all the Q-sorts in the group. According to Watts & Stenner, (2012) the resulting correlation matrix *"evidently represents or encapsulates 100% of the meaning and variability represented in the study".*

4.1.2. Factor extraction

The overall variance of a Q-sort is constituted by the common variance by the group, the specific variance of each Q-sort and the error variance. Four factors were extracted from the data to explain as much of the studies variance as possible in order to explain as much about the relation between the Q-sorts in the group as possible (Watts & Stenner, 2012). Hence factors represent *"sizable portions of common or shared meaning"* and aim to identify patterns of similarity between the individual Q-sorts. A factor can be seen as a shared viewpoint of the responding Q-sorts and therefore participants. As factors describe the similarities between the Q-sorts they naturally only capture a part of the studies total variance.

Centroid factor analysis was employed to extract the factors from the data. Factor extraction is an iterative process as the decision over the amount of extracted factors depends on a number of criteria. In theory, each extracted factor reduces the remaining common variance and factors are extracted until no more common variance can be detected. From the unrotated factor matrix as shown in appendix A6, several important aspects can be extracted. First, it shows the loading of each individual Q-sort on each of the extracted, unrotated factors as flagged in light grey and white. Second, a measure known as *'communality'* h^2 is introduced by summing each Q-sorts squared factor loadings. Communality gives an indication on how much of the factor the respective Q-sort holds in common with all other Q-sorts in the study group. According to Watts & Stenner (2012) a high communality signals a Q-sort which is highly representative for the group as a whole while a low communality means that it is atypical. Hence they argue that *"Q-sorts with a particularly low communality tend to not be significantly associated with any of the extracted factors because they lack sufficient common variance".* The communality between the Q-sorts can be found in appendix A4.

Furthermore the eigenvalues (EVs) and estimates of explained variance of each factor can be seen in the table in appendix A5. The eigenvalues are calculated by summing the squared loadings of all Q-sorts on the factor. The variance of each factor gives information on how much of the common variance, and therefore how much of what the Q-sorts have in common, in the study is explained by this factor. The EV and the explained variance of each factor are closely related and high factor EVs and variances are generally considered to be good (Watts & Stenner, 2012). The sum of all variances explains how much of the total studies variance are explained by the extracted factors. According to Kline (1994 as cited by Watts & Stenner, 2012) explained variances between 35% and 40% or above are considered as a sound solution on the basis of common factors. The extracted four factors in this study explain 39% of the total variance which is sufficient.

4.1.2.1. Decision on amount of extracted factors

Four factors were extracted on the basis of the collected data. If too many factors are extracted, their main purpose to find common patterns is missed. If too little factors are extracted, nuances in differences might not be spotted and important information neglected. Following Watts & Stenner (2012) several decision making criteria were employed to decide how many factors to extract. In the following sections it will be elaborated on theoretical viewpoints on factor extraction and the choice to extract four factors will be justified. Some of the decision criteria are more, some are less strict. A combination of the criteria was used to determine the amount of factors to extract. According to Watts & Stenner, the final set of factors should *"account for as much of the variability in the original correlation matrix as possible"* and therefore contain as much valuable information as possible and not be seen as *"an important characteristic of a factor analytical solution"*. Apart from centroid factor analysis, also principal component analysis (PCA) was initially utilized to determine the amount of factors to be extracted. Centroid factor analysis was subsequently used to extract the determined amount of factors. Tables which are based on principal component analysis are labelled as such. All other tables are based on centroid factor analysis.

Eigenvalues (Kaiser-Guttman criterion)

According to the Kaiser-Guttman criterion (Guttman, 1954; Kaiser, 1960, 1970) factors with an EV of 1.00 or above are significant and should be extracted. EVs below 1.00 account for less variance than a single Q-sort (Watts & Stenner, 2005). However, S.R. Brown (1980 as cited by Watts & Stenner, 2012) argues that this can lead to the extraction of meaningless factors with an EV of larger than one while leaving behind factors which actually do contain information but have an EV of smaller than one. Table 7 shows all factors with an EV of above 1.00.

Table 7: Unrotated factors with an EV above 1

Factor	Total EV	% of Variance	Cumulative %
1	7,172	23,905	23,905
2	2,680	8,935	32,840
3	2,493	8,310	41,150
4	1,984	6,615	47,765
5	1,740	5,800	53,565
6	1,624	5,414	58,979
7	1,360	4,532	63,511
8	1,339	4,463	67,974
9	1,207	4,022	71,996
10	1,104	3,681	75,677

Extraction Method: PCA

Table 7 shows that a total of 10 factors with an EV above 1 were found which would explain a total variance of 75.7%. In Appendix A5 a table with the EVs of all calculated factors can be found. Following Browns argument, in addition to basing the decision over the amount of extracted factors solely on the EVs, other criterions have been taken into account as well.

Experience and intuition

S.R. Brown (1980) argues that instead of relying on objective factors like EV, *'experience'* should be applied when deciding upon the factors to extract. He argues that *"the magic number 7"* is generally suitable (S.R. Brown, 1980 as cited by Watts & Stenner, 2012). While it is argued that *'7'* is certainly not a *'magic number'* being applicable to all Q-sets, Watts & Stenner (2012) state that experience is indeed an important criterion when deciding on the amount of factors to extract and advice to extract one factor for approximately every 6-8 participants in the study. Following this suggestion, the amount of factors extracted for the purpose of this study should be somewhere between 3 and 5.

Significant loadings and Humphrey's rule

Brown (1980) suggests to accept the factors which have two or more significant factor loadings at the 0.01 level following extraction. A significant factor loading on the 0.01 level is present at a factor loading of ±0.47. Following from this argument, only three factors should be extracted. Additionally, Humphrey's rule states that *"a factor is significant is the cross product of its two highest loadings exceeds twice the standard error"* (S.R. Brown, 1980 as cited by Walls & Stenner, 2012). The standard error in a set of 30 Q-sorts is 0.183. Following this argument, only 2 factors should be extracted. However, according to Watts & Stenner (2012), Humphrey's rule can also be applied less strictly with the cross-product of the two highest loadings only exceeding the single standard error which would allow 9 factors to be extracted. Please find a table with the complete factor loadings in appendix A6.

Scree test

A scree tests plots the EVs of each factor in a diagram. It was designed and introduced by Cattell (1966) for use in principal component analysis but can be used as a valuable tool in determining how many factors to extract. The number of factors to extract is argued to be at the point at which the slope of the line connecting the points changes. In figure 13, it can be seen that the slope of the EV changes after factor 7.

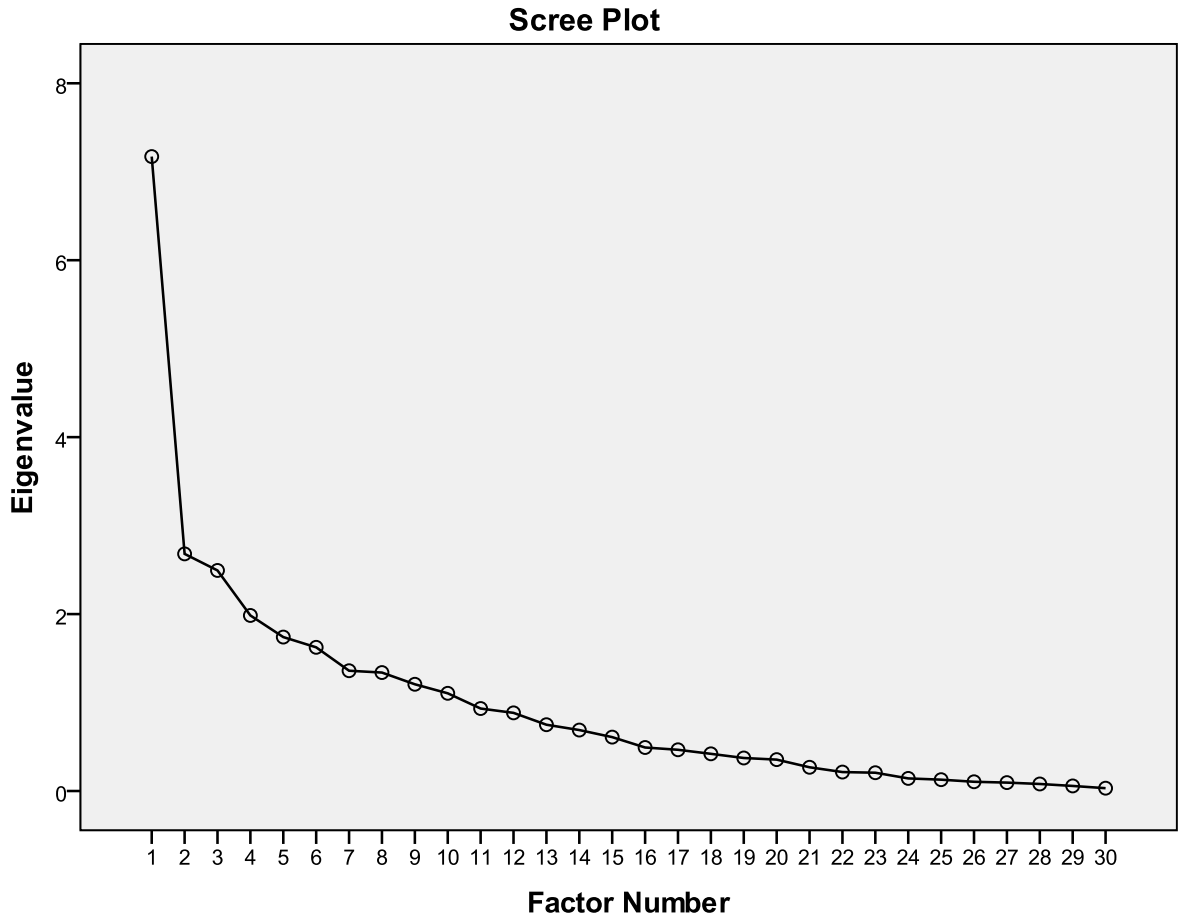


Figure 13: Scree test

Parallel analysis

In addition to the scree test, PCA was also used to perform a parallel analysis as introduced by Horn (1965). Parallel analysis calculates the EVs that would result from the data set if all participants would have sorted their Q-sorts in a random way (Watts & Stenner, 2012). *"EVs are extracted from random data sets which parallel the actual data set with regard to the number of cases and variables"* (O'Connor, 2000). 1000 random data sets were chosen and the data was compared with the 95th percentile EV derived from these data sets. Following Watts & Stenner (2012), this means that if the actual EV exceeds the 95th percentile EV for 1000 random data sets, there is less than 5% chance that the observed EV would have also occurred in data sets in which no factors occurred. Factors which satisfy that criterion, the actual EV (Raw Data) exceeds the 95th percentile EV, should be extracted.

As shown in table 8, only one factor satisfied this condition and should therefore be extracted. The full table containing all factors can be found in appendix A7.

Table 8: Parallel analysis

Factor	Raw Data	Mean EV	95% prctl.
1	7,17	3,01	3,34
2	2,68	2,66	2,89
3	2,49	2,40	2,59
4	1,98	2,19	2,36
5	1,74	2,01	2,16

TUDelft

6	1,62	1,85	1,98
7	1,36	1,69	1,81
8	1,34	1,55	1,67
9	1,21	1,43	1,54
10	1,10	1,31	1,41

Extraction Method: PCA

4.1.2.2. Discussion

The different decision methods suggested different amounts of factors to be extracted. While following the Kaiser-Guttman criterion would have led to extracting 10 factors based on their EV larger than 1.00, parallel analysis suggested the opposite extreme of extracting only one factor. Four factors were finally extracted, going the middle way and following Humphrey's rule and Brown's *'rule of the thumb'*. This solution seemed to be the most promising as it mitigated the risk of abandoning factors bearing valuable information. Brown (1980 pp 223 as cited by Watts & Stenner, 2012) suggests *to "extract more factors ahead of time"* as *"insignificant factors frequently contain small amounts of systematic variance that can help in improving the factor loadings on a major factor".* Table 9 shows the EVs of the four extracted factors with the explained variance and the communality. Q-sorts with a factor loading exceeding ± 0,47 (0.01 level) are flagged in dark grey, Q-sorts with a factor loading exceeding ±0.36 (0.05 level) are flagged with light grey. Factors with two loadings on the 0.05 level were extracted. Factor 4 only showed one significant loading on the 0.05 level. However, as the factor loadings usually increase after rotation, the suggestions from literature to drag along factors on the boarder were followed (Watts & Stenner, 2012).

Table 9: Unrotated factor loadings of extracted factors

	Factor				
	1	**2**	**3**	**4**	**h^2**
1	0,46	0,01	0,35	0,31	0,43
2	0,37	0,18	-0,17	0,29	0,28
3	0,72	-0,14	-0,51	-0,14	0,82
4	0,43	0,10	0,03	0,08	0,21
5	0,64	0,10	-0,22	0,20	0,51
6	0,44	0,15	-0,13	0,10	0,24
7	0,38	0,16	-0,01	-0,08	0,18
8	0,27	0,49	-0,09	-0,24	0,38
9	0,26	0,07	0,54	0,07	0,37
10	0,50	-0,28	-0,10	0,19	0,37
11	0,62	-0,08	-0,04	0,28	0,47
12	0,21	0,15	0,08	-0,21	0,12
13	0,28	-0,38	-0,02	-0,13	0,24
14	0,29	0,29	-0,19	-0,01	0,21
15	0,50	-0,15	0,12	-0,15	0,31
16	0,37	-0,10	0,28	0,43	0,41
17	0,34	-0,18	0,50	0,10	0,41
18	0,51	-0,15	0,26	-0,13	0,36
19	0,32	0,15	0,14	-0,18	0,18
20	0,48	0,12	0,25	0,03	0,31
21	0,61	0,35	-0,16	-0,22	0,57
22	0,37	-0,02	0,35	-0,07	0,27
23	0,44	0,17	-0,21	-0,11	0,27

24	0,48	-0,49	-0,25	0,06	0,54
25	-0,12	0,47	0,27	0,34	0,42
26	0,50	0,28	-0,34	0,14	0,47
27	0,61	-0,29	-0,29	0,17	0,56
28	0,38	0,38	0,09	-0,26	0,37
29	0,70	0,03	-0,05	0,14	0,51
30	0,61	-0,50	-0,13	-0,33	0,75
Ei	6,45	1,99	1,88	1,19	
%	22,00	7,00	6,00	4,00	39,00

4.1.3. Factor rotation

After extracting the factors, an orthogonal varimax factor rotation was performed. The extracted, unrotated factors span the so called *'factor space'* and represent it's, in this case, four dimension. As every Q-sort has a loading on each factor, it takes a position in a map in which the unrotated factors represent the coordinates. Hence, they are used to map the relative positions of the respondents' viewpoints. However, the unrotated factors represent perspectives that are not directly shared by any of the corresponding viewpoints which would be represented by a factor loading of 1.00 on one factor and 0.00 on all others. Therefore the Q-sorts lie somewhere between the axes and are commonly correlated to several factors. Figure 14 shows the diagram of the unrotated factors one and two.

