Mapping the types of business experimentation in creating sustainable value:

A case study