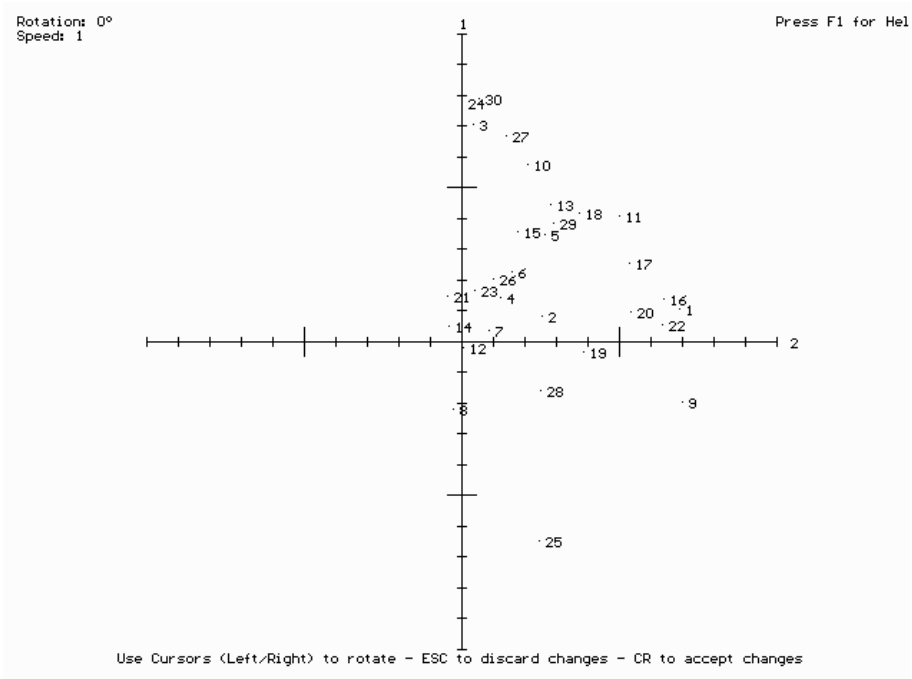


Figure 14: Diagram of unrotated factors 1 and 2

By rotating the factors axes it is possible to focus the viewpoints of the various factors in relation to the collected data. The goal is to achieve a closer approximation of a particular group of Q-sorts. According to Watts & Stenner (2012) re-positioning of all factor axes and therefore factors in the study allows to look at the subject matter from a *"series of key positions"* within the conceptual space and therefore for close approximation of the viewpoints of a particular group of Q-sorts. Hence

the goal is to maximise the loading of any Q-sort on one factor and to minimize its loading on the others to allow for a full and proper interpretation.

Orthogonal vs. oblique rotation

Factor rotation can either be orthogonal or oblique. In orthogonal rotation, the angle between the factor axes is fixed at 90°, theoretically leading to zero correlation and statistical independence between the factors (Dancey & Reidy, 2011 as cited by Watts & Stenner, 2012). Orthogonal rotation is the standard rotation method in Q-methodological research due to its simplicity and higher replicability (Pedhazur & Schmelkin, 1991 as cited by Rennie, 1997). It was argued that especially the aspect of replicability is of paramount importance when choosing a rotation method as it is one of the main concerns in Q-methodology (Nicholas, 2011).

Oblique rotation on the other hand allows for correlation between the factors, represented by angles of <90° between the axes. It is argued that oblique rotation is *"more representative of the nature of reality"* as in the real world, factors are very unlikely to show no interrelation between each other (Rennie, 1997). Furthermore Rennie states that oblique rotation provides results *that "best fit the data"*. This means that the correlation between the factors will vary from study to study. While this might be an advantage in large data sets it also introduces the issue of reproducibility as no study will result in the same factor matrices.

Varimax rotation was chosen as orthogonal rotation technique due to several reasons. First it is easier to perform and interpret as it is a basic part of most available software packages such as PQMethod. Second, orthogonal rotation mitigates the issue of reproducibility as it doesn't allow for correlation between the factors. Furthermore, Rennie (1997) argues that *"results from an oblique rotation and an orthogonal rotation almost always produce generally similar results"* and that differences are often insignificant.

Varimax rotation

Varimax rotation was performed and resulted in the factor loadings shown in table 10. Factors flagged in grey indicate a defining sort. In total, 23 Q-sorts were significantly (factor loading exceeding ± 0,36 on the 0.05 level) defining a factor where as 4 were not significantly loaded on any of them and 3 were confounded as shown in table 11. Q-sorts with a factor loading exceeding ± 0,47 (0.01 level) are flagged in dark grey and indicate a defining sort, Q-sorts with a factor loading exceeding ±0.36 (0.05 level) are flagged with light grey. For the purpose of this thesis the significance level was set on the 0.05 level. A Q-sort with a factor loading of ±0.60 was counted for this factor and not as confounded if it also significantly (on the 0.05 level) loaded on a second factor with a factor loading not exceeding ±0.47. Factor two is a bipolar factor as one Q-sort (#25) loads significantly negative while all other significantly positive on it.

Table 10: Rotated factor matrix after varimax rotation

	Factor				
Q-sort	**1**	**2**	**3**	**4**	**h^2**
1	0,31	0,01	0,58	0,02	0,43
2	0,52	-0,05	0,07	0,08	0,28
3	0,58	0,60	-0,12	0,32	0,82
4	0,32	0,08	0,23	0,21	0,21

5	0,64	0,18	0,15	0,21	0,51
6	0,42	0,07	0,10	0,22	0,24
7	0,23	0,08	0,13	0,32	0,18
8	0,17	-0,14	-0,07	0,57	0,38
9	-0,04	-0,10	0,58	0,13	0,37
10	0,41	0,39	0,22	-0,06	0,37
11	0,55	0,23	0,32	0,04	0,47
12	0,00	0,04	0,09	0,32	0,12
13	0,03	0,47	0,13	-0,02	0,24
14	0,33	-0,05	-0,06	0,31	0,21
15	0,13	0,36	0,31	0,24	0,31
16	0,33	0,00	0,52	-0,17	0,41
17	-0,01	0,13	0,62	-0,01	0,41
18	0,09	0,33	0,44	0,23	0,36
19	0,05	0,07	0,21	0,36	0,18
20	0,22	0,05	0,42	0,27	0,31
21	0,40	0,13	0,05	0,63	0,57
22	0,02	0,13	0,45	0,21	0,27
23	0,34	0,16	-0,02	0,36	0,27
24	0,35	0,63	0,09	-0,12	0,54
25	0,09	-0,61	0,20	0,01	0,42
26	0,62	0,04	-0,06	0,29	0,47
27	0,56	0,49	0,11	-0,02	0,56
28	0,12	-0,04	0,14	0,58	0,37
29	0,54	0,24	0,31	0,24	0,51
30	0,14	0,82	0,15	0,19	0,75
EV	3,6	3,0	2,7	2,4	
%	12	10	9	8	39

Table 11: Factor defining Q-sorts for four study factors

Factor number	Q-sort number	Total	Cumulative total
1	2, **5***, 6, 11, **26***, 29	6	6
2	13, 15, **24***, **25*BP**, **30***	5	11
3	1, 9, 16, **17***, 18, 20, 22	7	18
4	8, 19, **21***, 23, 28	5	23
Confounded	**3***, 27, 10	3	26
Non-significant	4, 7, 12, 14	4	30

Bold type indicates a factor loadings of 0,60 or above, **BP** indicates a bipolar factor

4.1.4. Computation of factor scores - factor estimates and arrays

The conducted factor rotation identified which Q-sorts load significantly on any of the four extracted factors. Q-sorts loading significantly on a factor (0.05 level) were used to create the factor estimates and subsequently factor arrays. As example, the factor array of factor one is shown in figure 15. The numbers in the box of the factor array represent the number of the statement as introduced in chapter 3.3.1. All factor arrays and the detailed z-scores for factors one to four can be found in appendix A8.

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DISAGREE								AGREE
-4	-3	-2	-1	0	+1	+2	+3	+4
34	3	10	2	1	4	17	19	9
37	12	27	11	5	6	26	20	14
40	35	29	13	8	7	28	21	25
	39	33	16	15	23	36	24	
		41	22	18	30	43		
			42	32	31			
				38				

Figure 15: Factor array factor one

While the score of each statement in the respective factor array only gives a first impression on how each factor ranked the statements, the z-score represent the normalized factor scores of each statement and allow for cross-factor comparisons. The factor arrays inherit a loss of information relative to the z-scores as they only show the grouping of items of one Q-sort which is configured to represent the cumulative viewpoint of a single factor. Hence the factor ranks in the factor arrays are derived from the factor scores, sorting the highest ('most positive') value in the rightmost ('agree' column with a remaining free spot in descending order from +4 till -4.

5. Interpretation of results

From factor analysis, four factors describing the common variance of a number of Q-sorts emerged. Each factor describes the common variance of a number of Q-sorts and therefore the shared viewpoints of a group of start-ups. Being associated with a factor means that the Q-sort of the start-up is significantly correlated with the Q-sorts of the other firms associated with it. Each factor therefore represents a *'profile'* of the sum of the firms associated with it. Evaluating which challenges each factor faces and interpreting why this could be the case leads to the emergence of four distinct profiles of start-ups. Following the theoretical model introduced in part two of this thesis, these start-ups share viewpoints on challenges and therefore also contextual elements.

Part five of this thesis interprets the four factors, elaborates on the proposition introduced in section 3.1.1 and aims to answer the research questions introduced in section 1.4. Furthermore, conclusions and recommendations as well as limitations of the research are presented.

5.1. Approach

Start-ups with significant loading on a factor have something in common and share their perceptions on the statements and therefore certain challenges. Interpretation of factor loadings and factor arrays follows a holistic approach, aiming to interpret the entire item configuration rather than picking specific items and looking at them in isolation (Watts & Stenner, 2012). Hence the viewpoints

are interpreted holistically on the basis of how the items are placed relative to each other and not by only looking at the extremes with values of +4 or -4.

Watts & Stenner (2012) introduce a so called *'crib-sheet'* to analyse how the items are related to each other for every factor. They argue that this forces the researcher to engage with every item from the factor array, thus providing a holistic view and following the logic of abduction. Combining the extremes with items in the middle of the distribution – which are often expected to be unimportant – is argued to often result in important findings. A ranking of 0 on an item can for instance be interpreted as cautious agreement when looked upon in relation to other factors if they uniformly ranked the same item very low (-2, -3 or even -4) (Watts & Stenner, 2012). In the following paragraphs, each factor will be looked upon following Watts & Stenner's methodology.

5.2. Factor interpretation

The factors are interpreted by using Watts & Stenner's crib sheet, connecting them with demographic information as well as with qualitative information collected during the Q-sorting process. A detailed overview on the demographics of the P-set can be found in section 3 and a short summary is presented under each factor. Apart from distinguishing statements for each factor, three consensus statements emerged and are interpreted upfront. Q-values are used for interpretation to achieve a better and clearer visualisation. However, Q-values are based on z-scores as introduced in part four of this thesis.

5.2.1. Consensus statements

Three statements emerged to be consensus statements as shown in table 12. This means that no significant difference was found in their z-scores between the four factors. While statements 1 and 20 are not significant, statement 14 is significant on the 0.05 level. A few start-ups however pose interesting exceptions and allow for further interpretation.

Table 12: Consensus statements

Consensus statements		
#	**Statement**	**Value**
1	Lack of knowledge spillover or leakage from other firms	1
14	**High pressure from incumbent industry (existing regimes pressure on radical entrants)**	**4**
20	Long sales cycles	3

Bold type indicates statements with significant loading on the 0.05 level on the factor

Statement one refers to a lack of knowledge spillovers from other firms. Literature identified a strong correlation between knowledge spillovers and entrepreneurial activity (Acs, Braunerhjelm, Audretsch, & Carlsson, 2008) as it leads to recognition of new opportunities. The respondents in this thesis indicated that they did not really spend thoughts (avg. #1: 1) whether or not there is a lack in knowledge flow from incumbent firms.

All factors were uniform (significant on 0.05 level) in the viewpoint that there is a high pressure from the incumbent industry (avg. #14: 4). Competition with established innovation systems was earlier identified of one of the main characteristics of high-technology and especially clean-technology start-ups. As one clean-technology entrepreneur puts it: *"We are bringing a clean-tech solution to a problem that is currently solved by fossil fuel technologies. They are not good from environmental*

perspective but from performance perspective they are very competitive". Even though the factors as a whole seem to agree with this statement, a few respondents did not agree to such an extent and individually only expressed modest agreement (0-2). Interestingly, these start-ups were most often firms who built their business models on combinations of hardware or software and services and served carefully selected niche markets. These start-ups served new or previously not heavily contested markets and niches and positioned themselves in a way that their activities re-enforce each other. As result, they do not perceive such high pressure from incumbent industry. This underlines the importance of choosing the right market and strategic niche management from early stages on.

Statement 20 – long sales cycles – was found to be the last consensus statement (avg. #20: 3). However, the finding was not significant on the 0.05 level. Further analysis of statement 20 can be found in section 6.

The consensus statements applied for each factor. Additionally several other statements emerged to be of importance for the group of start-ups contained in each individual factor.

5.2.2. Factor one – Clean-tech behemoths: Strategically on the way to success

5.2.2.1. Overview

Factor one has an eigenvalue of 3.6 and explains 12% of the study variance. Six start-ups showed significant association with the factor with two having a factor loading of >0.60. The loadings of the firms on factor one can be found in chapter 4.1.3. They are all either in incubators or affiliated with a university of other academic institutions. All of them follow the definition of clean-technology start-ups as introduced in chapter two and all of them are hardware start-ups. All the founding entrepreneurs received some kind of entrepreneurial education prior to starting up or in the first phases of the start-up. Table 13 contains the start-ups with significant loading on factor one, following the same explanation of the abbreviations as introduced in chapter 3.3.1. Table 14 shows a list of the relevant statements to generate a holistic picture of factor one.

Table 13: Start-ups with significant loading on factor 1

#	ID	INC	SPIN	CT	HW/SW/SE	EXP	EDU	YR	EMP
2	BI	No	Yes	Yes	HW	Yes	Yes	2012	5
5	**EL**	**Yes**	**No**	**Yes**	**HW**	**No**	**Yes**	**2009**	**6**
6	ES	Yes	Yes	Yes	HW	Yes	Yes	2011	8
11	SG	Yes	No	Yes	HW	Yes	Yes	2009	56
26	**TK**	**Yes**	**No**	**Yes**	**HW**	**No**	**Yes**	**2011**	**1**
29	MO	Yes	Yes	Yes	HW	No	Yes	2012	7

Bold type indicates a factor loading of >0.60

5.2.2.2. Interpretation

Start-ups associated with factor one generally have a close proximity to universities and university incubators. This fact gives this start-ups an edge when it comes having access to innovation network s (#37: -4) which exposes them to a large selection of highly educated personnel (#29: -1, #41: -2, # 42: -2) and gives them access to high quality education and training (#40: -4) and knowledge (#3: -3). However, being close to academia seems to make their activities technologically complex (#4: 1), resulting in long product development phases (#9: 4). Interestingly, technological complexity was not

only found to be the result of proximity to academia. Also *'perceived complexity'* by the customers due to an offset of technological knowledge between the founding team and the customers seems to impact times to market. As one of the founders put it *"It took much longer to bring the product to the market as we encountered more product-testing cycles than expected with longer lead times to make changes in the product and test them*". He also states: *"Marketing and value propositions to our customers [in developing countries] are totally different to what we learn in classes here".* Looked upon in the context of the whole factor, this statement can be interpreted as that the entrepreneur finds it difficult to reduce complexity when communicating the added value of his products to his customers because they follow different values and often are on a different education level.

Technological complexity and long product development phases demand relatively high investments (#23: 1, #25: 4). When looking at the products of the firm, it turns out that they are either capital intensive hardware goods or products which demand economies of scale in production. One entrepreneur confirms*: "Our investments to even make a first product are very high compared to the sales price of one product: we are in mass production which is efficient at high turnover"*. Long sales cycles (#20: 3) make cashflow an even larger issue. One entrepreneur says that *"We have customers that are willing to buy. We already have orders for two years worth of production. But the investment climate in Europe makes it very hard to go beyond the very early stage".* The same was expressed by another entrepreneur who states *"we have orders but we lack working capital".* The same entrepreneur added: *"banks and investors are at present very wary to lend money for pre-financing working capital".*

The focus on complex technologies is on the one hand very appealing for early adopters who want to experiment with new technologies (#11: -1) but on the other hand leads to very specialized teams with have difficulties to effectively communicate its capabilities to its customers (#36, 2), resulting in longer product development times. This might be the case because the members of the team think different and more complex than the customers. Also, they focus very close on technology as the entrepreneurs tend to be more concerned with the direction of technological pathways (#17, 2) rather than on user practises or on market needs (#18: 0) which they deal with on an everyday basis. However, even though hampered by the large investments needed, the entrepreneurs associated with factor one are experienced (#27: -2) and/or well advised (#39: -3), well prepared (#7: 1; #8: 0) and are successfully working their way from early adopters towards mainstream markets (#11: -1; #12: -3) in a strategic and analytical way.

This focus on technology rather than on market overlaps with the typical issues of being a clean-technology start-up. Start-ups making up factor one suffer from clean-technology typical factors like high pressure from the incumbent industry (#14: 4), dependency on regulatory frameworks and generally highly regulated markets (#19: 3).

Table 14: Crib-sheet factor 1

Items ranked at 4+		
#	**Statement**	**Value**
9	Long product development process/phase	4
14	High pressure from incumbent industry (existing regimes pressure on radical entrants)	4
25	Height of required investment	4

Items ranked higher in factor 1 array than in any other factor array		
#	**Statement**	**Value**
19	Uncertainties about regulatory frameworks - potential shifts in negative direction (e.g. solar subsidies)	3
24	General lack of accessibility of seed/start-up/early stage funding (investment) in the industry	3
36	**Lack of organizational legitimacy to customers**	**2**
43	long and difficult procedures to employ personnel	2
Items ranked lower in factor 1 array than in any other array		
#	**Statement**	**Value**
1	Lack of knowledge spillover or leakage from other firms	0
11	**Little buyer concentration - lack of early stage customers**	**-1**
18	**Uncertainty about user practices**	**0**
29	Difficulties in attracting highly qualified and competent business personnel (low wage rates, career development, job security)	-1
41	General lack of personnel with diversified business skills and abilities on labour market (there are simply no people who fit the job)	-2
42	General lack of personnel with diversified technical skills and abilities on labour market (there are simply no people who fit the job)	-2
Items ranked at -4		
#	**Statement**	**Value**
34	lack of strategic vision and alignment	-4
37	Lack of regional innovation network (cluster)	-4
40	Lack access to entrepreneurial education and training	-4
Other relevant factors:		
12	Little buyer concentration - lack of mainstream customers	-3
17	**Uncertainty about technology pathways**	**2**
38	**lack of assistance and support when securing funding**	**0**

Bold type indicates statements with significant loading on the 0.05 level on the factor

5.2.3. Factor two – Young, intuitive and enthusiastic – Raw diamonds

5.2.3.1. Overview

Factor two has an eigenvalue of 3.0 and explains 10% of the study variance. Five start-ups showed significant association with the factor with three having a factor loading of >0.60. The loadings of the firms on factor two can be found in chapter 4.1.3. Factor two was found to be a bipolar factor as one associated statement shows a negative relation. All start-ups are or were part of an incubation program and four resulted from graduation projects or are somehow else university spin-offs. Apart from the #25, all firms follow the definition of clean-technology start-ups with #25 being the negatively associated sort. All the founding entrepreneurs apart from the entrepreneurs in firm #25 received some kind of entrepreneurial education prior to starting up or in the first phases of the start-up. Interestingly, the firm with the negative loading on factor two seems to be rather mature firm already compared to the other firms defining this factor. Table 15 shows the start-ups significantly associated with factor two.

Table 15: Start-ups with significant loading on factor 2

#	ID	INC	SPIN	CT	HW/SW/SE	EXP	EDU	YR	EMP
13	SO	Yes	No	Yes	SE	No	Yes	2011	3
15	VF	Yes	Yes	Yes	HW	Yes	Yes	2010	5
24	**DP**	**Yes**	**Yes**	**Yes**	**HW**	**Yes**	**Yes**	**2013**	**3**
***25**	***IS***	***Yes***	***Yes***	***No***	***HW/SE***	***No***	***No***	***2007***	***40***
30	**EW**	**Yes**	**Yes**	**Yes**	**HW**	**Yes**	**Yes**	**2012**	**8**

Bold type indicates a factor loading of >0.60, *italics indicates a bipolar statement*

5.2.3.2. Interpretation: Positively correlated start-ups

Start-ups positively associated with factor two are clean-technology start-ups in a relatively early stage of existence. That said, they suffer from the typical clean-technology challenges of competing against large existing innovation systems (#14: 4) and being dependent on commodity prices (#21: 4). The entrepreneurs acknowledge are aware of that and say *"Lower [commodity] prices and higher hardware prices for [complementary goods] could impact our offer for clients"*. The markets are usually also heavily regulated (#19: 2). One entrepreneur says *"[commodity] supply is monopolized by governments and private companies, making it hard to get a project for a private customer".*

The entrepreneurs acknowledge a relative lack of entrepreneurial experience (#27: 0) and often started their firms out of their graduation projects at technical universities. Doing so, they are able to utilize existing resources very efficiently by being able to rely on the university network (#37: 4; #40: 4) and associated incubators. One entrepreneur says: *"[Incubator] offers all opportunity, as well as [innovation network]".* Coming right out of university or existing firms, the entrepreneurs are used to team-work and team management (#32: -3). They also manage to easily access university resourced in terms of training and education (#28: -2) and have no problem in getting in contact with highly qualified engineers (#42: 0). Even more, with their enthusiasm they are not only able to convince these employees to work for their firm (#30: -1), they are also able to convince seed funds (#24: -3) and investors (#22: -2) of their capabilities. Often coming from a very technical background however leads to a lack of product commercialisation and marketing skills (#31: 2) and slight difficulties to find people who possess these skills in their network (#41: 0). Dedication to their graduation project, access to coaching, seed-funding, peers and personnel and good management skills resulted in short product development times and iteration cycles (#0: -2) of their first products.

However, their sole focus on their graduation project led to issues in intellectual property (#6: 3) and a lack of knowledge of the business environment the firm is operating in (#18: 3). As one entrepreneur puts it: *"[Our concept] is new to the market and our target group [of customers] needs to find out what their preferences are".*

The chosen markets are perceived as very fast changing and hard to predict (#13: 2) and there is uncertainty about future technological pathways (#17: 4). This indicates that they do not know enough about the market (or the respective market niche) yet but are very well aware that communication with customers is important. The focus on *'the product'* gives them an edge in being able to rapidly develop minimal viable products but their lack of sufficient marketing skills (#31: 2) gives them a hard time to pin-point the exactly right niche, cross the chasm and find mainstream customers (#12: 3). One entrepreneur says: *"Investors and customers understand our technical and commercial concept really well although that doesn't mean that they immediately want to buy it"*.

In fact, their easy access to education and network even hampers them in some aspects and the entrepreneurs start to realize that *"there is an overkill of network activities, workshops, etc. and the network doesn't get me to my customers"* even though they acknowledge and appreciate the support they received by stating that *"it did help in an early phase".*

5.2.3.3. Interpretation: Negatively correlated start-up

Start-up #25 (IS) is negatively associated with factor two. Compared to the other start-ups, it is not a clean-technology start-up and operates in a well defined niche. Also, the company is already mature and not in the early stages of development anymore. As their market is a relatively specialized niche and comparably young, there is hardly any incumbent industry and therefore no considerable pressure compared to other firms (#14: 1). Also, due to the industry specialisation there is no dependence on commodities and rare resources (#21: -4). The company is well established in its niche and globally active (#12: -3). They possess good market knowledge (#13: -4) and know in which direction technology and market needs are going to develop (#17: -4; #18: -1). Thus the firm represents exactly the opposite to the other firm associated with factor two.

Interestingly, they experience a lack of access to tailored education for all its employees in different disciplines. Due to the size of the company and the already collected knowledge and experience, their focus shifted from training provided by incubators or university to internal training. A senior executive says: *"There is a lack of internal training and a lack of tracking/archiving codified knowledge".* Due to relatively fast expansion and large size, conflicts within the team arise as differences within the team are not perceived as very well managed (#32: 4; #33: 4; #34: 3). As the interviewed executive puts it they often experience for instance *"cultural difference in the way of working"* which leads to conflicts in the team.

Table 16: Crib-sheet factor 2

Items ranked at 4+		
#	**Statement**	**Value**
14	High pressure from incumbent industry (existing regimes pressure on radical entrants)	4
17	Uncertainty about technology pathways	4
21	Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)	4

Items ranked higher in factor 2 array than in any other factor array		
#	**Statement**	**Value**
6	**Problems over intellectual property rights**	**3**
10	**lack of a clear product and development roadmap**	**1**
12	**Little buyer concentration - lack of mainstream customers**	**3**
13	**Fast changing business environment and uncertainties about market developments**	**2**
17	**Uncertainty about technology pathways**	**4**
21	Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)	4
27	Lack of entrepreneurial experience	0
31	Team lacks of sufficient Marketing skills (Product commercialization)	2
41	General lack of personnel with diversified business skills and abilities on labour market (there are simply no people who fit the job)	0

Items ranked lower in factor 2 array than in any other array		
#	**Statement**	**Value**
8	Production capacity issues ("too small to grow")	-1
9	**Long product development process/phase**	**-2**
22	**Lack of organizational legitimacy to investors**	**-2**
23	General lack of accessibility 2nd/3rd state funding (investment) in the industry - funding gap (valley of death)	0
24	General lack of accessibility of seed/start-up/early stage funding (investment) in the industry	-3
28	**High training costs for personnel (time and finance)**	**-2**
30	**Difficulties in attracting highly qualified and competent technical personnel (low wage rates, career development, job security)**	**-1**
32	Team lacks of sufficient Management skills (Financial Management, Team Management, Project Management)	-3
Items ranked at -4		
#	**Statement**	**Value**
34	Lack of strategic vision and alignment	-4
37	Lack of regional innovation network (cluster)	-4
40	Lack access to entrepreneurial education and training	-4
Other relevant factors:		
3	**Limited access to external knowledge bases and sources of information**	**-1**
18	**Uncertainty about user practices**	**3**
25	**Height of required investment**	**0**

Bold type indicates statements with significant loading on the 0.05 level on the factor

5.2.4. Factor three – Innovators eager to grow

5.2.4.1. Overview

Factor three has an eigenvalue of 2.7 and explains 9% of the study variance. Seven start-ups showed significant association with the factor with one having a factor loading of >0.60. The loadings of the firms on factor three can be found in chapter 4.1.3. Six start-ups are or were part of an incubation program and one (#20) is not part of one but closely related. Four of them are spin-offs of university projects. All the founders apart from the ones of firm #18 received some kind of entrepreneurial education prior to starting up or in the first phases of the start-up. However, also start-up #18 was joined by an experienced entrepreneur who brought that knowledge on board from early on. Apart from two firms, all founders either had entrepreneurial experience of some kind before starting up or brought it on board in very early phases. The firms making up factor three are all comparably young and apart from start-up #16 all less than 2 years old. Table 17 contains the start-ups with significant loading on factor three.

Table 17: Start-ups with significant loading on factor 3

#	ID	INC	SPIN	CT	HW/SW/SE	EXP	EDU	YR	EMP
1	AQ	Yes	No	Yes	HW	No	Yes	2012	3
9	PE	Yes	No	Yes	HW	Yes	Yes	2012	3
16	WC	Yes	Yes	Yes	HW	No	Yes	2010	8
17	**AC**	**Yes**	**Yes**	**No**	**SW/SE**	**Yes**	**Yes**	**2012**	**2**
18	DI	Yes	Yes	Yes	HW	Yes	No	2012	4

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20	JS	No	No	No	HW	Yes	Yes	2013	4
22	SS	Yes	Yes	No	SW/SE	Yes	Yes	2013	8

Bold type indicates a factor loading of >0.60

5.2.4.2. Interpretation

The start-ups constituting factor three are *'lean and mean'.* They managed to rapidly bring a minimal viable product (MVP) to the market (#5: -4) and selected a suitable market niche. Even though they compete with established innovation systems and bring radical technologies to the market (#14: 4) they are at first glance well aware of its dynamics (#13: -2, #15: -2). One entrepreneur says *"[we] are working in a market where the old boys' networks rule. We try to break that […]".* Another entrepreneur acknowledges that fact by saying that *"we are bringing clean-tech solution to a problem that is currently solved by fossil fuel technologies. Fossil fuel technologies are not good from environmental perspective but from a performance perspective they are very competitive".* After working on their MVPs, they are currently in a process of scaling up (#8: 3) or improving it in order to sell their products to more early adopters.

However, this poses several challenges to them. While they can rely on their network (#37: -4) to get in contact with investors and to receive coaching (#40: -4), they require help when it comes to negotiating terms and legal issues (#38: 3). One entrepreneur states that *"there are a lot of investors and support in the entrepreneurial activities, but when it comes to negotiation or any other contract thinks, it is hard to find knowledge or workshops for this"*.

They are extensively working on their value proposition to investors (#5: -4; #25: -3; #26: -2) and focus on improving their MVP. That said, they are focusing so much on scaling up (#8: 3; #35: 0; #42: 3) and improving their product (#3: 3; #4: 2) that at the same time the needs of their prospective customers tend to move a bit out of sight (#18: 4). Instead of achieving deeper understanding of how customer needs look like and develop (#18:4) they stick to their initial product development roadmap they use or used to pitch for investment (#10: -3) and do not update their view on market developments (#13:-2). One entrepreneur argues that *"..it is a new market with a new invention. Nobody knows what they would like to get.".* Another entrepreneur admits that this is the case and says that *"we didn't talk to users that much yet"* and *"[…] details are not really understood [by customers]. They just care about the end product or return on investment".* This makes it hard to find the next launching customer (#11: 1). In these times, tensions within the teams build up and cultural differences in how to approach these topics surface (#33: 2).

Table 18: Crib-sheet factor 3

Items ranked at 4+		
#	**Statement**	**Value**
9	Long product development process/phase	4
14	High pressure from incumbent industry (existing regimes pressure on radical entrants)	4
18	Uncertainty about user practices	4

Items ranked higher in factor 3 array than in any other factor array		
#	**Statement**	**Value**

3	**Limited access to external knowledge bases and sources of information**	**3**
4	Lack of technological knowhow to overcome technological problems	2
8	**Production capacity issues ("too small to grow")**	**3**
18	**Uncertainty about user practices**	**4**
33	**Internal difficulties among the team (lack of communication, differences between team members)**	**2**
35	**Lack of organizational legitimacy to suppliers**	**0**
38	**lack of assistance and support when securing funding**	**3**
42	**General lack of personnel with diversified technical skills and abilities on labour market (there are simply no people who fit the job)**	**3**

Items ranked lower in factor 3 array than in any other array

#	Statement	Value
5	**Difficulties in validating technology (developing MVP to acquire funding)**	**-4**
10	lack of a clear product and development roadmap	-3
13	Fast changing business environment and uncertainties about market developments	-2
15	**High pressure from established direct competitors with similar products in the market**	**-2**
19	**Uncertainties about regulatory frameworks - potential shifts in negative direction (e.g. solar subsidies)**	**-1**
25	**Height of required investment**	**-3**
26	**Long payback time, resulting in being unattractive for investment**	**-2**

Items ranked at -4

#	Statement	Value
5	Difficulties in validating technology (developing MVP to acquire funding)	-4
37	Lack of regional innovation network (cluster)	-4
40	Lack access to entrepreneurial education and training	-4

Other relevant factors:

11	**Little buyer concentration - lack of early stage customers**	**1**
21	**Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)**	**0**

Bold type indicates statements with significant loading on the 0.05 level on the factor

5.2.5. Factor four – In the valley of death

5.2.5.1. Overview

Factor three has an eigenvalue of 2.4 and explains 8% of the study variance. Five start-ups showed significant association with the factor and one had a factor loading of >0.60. The loadings of the firms on factor three can be found in chapter 4.1.3. All firms except for #28 are somehow affiliated with incubation programs. Three of them are spin-offs of university projects. All the founders received entrepreneurial education prior to starting up or in the first phases of the start-up and two founders had entrepreneurial experience prior to starting up. However, also start-up #18 was joined by an experienced entrepreneur who brought that knowledge on board and the first employees in start-up #8 also possess entrepreneurial experience. The firms making up factor four are all more than two years old and have all between three and four employees including the founding team. Table 19 contains the start-ups with significant loading on factor three.

Table 19: Start-ups with significant loading on factor 4

#	ID	INC	SPIN	CT	HW/SW/SE	EXP	EDU	YR	EMP
8	OF	Yes	No	Yes	HW	No	Yes	2008	4
19	GM	Yes	Yes	No	SE	Yes	Yes	2010	3
21	**SA**	**Yes**	**Yes**	**No**	**HW**	**No**	**Yes**	**2009**	**4**
23	TM	Yes	Yes	No	HW	No	Yes	2011	3
28	VV	No	No	No	SW/SE	Yes	Yes	2008	3

Bold type indicates for a factor loading of >0.60

5.2.5.2. Interpretation

Even though already existing for several years, the start-ups associated with factor four did not manage to grow substantially yet reflected by their comparably low number of employees and their struggle to raise funding. The entrepreneurs argue that long payback times (#26: 3), the height of the required investment (#25: 4) and a general lack of funding (#23: 2) inhibit them from growing. However, the reason might lie in the fact that the start-ups share that they had difficulties in validating their technologies and took long time to develop their products into a minimal viable product (MVP) (#5: 3; #9: 4). This might be due to a combination of complexity of the product and a lack of knowledge of what customers expect from an MVP. Also, the entrepreneurs experienced a lack of early customers needed to validate their products (#11: 3) and therefore had difficulties to proof their legitimacy as a firm to potential investors (#22: 3). One senior executive says: *"The first stage is most difficult. Once we have a prototype it becomes easier".* At this stage, they do not worry about mainstream customers yet but mainly try to sell to early adopters (#12: 0).

Interestingly, the entrepreneurs are very well seasoned, possessing a lot of entrepreneurial experience (#27: -4) and marketing and management skills (#31: -2; #32: -1). It seems that the firms have not been aware of the dynamics of their markets (#13: 0), did not choose appropriate niches (#14: 4; #15: 1) and thus took too long to develop early versions of the product for launching customers and to pivot accordingly (#5: 3; #9: 4). In fact one entrepreneur acknowledges that *"[we introduce] an unknown technology [to an] unknown market".* Another entrepreneur states that *"originally it was planned to release in February, however due to consistent problems with the [function] and in ever increasing the scope that needed to be redeveloped before being able to launch publicly, we kept on postponing this. This drastically delayed our time-to-market by four months, which also caused subsequent issues in the sales process."* Hence, instead of bringing iterations of the MVP to the market, formulating hypotheses and updating the products with the outcomes (*"build, measure, learn"* as Ries (2011) would put it), the entrepreneurs were busy with adding additional functions and making a complex product from the beginning on.

Maybe the entrepreneurs are, in all their experience, a bit too certain in assuming how technologies will develop in the future and what the market demands (#17: -1, #18:1) instead of continuously listening to their customers and iterating their MVP.

Firms associated with factor four are predominantly high-tech start-ups and do not feel challenged by potential changes in commodity prices (#21: -4) or changes in regulatory frameworks (#19: 1).

Table 20: Crib-sheet factor 4

Items ranked at 4+		
#	**Statement**	**Value**
9	Long product development process/phase	4
14	High pressure from incumbent industry (existing regimes pressure on radical entrants)	4
25	Height of required investment	4

Items ranked higher in factor 4 array than in any other factor array		
#	**Statement**	**Value**
5	**Difficulties in validating technology (developing MVP to acquire funding)**	**3**
11	Little buyer concentration - lack of early stage customers	3
16	Lack of government (and policy) support	2
22	**Lack of organizational legitimacy to investors**	**3**
23	**General lack of accessibility 2nd/3rd state funding (investment) in the industry - funding gap (valley of death)**	**2**
26	**Long payback time, resulting in being unattractive for investment**	**3**
29	**Difficulties in attracting highly qualified and competent business personnel (low wage rates, career development, job security)**	**1**
34	lack of strategic vision and alignment	0
39	Lack of entrepreneurial peers	0
40	Lack access to entrepreneurial education and training	-3

Items ranked lower in factor 4 array than in any other array		
#	**Statement**	**Value**
2	**Knowledge spillover or leakage to other firms**	**-3**
6	**Problems over intellectual property rights**	**-2**
7	Development capacity issues	-3
17	Uncertainty about technology pathways	-1
21	**Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)**	**-4**
27	**Lack of entrepreneurial experience**	**-4**
31	**Team lacks of sufficient Marketing skills (Product commercialization)**	**-1**
36	Lack of organizational legitimacy to customers	-2
43	**long and difficult procedures to employ personnel**	**-1**

Items ranked at -4		
#	**Statement**	**Value**
21	**Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)**	**-4**
27	Lack of entrepreneurial experience	-4
37	Lack of regional innovation network (cluster)	-4

Other relevant factors:		
18	**Uncertainty about user practices**	**1**
12	**Little buyer concentration - lack of mainstream customers**	**0**

Bold type indicates statements with significant loading on the 0.05 level on the factor

5.2.6. Factor Summary

This section provides an overview about an exemplary start-up described by each factor. It has to be noted that the description of the *'typical'* start-up for each factor is fictional as the associated start-ups only correlated to a certain extend.

5.2.6.1. Factor 1 - Clean-tech behemoths

A start-up associated with factor one belongs to the category of *'clean-tech behemoths'*. It is a clean-technology start-up developing complex (#4: 1) and capital intensive (#25: 4) technological products which is already relatively mature in its development. The entrepreneur and his team usually have an affiliation with academia or are at least geographically close to universities and incubators (#37: -4). From early on, the firm strategically worked towards a minimal viable product for a specific target market (#11: -1) and successfully identified a niche in which the entrepreneur positioned the company (#12: -3). Instead of blindly putting a product on the market, the team pivoted several times and adapted their value proposition to the customers' needs (#9: 4; #18:0). Strategic sales to carefully selected early adopters make it easier for the start-up to access mainstream markets. Despite needing cash flow and working capital (#20: 3; #23: 1, #25: 4), the entrepreneur does not rush into unfavourable agreements but remain calm and utilize their network to acquire needed resources and knowledge (#3: -3; #7: 1; #8: 0; #27: -2; #29: -1, #39: -3; #40: -4; #41: -2, # 42: -2).

5.2.6.2. Factor 2 – Raw diamonds

A typical start-up associated with factor two is usually a clean-technology start-up (#14: 4; #21: 4; #19: 2) in a relatively early stage of existence and with relatively inexperienced entrepreneurs (#27: 0; #41: 0) with technical backgrounds (#31: 2). One could also call it *'a raw diamond'*. The probably resulted from a graduation project and the founder and his team are still close to university and/or an incubator (#37: 4; #40: 4; #42: 0). The entrepreneur is young, enthusiastic and manages to engage the people around him (#22: -2; #24: -3; #30: -1). The firm is at present trying to attract launching customers with its first iterations of its minimal viable product (#0: -2) but struggles to take the momentum to the next level of mainstream customers (#12: 3). This is because the target market is not carefully selected as too little is known about the customers yet (#13: 2; #17: 4; #18: 3) and the value proposition needs to be adapted (#31: 2).

Start-ups associated with factor two are one step before becoming a *'clean-tech behemoth'* from factor one and are lacking the analytical approach these start-ups took. Depending on how they develop in the next phase, they will either successfully determine the right market niche and target it with the right value proposition or not be able to *"cross the chasm"* (Moore, 1991). However, they are well aware of the way they want to go and that they need to gain more knowledge before they will be able to access mainstream markets.

5.2.6.3. Factor 3 – Innovators ready to grow fast

A start-up which is associated with factor three is an *'innovator ready to grow fast'*. At least that is the plan. After finishing its business plan (#13: -2, #15: -2) the entrepreneur and his team developed a minimal viable product (#5: -4) and really want to scale up (#8: 3). The entrepreneur seeks investment (#5: -4; #10: -3; #25: -3; #26: -2) and pitches his ideas wherever and whenever possible. The focus lies so much on scaling up (#8: 3; #35: 0; #42: 3) and improving the product (#3: 3; #4: 2) that at the same time the needs of the customers are forgotten (#18: 4; #13:-2). This makes it harder to find launching customers without adapting the MVP (#11: 1).

Start-ups associated with factor three are one step before start-ups associated with factor two. Instead of selecting a suitable launching market and iteratively improving the MVP to the launching customers needs and actually trying it out, the entrepreneurs seem to think two steps ahead and that they have got it all right already. As a result they try to grow too fast, too early.

5.2.6.4. Factor 4 – In the valley of death

A start-up associated with factor four already exists for some time and the entrepreneurs are rather experienced (#27: -4; #31: -2; #32: -1) but did not manage to get off the ground substantially (#12: 0). It is somehow trapped *'in the valley of death'*. That does not mean that diffusion in mainstream markets will never happen, but certainly it could have gone faster. The entrepreneur believes that a lack of funding is the cause of this stagnation (#23: 2; #25: 4). However, it seems that in fact a misinterpretation of market needs (#17: -1, #18: 1) and a too detailed product development (#9: 4) with too little iterative steps (#5: 3) made it difficult to find suitable launching customers (#11: 3), win ground in the chosen niche (#14: 4; #15: 1) and to convince potential investors (#22: 3).

Start-ups associated with factor four missed to continuously ask for and implement feedback from the market. They took too long to choose a certain market segment which made it difficult to find launching customers and investors. Especially start-ups which are currently associated with factors two and three are prone to follow that direction. Even though a lot of time is lost, it is usually not too late to pivot and start listening to the customer again.

6. Conclusions

In this chapter, the emerged factors are used to give answers to the research questions as introduced in chapter 1.4.

6.1. Research question one (Q1)

> ***Q1:*** *What are common challenges that entrepreneurs in high-technology and clean-technology start-ups face?*

Based on the conducted research, four different profiles with different sets of challenges emerged. However, as introduced in chapter 5.2.1, three consensus statements, applicable for all observed high-technology and clean-technology start-ups, emerged (#1, #14, #20). Two of which showed significantly positive z-scores (#14, #20) and one (#14) was significant on the 0.05 level. A table with the consensus statements can be found in table 15 in chapter 5.2.1. In the following paragraphs each of these statements will be briefly discussed.

> ***Statement #5: Lack of knowledge spillovers***
> Statement five refers to a lack of knowledge spillovers from other firms. As argued in earlier sections, literature identified a strong correlation between knowledge spillovers and entrepreneurial activity (Acs et al., 2008). Across all factors, the respondents indicated that a lack of knowledge spillovers is something they do not consider as being of overly importance (avg. #1: 1). However, this does not give information over whether or not there is a lack in knowledge flow from incumbent firms. Although the shared perception of statement five does not reveal if a lack of knowledge spillovers is a challenge for the entrepreneurs, it

1 shows that the concept is widely unknown or even neglected and at best intuitively used. Even though not significant on the 0.05 level, this is especially interesting when looking at how the entrepreneurs came up with their ideas prior to starting up. A high number of start-ups participating in this study resulted out of research projects or are somehow else affiliated with universities or larger firms. Actively *'seeking'* these spillovers in a systematic way to identify opportunities in combination with a creative thinking process on how to valorise them might be beneficial for the start-ups. Additionally it might also be in the interest of the *'knowledge creators'* to have entrepreneurs valorise ideas which cannot be exploited internally.

Statement #14: High pressure from incumbent industry

All start-ups in the P-set agreed that they suffer from high pressure from incumbent industry. The z-score of this statement for each factor was between 1.44 and 2.12 which ranked it as in average most important between all factors.

However, the agreement with statement #14 can be interpreted differently for the factors. The start-ups associated with factor one are all clean-tech start-ups and very consciously chose a market niche they want to operate in. Even though they still perceive pressure by the incumbent industry due to large existing investments in incumbent infrastructure or strongly entrenched patterns of use, they positioned themselves in a way to not directly compete with them. Instead they aim to occupy niches in which they can add superior value compared to established solutions. A similar pattern was observed with start-up #25 (factor two). In this case however, the market on its own is relatively immature and the firm managed to position itself in this niche from early on.

2 Similarities between factors one, two and three can be observed. Similar as the start-ups of factor one, start-ups associated with factor two and three seem to be well aware of the importance of choosing the right niche. They spend large efforts on developing a minimal viable product but sometimes seem to lose the goal – to give answers to customer needs– out of sight. In that aspect they are on an earlier stage of development compared to the firms associated with factor one.

Firms associated with factor two often already sell to early adopters but did not manage to cross the chasm to mainstream customers yet as they have to compete with proven and established solutions in that segment of the market. A narrower focus and more strategic approach could help them to establish themselves in that customer group as well.

Firms associated with factor three seem to be even one step behind the start-ups of factor two in their life-cycle. They are just finishing to develop their minimal viable product and at the same time focus on growth and raising investment. Instead focusing on re-assessing the market and iteratively improve their minimal viable product. In that sense they might be too eager to grow immediately at any cost instead of analytically selecting suitable market segments and strategically move forward.

Contrary, start-ups in factor four did not manage to find a unique niche. As a result they are competing with established solutions or beliefs or operate in niches which are only very small. Not consciously choosing a distinct market segment and target customer or doing so too late caused them to spend a long time on developing a minimal viable product and inhibited their growth.

Statement #20: Long sales cycles

Even though all factors acknowledged statement #20 as being important (z-scores between

3 0.83 and 1.39), the association was not significant on the 0.05 level. However, the correlation with statement #14 indicates that selection of an appropriate niche in which a maximum of value is added allows minimizing sales cycles. Nevertheless it has to be stated that this assumption is not significantly supported by the data and demands further research.

6.2. Research question two (Q2)

Q2: *Is there a difference in perception and prioritization of challenges between entrepreneurs in different high-technology start-ups and specifically clean-technology start-ups?*

Furthermore, several propositions were formulated:

P1: *There is a difference in challenge perception and prioritization between clean-technology and other high-technology start-ups*

P2: *There are differences in challenge perceptions between hardware, software, service start-ups due to their different contexts.*

P3: *Start-ups with similar context perceive similar challenges.*

The answer is: Yes, there are differences. However, they need to be looked upon in a differentiated way.

P1: It was observed that compared to other high-technology start-ups, clean-technology start-ups most often operate in heavily regulated markets and are often dependent on commodity prices and policies. This observation is in line with the theoretical definition of clean-technology start-ups as introduced in chapter 2. However, it has to be noted that not all clean-technology start-ups suffer from these contextual elements. Some managed to find niches which are currently almost unregulated and in which they are already able to successfully compete with incumbent technologies. Introduction of regulations would even be in their favour.

P2: No significant difference in challenge perception or prioritization was found between hardware, software and service start-ups. The kind of industry the start-up could not be identified to be the main moderating factor in the context of a start-up. Tendencies of hardware start-ups towards higher-needed investments compared to software and service start-ups were found. Also, several hardware entrepreneurs stated that *"all the investment goes to apps nowadays anyway".* However, no significant difference emerged based on the conducted analysis. Further research is needed to gain further insight into this topic.

P3: Four significant factors describing start-ups with common challenges were found. Instead of hardware, software or service start-ups being the main determining factor in how the context and challenges of a start-up look like, a more holistic picture emerged. Connections between contextual elements were observed to be much more complex than just being reduced to industry, educational background or product.

Analogies with van Vredes (2012) work on project management practices in high-technology start-ups were found and the findings of this thesis expand on them. Van Vrede argues that while some start-ups are still in a process of validating their business model (*"searching")* or developing their technologies (*"developing technology")*, some firms are already further in their lifecycle and are ready for market entry (*"entering market")* (van Vrede, 2012). While Van Vrede refers to project management practices in hardware start-ups, the findings of this thesis expand that perspective on the life cycle of high-technology start-ups in general. While the *"searching phase"* is predominantly about finding the right business model and the right market, firms in the *"developing technology phase"* try to develop a minimal viable product according to the target customers needs with the goal to come up with a final design. This process follows several iterative steps and feedback loops and results in a proven and standardized product which is accepted by launching customers and ready to roll out. In the last phase, the *"entering market"* phase, the product is then marketed to mainstream customers. The research conducted in this thesis shows that start-ups in each phase face different challenges as the context of the firm continuously transforms. This is in line with Van Weele's (2012) theory that needs and challenges of a start-up change over its lifecycle and with its level of maturity.

Factor one (clean-tech behemoths) contains start-ups which already beyond developing a minimal viable product in several iterative steps. The sold their products to launching customers in a consciously chosen niche and successfully moved to the very end of the searching and developing technology phase. As they are entering the *"entering market phase"*, their main challenge is to scale up their capacities in a sustainable way and they need capital to do so. Contrary, start-ups in the early searching and technology development phases need to balance between speed to market and careful preparation. Entrepreneurs in this phase need to be aware of the importance to find the right niche and develop a minimal viable product which enables them to get first customer feedback as soon as possible. The early phases describe an iterative back and forth between the searching and the developing technology phase, similarly as described by Ries (2011).

Start-ups associated with factors two (raw diamonds) and three (innovators eager to grow) are usually in the middle of this phase and strive to cross it towards introduction into mainstream markets. Raw diamonds are in a process of switching back and forth between searching and technology development and will (or will not) eventually find the right market for entering. They are well aware that they still lack knowledge and skills and try to acquire them. If they are able to move to the next stage is dependent on how well they are able to position themselves in the market. Innovators eager to grow think that they already identified the right niche and try to aggressively expand into it. However, by focusing too much on entering the market, they overlooked an offset between actual market needs and their value propositions which hampers their diffusion and ability to expand. In that aspect they are lacking behind start-ups associated with factor one (who already found their niche) and factor two (who are well aware of the fact that they have to keep pivoting).

Firms associated with factor four (in the valley of death) are such which are stuck in the searching and technology development phase. They did not acknowledge the iterative process between these phases sufficiently and therefore lack momentum. As a result they have difficulties to verify their business models and stagnate in their growth. Surfacing challenges are often of financial nature.

However, they can be understood as a direct result of an offset between the start-ups value proposition and the market needs.

Knowing in which phase a start-up currently is helps to directly pin-point specific challenges and needs of the entrepreneur. It allows to create awareness of necessities like acknowledging the importance of continuously pivoting between searching and technology development.

6.3. Summary of results

This chapter summarizes the scientific results and conclusions. Suggestions for further directions of research are given and limitations of the research are explicitly pointed out.

6.3.1. Scientific results and conclusions

In Chapters 1 and 2, it was argued that high-technology start-ups and particularly clean-technology start-ups play an important role in providing a sustainable future and contribute to economic growth. It was pointed out that start-ups need to overcome different challenges posed by their context by choosing certain strategic activities. The elements in the context of a start-up and how they are dealt with by choosing suitable strategies was found to have an impact on new venture performance (NVP). Understanding the context and the challenges start-ups face was therefore found to be crucial in supporting the entrepreneur in his strategic decision making process.

This thesis contributed to that field in several ways. First, it was shown that indeed the context of a start-up determines the challenges the start-up faces and NVP as implied by Welter (2011) and Zahra (2007). Elements like proximity to innovation networks, incubators and universities, education of the entrepreneur etc. build a complex contextual web and influence the ability of the firm to pivot between *"searching"* and *"technology development"* to finally *"enter the market*" as found by Van Vrede (2012) or implied by Ries (2011) and Blank (2013). The example of the four emerged factors indeed shows that entrepreneurs take decisions on strategic activities based on their perceived context as indicated by different scholars (Child, 1972; Starbuck, 1976; Weick, 1979 as cited by Gartner, 1985). While entrepreneurs associated with factor one (clean-tech behemoths) acknowledge the importance of continuous iteration and strategic niche management, entrepreneurs associated with factor four (in the valley of death) often seem to neglect this. This might be due to contextual factors like the experiences they made prior to starting up, their social network or simply their personality. In fact, not only challenges were found to force the entrepreneur to choose certain strategic activities, these activities again lead to certain challenges and path dependencies.

Second, it was shown that certain strategic activities like rapid development of a minimal viable product (as suggested by Ries (2011) and Blank (2013)), constant evaluation of market feedback, careful selection of a niche and a sound market entry strategy (as implied by Moore (1991)) are important elements in new ventures strategies. Interestingly, similar results were found by Gartner et al. (1998) who found niche strategies and choice of growth markets to be significantly associated with survival of the venture. Even though these activities do not guarantee the *'success'* of a start-up, a steady growth in the number of employees, early sales to strategically important launching customers and subsequent smooth entry into clearly defined mainstream markets indicate a likely future success and are expected to positively influence NVP and survival of the firm.

6.3.2. Practical results and conclusions

In this section it will be reflected on the implications of the research findings for incubators, innovation networks and start-ups. A connection between the research and the practical relevance of the topic introduced in chapter one is made.

Recommendations for incubation programs and innovation networks

As argued in section 2.6, incubators aim to optimize the performance of start-ups by shaping the context of a start-up in the most beneficial way. Similar to the observations of Van Weele (2012), the research conducted in this thesis showed that a *"one size fits all"* approach is not the optimum as start-ups encounter challenges dependent on complex relations in their context. However, four different profiles of start-ups emerged, each with specific challenges as introduced in parts four and five of this thesis. Hence, when a start-up is identified to being associated with one of the factors, appropriate support measures should be undertaken. For instance, the iteration cycles between searching and technology development of start-ups associated with factor one can be accelerated when they are taught on how to better communicate the added value of their complex products to the customers. Entrepreneurs in start-ups associated with factor two should be supported in choosing the right niche market and showed how to market their products to mainstream customers (e.g. Moore, 1991). Start-ups associated with factor three should be encouraged to focus on delivering the right product to the right customer instead of investing all resources on early growth. The goal is to support start-ups associated with factor two and three do develop into start-ups associated with factor one and not into start-ups of factor four. Start-ups associated with factor four should be confronted with their shortcomings and encouraged to reflect on their situation and to take appropriate measures to change it.

All these advice should be considered with care. As stated in section 2.6 of the thesis, Trott et al. (2008) argue that support measures by incubators might even hamper start-ups. They note that overly supported entrepreneurs might not able to develop a sense of independence and therefore run into difficulties when on their own after graduation from the incubator.

Recommendations for policy makers

Even though not in the focus of this thesis, it was found that policy makers play an important role in championing clean-technologies. Similar as implied by literature (Kemp & Volpi, 2008; Schot, 1992), the research conducted in this thesis showed that start-ups, and in particular clean-technology start-ups, suffer from high pressure from incumbent industry and innovation systems. Based on the findings of this thesis, policy makers should support clean-technology start-ups in order to bring their technologies to the market. Clear goals on what is to be achieved by a shift towards clean-technologies should be formulated. Subsequently, backcasting (Quist & Vergragt, 2006) and constructive technology assessment (Schot, 1992) could be applied. Following innovation systems theory, policy makers should enhance the diffusion of disruptive technologies by providing protected niches (Geels, 2002; Verbong & Geels, 2007). In these niches emerging technologies could develop until they are ready to compete with established technologies.

Recommendations for start-ups

Start-ups should look at the emerged factors and critically assess their own situation compared to the example start-ups presented in the research. Discussing their situation with third persons like other entrepreneurs is expected to help them becoming aware of potential shortcomings and future

pathways in their choice of strategic activities. Furthermore, several strategic activities emerged as being beneficial as a result of this thesis. Proximity to the customers, development of minimal viable product and an iterative product development cycle with feedback loops were found to benefit the firms in terms of perceived challenges. Moreover, the results of the research conducted in this thesis can serve entrepreneurs to anticipate future challenges and from early on work towards mitigating risks associated with them.

6.4. Further research

The research conducted in this thesis showed that certain contextual elements influence the challenge perception and hence the choice of strategic activities. By employing Q-methodology to identify shared viewpoints of groups of start-ups and entrepreneurs, a holistic picture of what challenges entrepreneurs face and the bilateral relation between challenges and strategic activities was drawn. However, the research in this thesis did not aim to analyze certain challenges more specifically and in detail. Especially the connection between long product development times and proximity to the customer is one which is expected to be worthwhile looking deeper into. Relations between proximity to the market and the customer (e.g. in terms of amount of iterative product development cycles) and times until sales to mainstream customers could help understand this phenomenon. Why do some entrepreneurs acknowledge the importance of iterating between searching and technology development while others do not? Are there any methodologies which make this process more likely to be successful? Ries (2011) and Moore (1991) already contributed to understanding this field in a rather intuitive way but lack scientific depth when it comes to explaining why these mechanisms are in place and how exactly they work.

Furthermore, the contextualisation of new ventures is still relatively unexplored as argued in academic literature (Welter, 2011; Wiklund et al., 2011; Zahra, 2007). Even though this thesis stresses that the context of a start-up is crucial for its development and the strategic choices of the entrepreneur, it fails to carve out causal relationships between certain contextual elements.

6.5. Limitations

As argued in chapter three, Q-methodology is not suitable extrapolate the characteristics of the whole population but aims to reveal general viewpoints and extremes which allow further in-depth exploration and a starting point for developing further hypotheses. Replicability instead of generalizability stands in the focus of Q-methodology which is reflected by several deliberate choices taken during the analysis process (e.g. choosing orthogonal factor rotation instead of oblique rotation). Furthermore, Q-methodology relies on convenience sampling as it works best in revealing the viewpoints of a certain group of respondents. Hence the P-set was chosen amongst Dutch high-technology and clean-technology start-ups. The researcher tried to pay special attention to clean-technology start-ups in incubation programs as these were earlier observed to play an important role in the sustainable development of the country. However, this means that other technology start-ups from outside incubators may have been underrepresented in the study.

Furthermore it has to be noted that the emerged factors by no mean fully apply to every associated start-up. Clean-technology behemoths (factor one) have no guarantee to be successful and start-ups which are currently in the valley of death (factor four) may as well be the rising stars of the future. The factors indicate how structured and analytical the start-ups are moving forward by choosing certain strategic activities which was agued to be an indicator of potential success.

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9. Appendicies

9.1. A1

Table 21: Challenges from literature review

Challenge	Source
Technological uncertainty	
Lack of knowledge spillover or leakage from other firms.	(Thompson, Herrmann, Stam, & Hekkert, 2011), (Chen, Liu, & Tao, 2012)
Knowledge spillover or leakage to other firms.	(Thompson et al., 2011)
Limited access to external knowledge.	(Freel, 2000)
Lack of technological knowhow.	(Freel, 2000)
Difficulties in validating technology.	(Freel, 2000)
Difficulties in IP protection.	(Freel, 2000)
Too small production capacity.	(Fielden, Davidson, & Makin, 1997)
Market uncertainty	
Little buyer concentration – early customers	(Roure & Keeley, 1990), (Stein, 2012)
Little buyer concentration – mainstream customers	(Stein, 2012)
Uncertain business environment.	(Roure & Keeley, 1990)
High competition from similar companies as ours.	(Busenitz & Barney, 1997)
Lack of government (and policy) support.	(Freel, 2000), (Ghosh & Nanda, 2010)
Uncertainty about technology pathways.	(Coenen & Avdeitchikova, 2011)
Uncertainty about user practices.	(Coenen & Avdeitchikova, 2011)
Uncertainties about regulatory frameworks.	(Coenen & Avdeitchikova, 2011)
Lack of financial resources	
Lack of organizational legitimacy to investors.	(Thompson et al., 2011), (Delmar & Shane, 2004)
No 3nd/4rd stage funding available.	(Freel, 2000)
No early stage funding available.	(Freel, 2000)
High investment required.	(Leamy, 2000), (Stein, 2012), (Ghosh & Nanda, 2010)
Long payback time for investors.	(Freel, 2000), (Stein, 2012), (Ghosh & Nanda, 2010)
Lack of human capital	
Lack of entrepreneurial experience.	(Duchesneau & Gartner, 1990), (Delman & Shane, 2006)
High training costs for personnel.	(Freel, 2000)
Difficulties in attracting highly qualified and competent business personnel.	(Freel, 2000), (Thompson et al., 2011)
Difficulties in attracting highly qualified and competent technical personnel.	(Freel, 2000), (Thompson et al., 2011)
Team lacks of sufficient Management skills.	(Freel, 2000)
Internal difficulties among the team.	(Kotelly, 2012)
Lack of strategic vision and alignment.	(Kotelly, 2012)

Lack of organizational legitimacy to suppliers.	(Thompson et al., 2011), (Delmar & Shane, 2004), (Howard E Aldrich & Fiol, 1994)
Lack of organizational legitimacy to customers.	(Thompson et al., 2011), (Delmar & Shane, 2004), (Howard E Aldrich & Fiol, 1994)
Lack of social capital	
Lack of regional innovation network.	(Freel, 2000)
Lack of assistance and support when securing funding.	(Fielden et al., 1997)
Lack of entrepreneurial peers.	(Duchesneau & Gartner, 1990), (Hitt & Bierman, 2001)
Lack of access to entrepreneurial education and training.	(Hitt & Bierman, 2001)
General lack of personnel with diversified business skills and abilities on labour market.	(Duchesneau & Gartner, 1990), (Freel, 2000), (Hitt & Bierman, 2001)
General lack of personnel with diversified technical skills and abilities on labour market.	(Duchesneau & Gartner, 1990), (Freel, 2000), (Hitt & Bierman, 2001)

Table 22: Challenges from exploratory interviews

Challenge	Source
Technological uncertainty	
Too little product development capacity.	Interview entrepreneur I&II
Long product development process/phase.	Interview entrepreneur I & II & III
Market uncertainty	
High competition from incumbent industry.	Interview entrepreneur III
Long sales cycles.	Interview entrepreneur I
Supply/Demand shocks in commodities.	Interview entrepreneur III
Lack of human capital	
Team lacks of sufficient product commercialisation skills.	Interview entrepreneur II & III
Lack of social capital	
Long and difficult procedures to employ personnel.	Interview entrepreneur I

Table 23: Paraphrased statements of the Q-set

#	Challenge	Paraphrased statement
Technological uncertainty		
1	Lack of knowledge spillover or leakage from other firms.	There is too little knowledge flow **from other firms to our firm**. We could benefit from this free knowledge.
2	Knowledge spillover or leakage to other firms.	There is too much knowledge flow **from our firm to other firms**. Other companies are "free-riders" and benefit from knowledge paid for by our firm.
3	Limited access to external knowledge.	We **lack access to external databases** (e.g. journals) or access to external sources of information would come at a too high cost.
4	Lack of technological knowhow.	We are facing **technological problems** in our

		product development and don't have sufficient knowhow to overcome them.
5	Difficulties in validating technology.	We have difficulties to **prove our technical and commercial concept** to investors and customers.
6	Difficulties in IP protection.	We **cannot protect our intellectual property** and are afraid that other companies will copy us in the future.
7	Too little product development capacity.	Our **production capacity** is not able to keep up with demand which results in missed opportunities and unsatisfied customers.
8	Too small production capacity.	Our **product development capacity** is not able to keep up with demand which results in missed opportunities and unsatisfied customers.
9	Long product development process/phase.	Our **product development takes much longer than expected** and the time until we can start selling is postponed.
10	Unclear product development roadmap.	We are **lacking a clear product development roadmap** and are not sure in which direction we are heading.
Market uncertainty		
11	Lack of early stage customers	We **cannot find** enough **potential customers** who are willing to buy **the first versions of our product** (minimal viable product) as launching customers.
12	Lack of mainstream customers	We **cannot find** enough **potential customers** who want to buy **proven, standardized solutions** without high level of customization.
13	Uncertain business environment.	Companies are constantly entering and leaving the market and the **business environment is continuously changing.**
14	High competition from incumbent industry.	Our radically different products have to **compete with traditional and long established firms, technologies and products.**
15	High competition from similar companies as ours.	The **market is very competitive** with a lot of other companies who also introduce new products that satisfy similar needs as ours.
16	Lack of government (and policy) support.	There is **not enough support by governments and policy makers** in our sector in terms of subsidies, new standards etc. Policy support in our favour would help us to compete.

17	Uncertainty about technology pathways.	There are **several competing technologies** on the market and it is unclear which one will be established as the standard which causes **uncertainty**.
18	Uncertainty about user practices.	It is **uncertain** what **user preferences** are **at present** and how they will develop **in the future**.
19	Uncertainties about regulatory frameworks.	Radical changes in regulations (e.g. termination of subsidies) might have a significant **negative impact** on our sector and our business.
20	Long sales cycles.	We have problems because **sales cycles in our industry are very long and complicated** (government tenders etc.).
21	Supply/Demand shocks in commodities.	Drastic changes in commodity prices (electricity, oil, rare metals,..) could have a negative impact on our business.
Lack of financial resources		
22	Lack of organizational legitimacy to investors.	We are incapable of **convincing potential investors that our organization is credible** (trustworthy, capable).
23	No 2nd/4rd stage funding available.	We have first customers and want to **scale up** but there is **not enough 2nd/3rd stage investment capita**l available in our sector.
24	No early stage funding available.	There is **too little early stage/seed funding available** in our sector.
25	High investment required.	The **investment** we would need is relatively **large** which makes it difficult to attract.
26	Long payback time for investors.	**Long pay back times** on investment makes it difficult to attract investors.
Lack of human capital		
27	Lack of entrepreneurial experience.	We are lacking **entrepreneurial experience**. Having that would help us in difficult situations.
28	High training costs for personnel.	We know which **skills** we are lacking in our team but it is **too cost and time intensive** to acquire them.
29	Difficulties in attracting highly qualified and competent business personnel.	We are **not able to attract** highly qualified or high profile **business personnel** as we are not able to offer sufficient compensation, job security etc.
30	Difficulties in attracting highly qualified and	We are **not able to attract** highly qualified or

	competent technical personnel.	high profile **technical personnel** as we are not able to offer sufficient compensation, job security etc.
31	Team lacks of sufficient product commercialisation skills.	Our team lacks sufficient **product commercialisation skills** (e.g. sales, marketing).
32	Team lacks of sufficient Management skills.	Our team lacks sufficient **management skills** (e.g. financial management, team management, project management).
33	Internal difficulties among the team.	Internal difficulties within the team (e.g. lack of communication, personal differences) might become a challenge for our firm.
34	Lack of strategic vision and alignment.	The **vision** of our company is **not fully aligned** within the founding team.
35	Lack of organizational legitimacy to suppliers.	We **cannot convince potential suppliers of our credibility** (trustworthy, capable**) as an organization**.
36	Lack of organizational legitimacy to customers.	We **cannot convince potential customers of our credibility** (trustworthy, capable) **as an organization**.
Lack of social capital		
37	Lack of regional innovation network.	There is **no innovation network** (other start-ups, universities etc.) available to us.
38	Lack of assistance and support when securing funding.	There is **not enough support** and assistance and **in fundraising** available. (contact initiation, network sharing, negotiation of terms, legal issues..)
39	Lack of entrepreneurial peers.	There is a **lack of entrepreneurial peers** who support us, share their experiences and provide us valuable feedback.
40	Lack of access to entrepreneurial education and training.	We **lack access to entrepreneurial education and training**.
41	General lack of personnel with diversified business skills and abilities on labour market.	We cannot find personnel with **qualified business skills** in our private and professional network.
42	General lack of personnel with diversified technical skills and abilities on labour market.	We cannot find personnel with **qualified technical skills** in our private and professional network.
43	Long and difficult procedures to employ personnel.	Administrative efforts to **employ personnel** are very **time intensive and complicated.**

9.2. A2

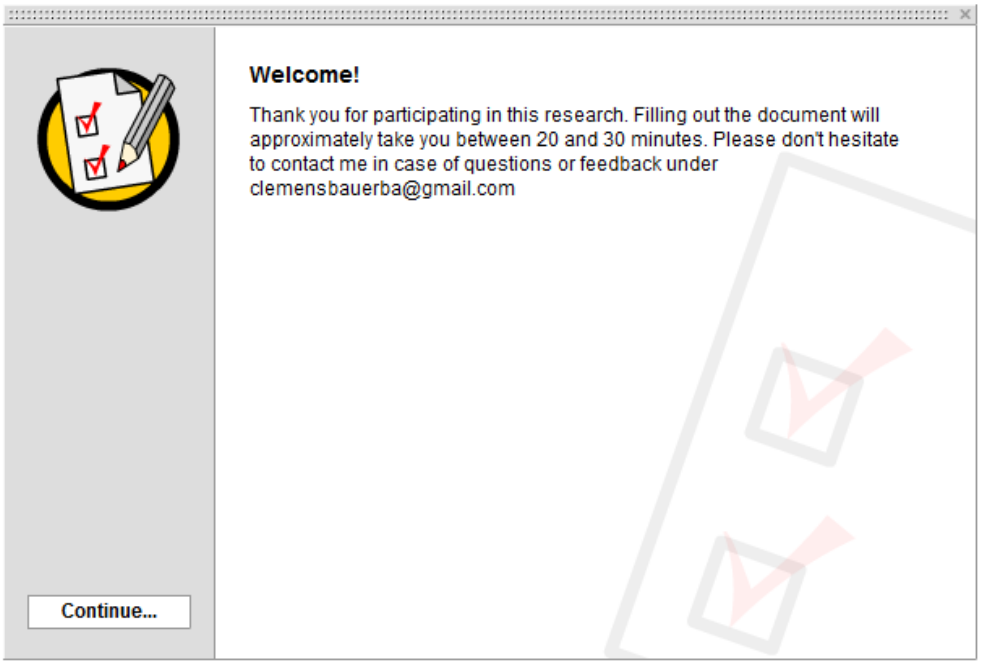


Figure 16: FlashQ - Start window

Step 1: Pre-sorting

1

When opening the software, a short introduction gave insights on the background of the research, information on the approximate duration and some instructions on how to use the tool. Subsequently the statements were presented to the respondents one by one. They were to be dragged into one of three piles, disagree, neutral or agree. This rough pre-sorting was expected to make the actual Q-sorting more convenient and allowed for a first segmentation of the statements.

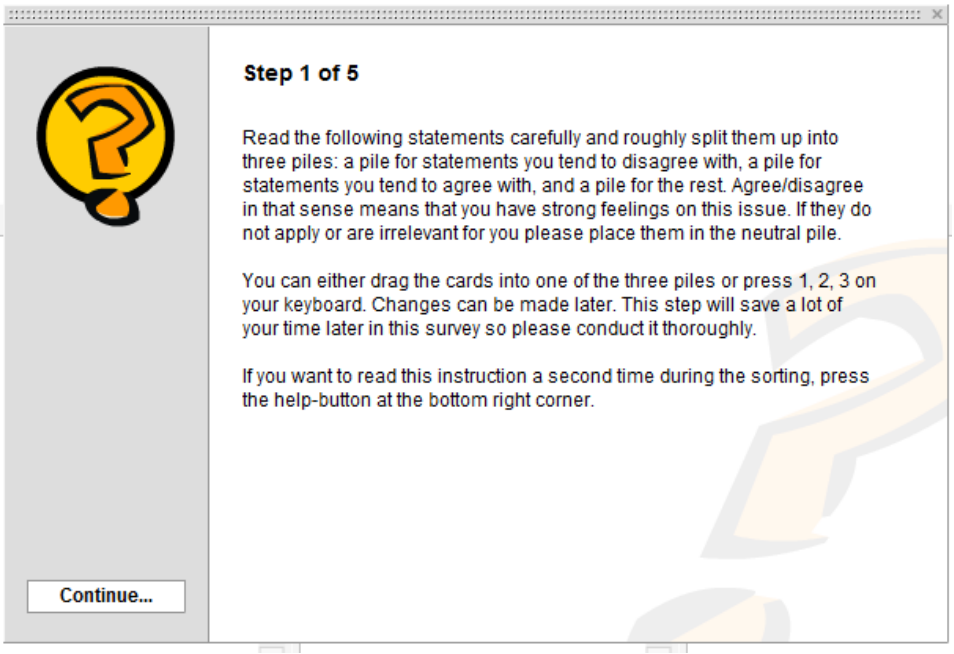


Figure 17: FlashQ - Step1/5

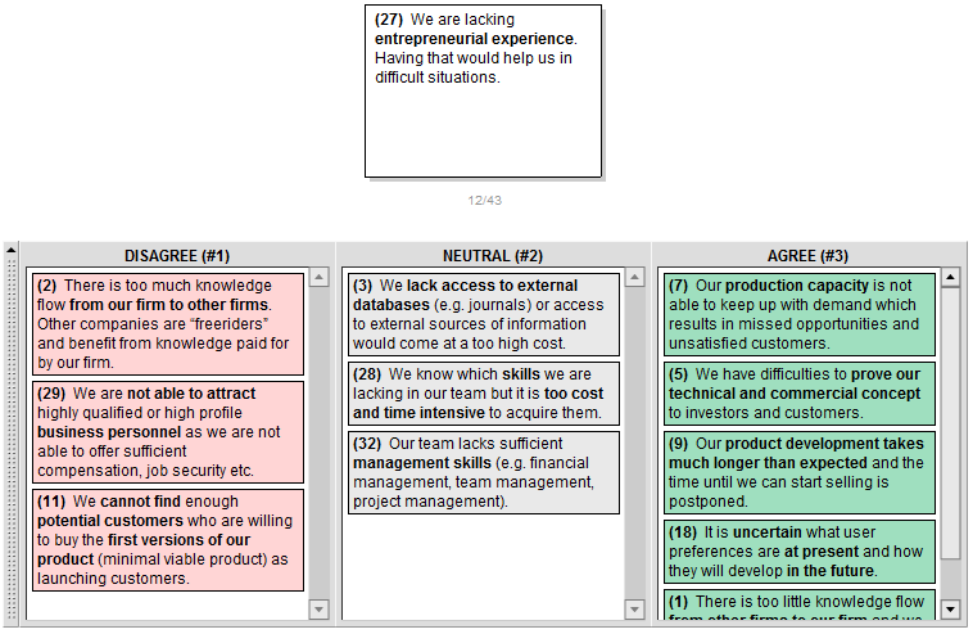


Figure 18: FlashQ - Step1/5 - Pre-Sorting

Step 2: Q-sorting

2

In the following step, the respondents were asked to go through the statements in the agree pile again one by one and choose the two statements which they agreed most with and drag them into the very right boxes on the 'strongly agree' side. This step was to be repeated for the two statements the respondents disagreed most with. These two statements were to be dragged in the boxes on the very left side, the 'strongly disagree' side of the diagram. Subsequently these steps were to be repeated for the statements the respondents second most agreed or disagreed with until all of them were placed on the board and so on. In the end all 'neutral' statements were asked to be placed in the remaining empty fields of the board.

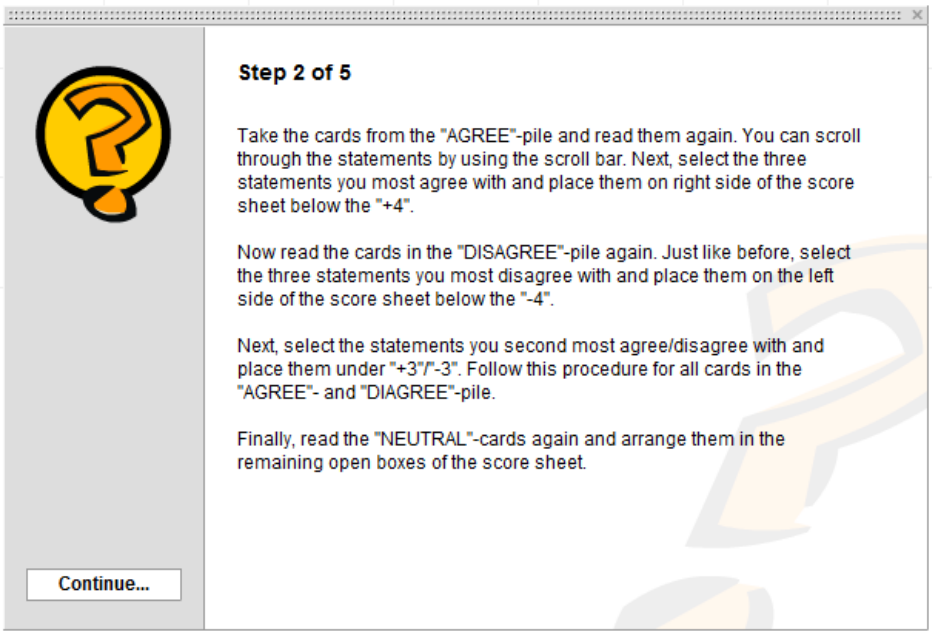


Figure 19: FlashQ - Step 2/5

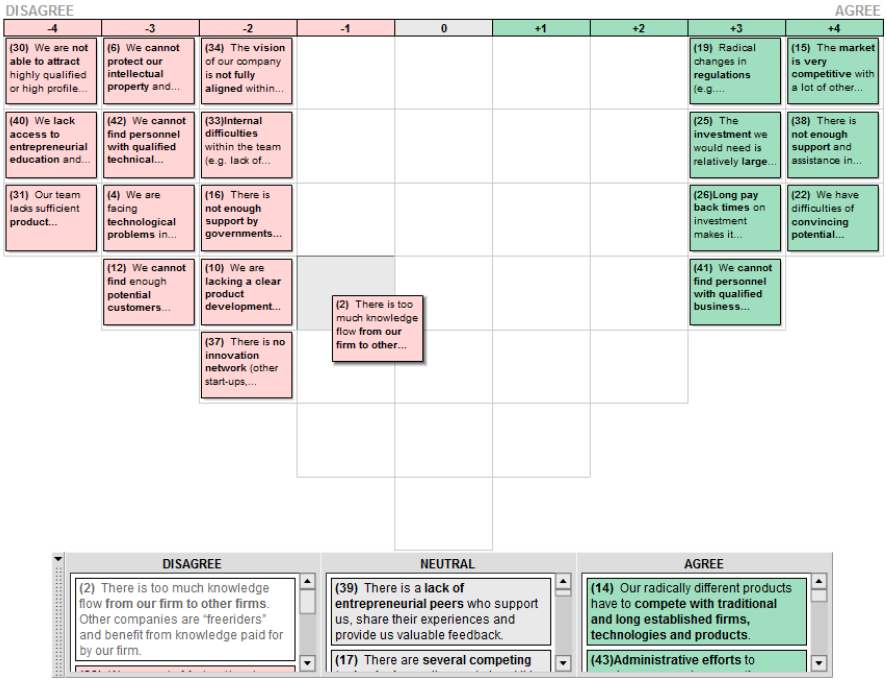


Figure 20: FlashQ - Step 2/5 - Q-Sorting

Step 3: Re-arrangement

3

In Step 3, the respondents were asked to have a look on the extremes again and control if the distribution really matches their preferences. The respondents were then able to rearrange the statements if the felt the need to do so.

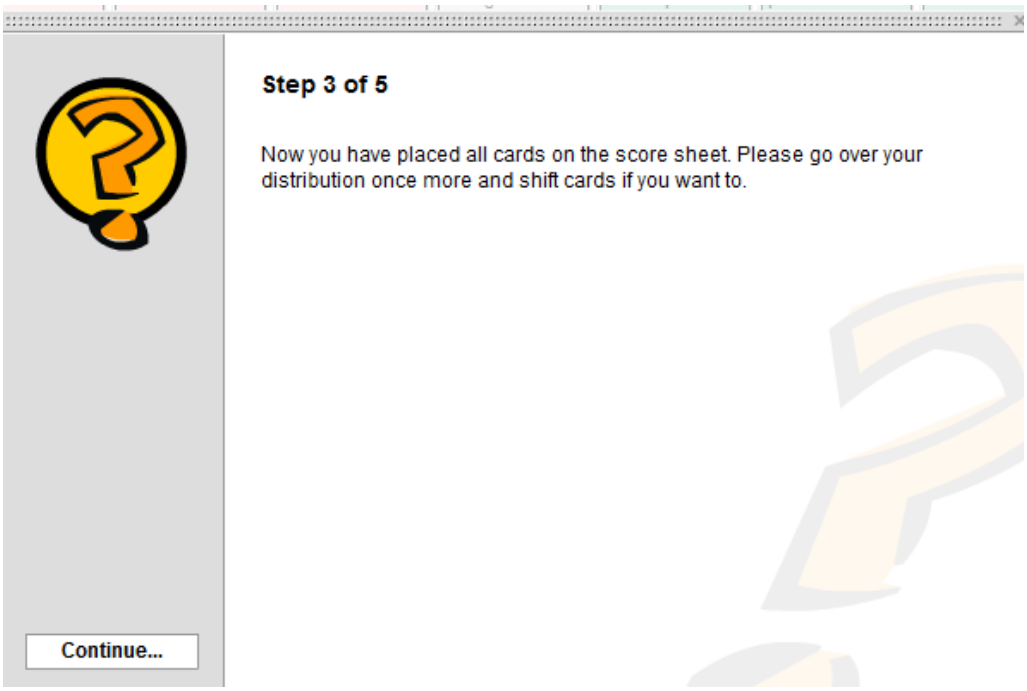


Figure 21: FlashQ - Step 3/5 – Re-arrangement

Step 4: Justification of choice

4

After finishing step 3, the respondents were asked to justify on their choice of the statements they agreed and disagreed most with. This step was optional to minimize the needed time for the respondents and used as an addition to the talks held with several respondents after the Q-sorting.



Figure 22: FlashQ - Step 4/5 - Justification of choice

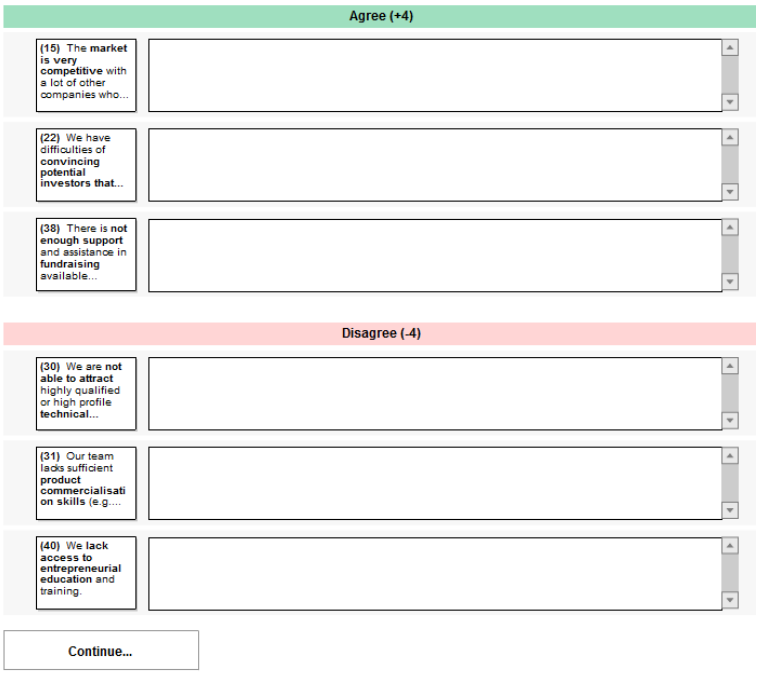


Figure 23: FlashQ - Step 4/5 - Justification of choice

Step 5: Additional Information

5

In the fifth and last step, the respondents were asked to give some further information on their demographics. This information was used to find shared viewpoints between respondents with similar attributes.

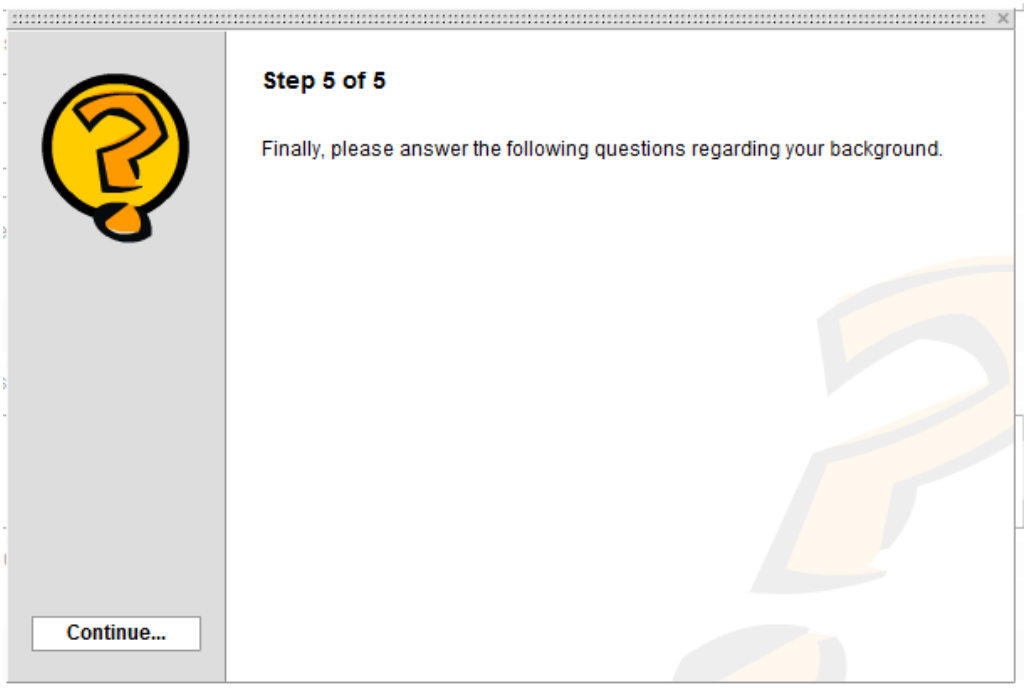


Figure 24: FlashQ - Step 5/5 - Additional Information

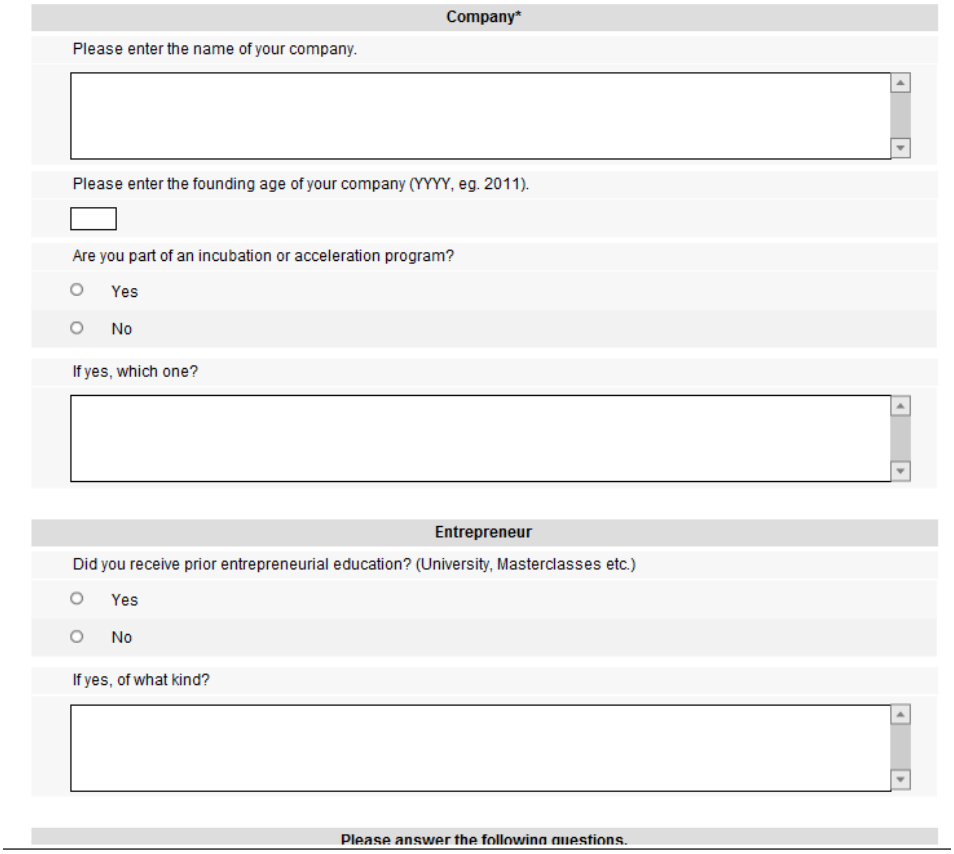


Figure 25:FlashQ - Additional information

9.3. A3

Table 24: Intercorrelation matrix for Q-sorts

Q-sort	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	100	20	20	23	23	24	-5	5	31	8	54	4	11	6	5	26	46	39	31	30	13	32	4	15	4	36	19	27	44	6
2	20	100	34	-5	41	31	31	16	14	21	25	1	-4	5	-4	31	1	18	10	16	19	5	29	20	15	20	34	23	37	2
3	20	34	100	23	56	52	25	11	-9	31	49	10	40	26	20	-2	6	41	11	17	42	19	42	51	-42	44	63	28	43	64
4	23	-5	23	100	24	30	22	16	9	16	25	17	-16	18	33	12	38	15	-2	19	55	13	25	35	19	24	30	20	30	25
5	23	41	56	24	100	36	29	13	14	46	39	11	12	35	29	25	10	17	19	36	40	24	35	32	18	47	39	6	41	47
6	24	31	52	30	36	100	5	9	4	2	29	-4	7	37	10	1	6	22	-6	38	19	17	23	12	-14	35	31	30	31	17
7	-5	31	25	22	29	5	100	18	15	14	8	15	10	8	31	28	15	0	14	1	47	11	18	15	7	25	15	33	32	16
8	5	16	11	16	13	9	18	100	2	1	16	24	-2	25	14	4	-25	4	28	17	47	6	29	2	12	30	0	33	17	-3
9	31	14	-9	9	14	4	15	2	100	17	21	15	10	-7	15	43	19	21	20	30	2	38	10	-12	28	2	-1	26	13	0
10	8	21	31	16	46	2	14	1	17	100	38	10	17	4	40	39	23	25	16	18	28	0	27	48	-10	17	41	-18	49	50
11	54	25	49	25	39	29	8	16	21	38	100	2	36	5	8	38	25	13	19	16	23	34	40	30	-5	33	53	13	48	30
12	4	1	10	17	11	-4	15	24	15	10	2	100	-7	-5	15	1	5	25	27	9	41	-7	12	3	-2	2	9	11	15	13
13	11	-4	40	-16	12	7	10	-2	10	17	36	-7	100	-10	5	12	2	15	24	22	4	33	-3	25	-31	25	33	7	1	27
14	6	5	26	18	35	37	8	25	-7	4	5	-5	-10	100	24	-18	4	5	7	33	29	21	21	0	-6	33	4	8	39	18
15	5	-4	20	33	29	10	31	14	15	40	8	15	5	24	100	36	35	25	0	17	36	27	5	35	-16	8	20	28	44	53
16	26	31	-2	12	25	1	28	4	43	39	38	1	12	-18	36	100	32	10	6	32	2	30	-4	20	15	7	28	5	32	12
17	46	1	6	38	10	6	15	-25	19	23	25	5	2	4	35	32	100	40	16	23	10	28	4	20	-2	-8	11	-4	26	24
18	39	18	41	15	17	22	0	4	21	25	13	25	15	5	25	10	40	100	20	35	19	22	22	35	-25	4	32	25	29	41
19	31	10	11	-2	19	-6	14	28	20	16	19	27	24	7	0	6	16	20	100	31	15	23	29	-3	0	20	0	11	8	14
20	30	16	17	19	36	38	1	17	30	18	16	9	22	33	17	32	23	35	31	100	10	28	11	8	-4	26	13	23	26	18
21	13	19	42	55	40	19	47	47	2	28	23	41	4	29	36	2	10	19	15	10	100	6	40	26	4	47	37	44	41	30
22	32	5	19	13	24	17	11	6	38	0	34	-7	33	21	27	30	28	22	23	28	6	100	8	4	14	2	11	26	9	24
23	4	29	42	25	35	23	18	29	10	27	40	12	-3	21	5	-4	4	22	29	11	40	8	100	12	-4	17	20	22	23	34
24	15	20	51	35	32	12	15	2	-12	48	30	3	25	0	35	20	20	35	-3	8	26	4	12	100	-33	22	51	-16	31	62
25	4	15	-42	19	18	-14	7	12	28	-10	-5	-2	-31	-6	-16	15	-2	-25	0	-4	4	14	-4	-33	100	-10	-30	1	-19	-48
26	36	20	44	24	47	35	25	30	2	17	33	2	25	33	8	7	-8	4	20	26	47	2	17	22	-10	100	42	24	33	12
27	19	34	63	30	39	31	15	0	-1	41	53	9	33	4	20	28	11	32	0	13	37	11	20	51	-30	42	100	16	42	43
28	27	23	28	20	6	30	33	33	26	-18	13	11	7	8	28	5	-4	25	11	23	44	26	22	-16	1	24	16	100	34	5
29	44	37	43	30	41	31	32	17	13	49	48	15	1	39	44	32	26	29	8	26	41	9	23	31	-19	33	42	34	100	36
30	6	2	64	25	47	17	16	-3	0	50	30	13	27	18	53	12	24	41	14	18	30	24	34	62	-48	12	43	5	36	100

9.4. A4

Table 25: Communalities for Q-sorts

Communalities	
Q-sort	**h^2**
1	,828
2	,806
3	,889
4	,824
5	,753
6	,699
7	,626
8	,602
9	,612
10	,778
11	,763
12	,613
13	,823
14	,806
15	,822
16	,794
17	,709
18	,752
19	,731
20	,671
21	,847
22	,796
23	,751
24	,689
25	,811
26	,777
27	,718
28	,857
29	,706
30	,853

Extraction Method: PCA

9.5. A5

Table 26: Extracted Factors - all EVs

Factor	Total EV	% of Variance	Cumulative %
1	7,172	23,905	23,905
2	2,680	8,935	32,840
3	2,493	8,310	41,150
4	1,984	6,615	47,765
5	1,740	5,800	53,565
6	1,624	5,414	58,979
7	1,360	4,532	63,511
8	1,339	4,463	67,974
9	1,207	4,022	71,996
10	1,104	3,681	75,677
11	,932	3,108	78,785
12	,883	2,944	81,729
13	,749	2,498	84,227
14	,689	2,297	86,523
15	,609	2,031	88,554
16	,492	1,639	90,193
17	,466	1,553	91,747
18	,420	1,401	93,148
19	,373	1,244	94,392
20	,355	1,183	95,575
21	,268	,894	96,469
22	,214	,714	97,183
23	,207	,689	97,872
24	,142	,475	98,346
25	,128	,427	98,773
26	,104	,348	99,121
27	,095	,317	99,438
28	,080	,265	99,703
29	,057	,191	99,894
30	,032	,106	100,000

Extraction Method: PCA

9.6. A6

Table 27: Unrotated factor matrix

Component Matrix[a]										
Q-sort	Component									
	1	2	3	4	5	6	7	8	9	10
1	,473	,323	,346	-,306	,107	-,138	,171	-,385	,193	-,202
2	,423	,193	-,104	-,148	-,515	-,046	,015	-,138	-,519	,037
3	,749	-,381	-,236	-,267	,010	,047	-,072	-,063	-,069	,200
4	,483	,139	-,114	,400	,149	-,339	,075	-,236	,413	,170
5	,685	,048	-,112	-,022	-,280	-,130	,212	,345	-,045	,085
6	,485	,034	-,241	-,384	,120	-,446	-,051	-,074	-,175	,075
7	,403	,204	-,180	,348	-,212	,164	-,427	,087	-,053	,062
8	,279	,371	-,492	,047	,037	,299	,028	,095	,113	-,169
9	,247	,548	,440	,009	-,027	,145	-,071	,050	-,141	,090
10	,558	-,265	,242	,300	-,313	,098	,273	,212	-,074	-,125
11	,641	,025	,195	-,279	-,294	,022	,098	-,169	,301	,139
12	,225	,147	-,134	,357	,207	,466	,215	-,236	-,089	-,159
13	,312	-,254	,248	-,454	-,007	,423	-,323	,192	,269	-,012
14	,341	,101	-,396	-,100	,316	-,409	,161	,458	-,017	-,104
15	,511	-,057	,139	,520	,268	-,103	-,317	,270	-,041	-,104
16	,387	,249	,553	,181	-,392	-,019	-,202	,095	-,067	-,187
17	,359	,076	,563	,244	,268	-,237	,144	-,185	,101	,068
18	,510	-,084	,259	-,037	,423	,124	,136	-,278	-,354	,031
19	,300	,299	,083	-,165	,165	,568	,364	,154	,081	-,068
20	,462	,284	,172	-,258	,260	-,091	,142	,285	-,159	-,279
21	,623	,150	-,475	,353	,050	,138	-,063	-,120	,214	,011
22	,372	,312	,371	-,223	,226	-,017	-,246	,298	,167	,381
23	,473	,069	-,307	-,006	-,036	,184	,341	-,005	-,134	,509
24	,552	-,550	,119	,192	-,111	-,018	,039	-,056	,107	-,031
25	-,185	,688	,020	,193	-,360	-,166	,154	,076	,146	,240
26	,539	,071	-,359	-,286	-,160	-,029	-,028	,025	,329	-,366
27	,660	-,349	-,001	-,114	-,254	,001	-,135	-,242	,071	-,023
28	,384	,437	-,255	-,103	,257	,093	-,514	-,260	-,182	,059
29	,709	,033	-,028	,124	-,056	-,214	-,019	-,098	-,177	-,309
30	,644	-,505	,100	,168	,216	,099	,015	,214	-,064	,195
Significant Loading: 0,471 Std Error: 0,183										

Extraction Method: PCA

9.7. A7

Table 28: Parallel analysis

Factor	Raw Data	Mean EV	95% prctl.
1	7,17	3,01	3,34
2	2,68	2,66	2,89
3	2,49	2,40	2,59
4	1,98	2,19	2,36
5	1,74	2,01	2,16
6	1,62	1,85	1,98
7	1,36	1,69	1,81
8	1,34	1,55	1,67
9	1,21	1,43	1,54
10	1,10	1,31	1,41
11	0,93	1,20	1,30
12	0,88	1,09	1,19
13	0,75	0,99	1,08
14	0,69	0,90	0,99
15	0,61	0,82	0,89
16	0,49	0,73	0,81
17	0,47	0,66	0,73
18	0,42	0,59	0,66
19	0,37	0,52	0,58
20	0,35	0,45	0,51
21	0,27	0,39	0,45

22	0,21	0,34	0,39
23	0,21	0,29	0,34
24	0,14	0,24	0,29
25	0,13	0,20	0,24
26	0,10	0,16	0,20
27	0,09	0,12	0,16
28	0,08	0,09	0,12
29	0,06	0,07	0,09
30	0,03	0,04	0,06

Extraction Method PCA, 1000 data sets, 95% percentile

9.8. A8

Table 29: Scoring in factor array

#	Statement	F1 array	F2 array	F3 array	F4 array
1	**Lack of knowledge spillover or leakage from other firms**	0	1	1	1
2	**Knowledge spillover or leakage to other firms**	-1	-1	-2	-3
3	**Limited access to external knowledge bases and sources of information**	-3	-1	3	-3
4	**Lack of technological knowhow to over come technological problems**	1	0	2	0
5	**Difficulties in validating technology (developing MVP to aquire funding)**	0	1	-4	3
6	**Problems over intellectual property rights**	1	3	2	-2
7	**Development capacity issues**	1	-2	1	-3
8	**Production capacity issues ("too small to grow")**	0	-1	3	0
9	**Long product development process/phase**	4	-2	4	4
10	**lack of a clear product and development roadmap**	-2	1	-3	-1
11	**Little buyer concentration - lack of early stage customers**	-1	2	1	3
12	**Little buyer concentration - lack of mainstream customers**	-3	3	-3	0
13	**Fast changing business environment and uncertainties about market developments**	-1	2	-2	0
14	**High pressure from incumbent industry (existing regimes pressure on radical entrants)**	4	4	4	4
15	**High pressure from established direct competitors with similar products in the market**	0	1	-2	1
16	**Lack of government (and policy) support**	-1	1	-1	2
17	**Uncertainty about technology pathways**	2	4	0	-1
18	**Uncertainty about user practices**	0	3	4	1
19	**Uncertainties about regulatory frameworks - potential shifts in negative direction (e.g. solar subsidies)**	3	2	-1	1
20	**Long sales cycles**	3	3	2	2
21	**Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)**	3	4	0	-4
22	**Lack of organizational legitimacy to investors**	-1	-2	0	3
23	**General lack of accessibility 2nd/3rd state funding (investment) in the industry - funding gap (valley of death)**	1	0	1	2
24	**General lack of accessibility of seed/start-up/early stage funding (investment) in the industry**	3	-3	-2	1
25	**Height of required investment**	4	0	-3	4
26	**Long payback time, resulting in being unattractive for investment**	2	2	-2	3
27	**Lack of entrepreneurial experience**	-2	0	-1	-4
28	**High training costs for personnel (time and finance)**	2	-1	1	2

29	Difficulties in attracting highly qualified and competent business personnel (low wage rates, career development, job security)	-1	0	0	1
30	Difficulties in attracting highly qualified and competent technical personnel (low wage rates, career development, job security)	1	-1	2	2
31	Team lacks of sufficient Marketing skills (Product commercialization)	1	2	0	-1
32	Team lacks of sufficient Management skills (Financial Management, Team Management, Project Management)	0	-3	0	-2
33	Internal difficulties among the team (lack of communication, differences between team members)	-2	-2	2	0
34	lack of strategic vision and alignment	-4	-4	-3	0
35	Lack of organizational legitimacy to suppliers	-3	-3	0	-2
36	Lack of organizational legitimacy to customers	2	-1	-1	-2
37	Lack of regional innovation network (cluster)	-4	-4	-4	-4
38	lack of assistance and support when securing funding	0	-2	3	-2
39	Lack of entrepreneurial peers	-3	-3	-1	0
40	Lack access to entrepreneurial education and training	-4	-4	-4	-3
41	General lack of personnel with diversified business skills and abilities on labour market (there are simply no people who fit the job)	-2	0	-1	-1
42	General lack of personnel with diversified technical skills and abilities on labour market (there are simply no people who fit the job)	-2	0	3	-1
43	Long and difficult procedures to employ personnel	2	1	1	-1

Table 30: Z-scores and ranking of each statement for each factor

		F1		F2		F3		F4	
#	Statement	z-score	Ranking	z-score	Ranking	z-score	Ranking	z-score	Ranking
1	Lack of knowledge spillover or leakage from other firms	0,11	22	0,35	17	0,06	18	0,07	18
2	Knowledge spillover or leakage to other firms	-0,51	31	-0,41	29	-0,59	32	-1,18	40
3	Limited access to external knowledge bases and sources of information	-0,95	38	-0,31	26	1,32	5	-1,04	38
4	Lack of technological knowhow to over come technological problems	0,36	15	0,17	20	0,77	10	-0,10	21
5	Difficulties in validating technology (developing MVP to aquire funding)	0,19	20	0,41	16	-1,86	41	1,14	7
6	Problems over intellectual property rights	0,31	17	1,37	5	0,65	11	-0,91	35
7	Development capacity issues	0,35	16	-0,75	32	0,21	16	-0,97	37
8	Production capacity issues ("too small to grow")	0,27	19	-0,33	27	1,42	4	-0,03	19
9	Long product development process/phase	1,89	2	-0,94	36	1,77	3	1,78	2
10	lack of a clear product and development roadmap	-0,67	32	0,33	18	-1,14	40	-0,71	31
11	Little buyer concentration - lack of early stage customers	-0,50	30	0,94	10	0,33	14	1,20	6
12	Little buyer concentration - lack of mainstream customers	-1,08	39	1,32	6	-0,90	39	-0,06	20
13	Fast changing business environment and uncertainties about market developments	-0,42	28	1,16	8	-0,66	34	-0,18	22
14	High pressure from incumbent industry (existing regimes pressure on radical entrants)	1,71	3	1,44	3	2,12	1	1,54	3
15	High pressure from established direct competitors with similar products in the market	-0,07	24	0,45	14	-0,81	35	0,68	14

16	**Lack of government (and policy) support**	-0,49	29	0,47	13	-0,39	29	0,88	11
17	**Uncertainty about technology pathways**	0,75	9	1,76	2	-0,06	23	-0,47	26
18	**Uncertainty about user practices**	-0,02	23	1,19	7	2,00	2	0,59	16
19	**Uncertainties about regulatory frameworks - potential shifts in negative direction (e.g. solar subsidies)**	1,32	5	0,99	9	-0,24	27	0,59	17
20	**Long sales cycles**	1,14	6	1,39	4	0,90	9	0,83	12
21	**Supply/Demand shocks in commodities (Oil, rare earths, electricity,…)**	1,42	4	1,92	1	-0,11	25	-1,89	43
22	**Lack of organizational legitimacy to investors**	-0,29	27	-0,84	34	-0,06	22	1,30	5
23	**General lack of accessibility 2nd/3rd state funding (investment) in the industry - funding gap (valley of death)**	0,28	18	-0,12	23	0,17	17	1,08	9
24	**General lack of accessibility of seed/start-up/early stage funding (investment) in the industry**	1,13	7	-0,98	37	-0,82	36	0,78	13
25	**Hight of required investment**	2,09	1	0,19	19	-0,88	38	1,98	1
26	**Long payback time, resulting in being unattractive for investment**	0,56	11	0,77	11	-0,65	33	1,39	4
27	**Lack of entrepreneurial experience**	-0,77	34	-0,26	24	-0,45	30	-1,74	42
28	**High training costs for personnel (time and finance)**	0,50	12	-0,53	31	0,51	13	0,91	10
29	**Difficulties in attracting highly qualified and competent business personnel (low wage rates, career development, job security)**	-0,19	26	0,05	21	0,05	19	0,67	15
30	**Difficulties in attracting highly qualified and competent technical personnel (low wage rates, career development, job security)**	0,42	14	-0,41	28	0,91	8	1,08	8
31	**Team lacks of sufficient Marketing skills (Product commercialization)**	0,43	13	0,67	12	0,01	21	-0,70	30
32	**Team lacks of sufficient Management skills (Financial Management, Team Management, Project Management)**	0,13	21	-1,36	39	0,03	20	-0,97	36
33	**Internal difficulties among the team (lack of communication, differences between team members)**	-0,69	33	-0,80	33	0,54	12	-0,28	24
34	**lack of strategic vision and alignment**	-1,90	42	-1,78	41	-0,85	37	-0,36	25
35	**Lack of organizational legitimacy to suppliers**	-0,87	37	-1,03	38	-0,11	24	-0,78	33
36	**Lack of organizational legitimacy to customers**	0,77	8	-0,44	30	-0,53	31	-0,88	34
37	**Lack of regional innovation network (cluster)**	-2,49	43	-1,87	43	-2,17	42	-1,32	41
38	**lack of assistance and support when securing funding**	-0,15	25	-0,87	35	0,92	7	-0,74	32
39	**Lack of entrepreneurial peers**	-1,25	40	-1,47	40	-0,32	28	-0,26	23
40	**Lack access to entrepreneurial education and training**	-1,90	41	-1,85	42	-2,39	43	-1,07	39
41	**General lack of personnel with diversified business skills and abilities on labour market (there are simply no people who fit the job)**	-0,81	36	-0,29	25	-0,13	26	-0,68	29
42	**General lack of personnel with diversified technical skills and abilities on labour market (there are simply no people who fit the job)**	-0,79	35	-0,10	22	1,22	6	-0,52	27
43	**Long and difficult procedures to employ personnel**	0,68	10	0,41	15	0,22	15	-0,63	28

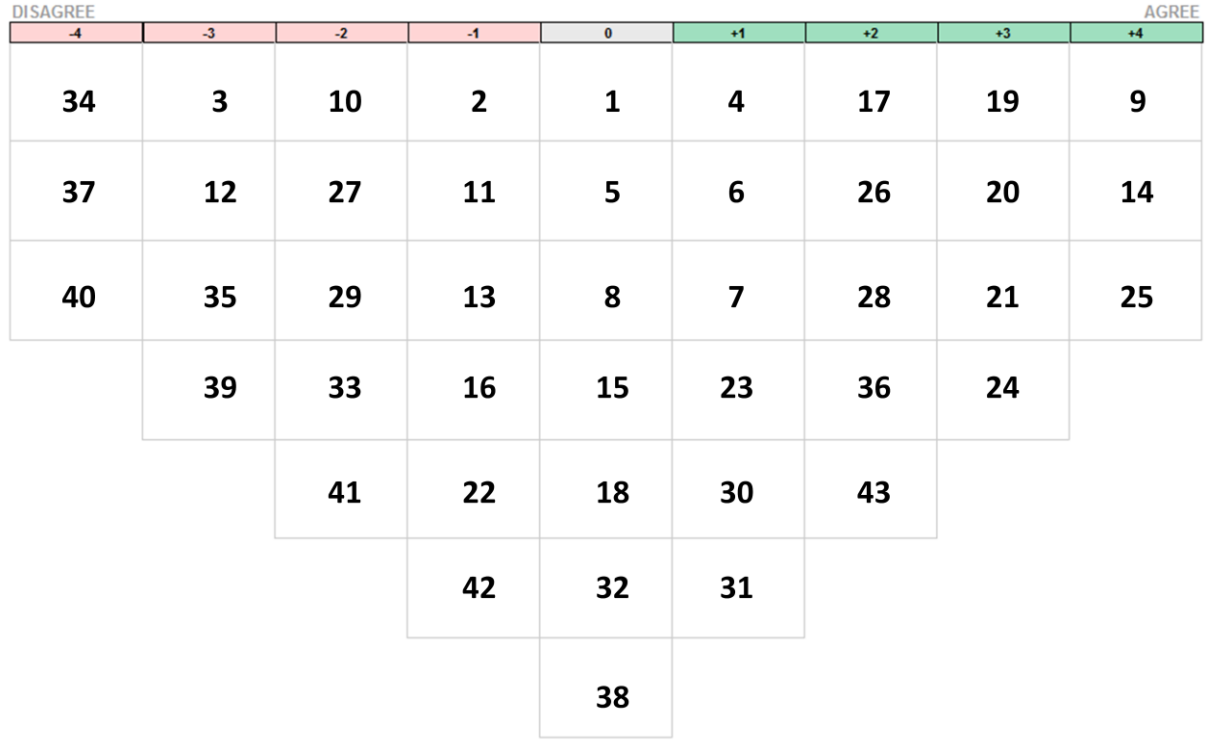


Figure 26: Factor array factor 1

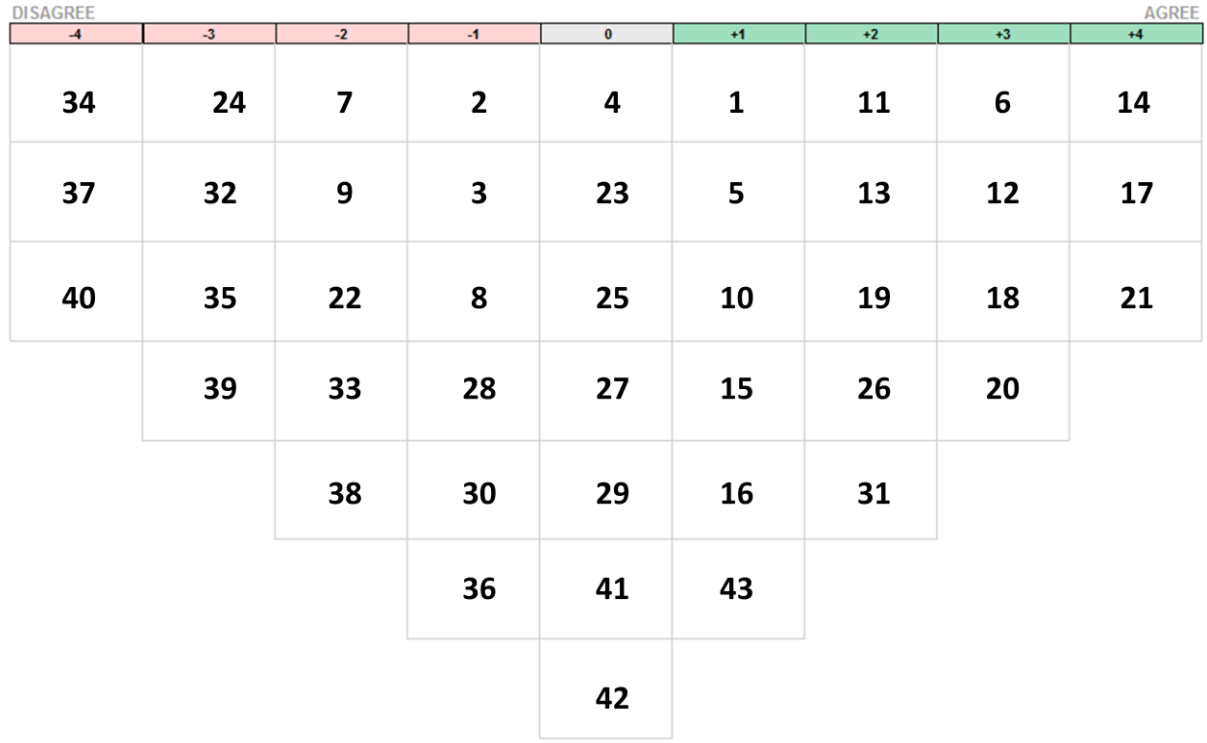


Figure 27: Factor array factor 2

DISAGREE								AGREE
-4	-3	-2	-1	0	+1	+2	+3	+4
5	10	2	16	17	1	4	3	9
37	12	13	19	21	7	6	8	14
40	25	15	27	22	11	20	38	18
	34	24	36	35	23	30	42	
		26	39	29	28	33		
			41	31	43			
				32				

Figure 28: factor array factor 3

DISAGREE								AGREE
-4	-3	-2	-1	0	+1	+2	+3	+4
21	2	6	10	4	1	16	5	9
27	3	32	17	8	15	20	11	14
37	7	35	31	12	18	23	22	25
	40	36	41	13	19	28	26	
		38	42	33	24	30		
			43	34	29			
				39				

Figure 29: Factor array factor 4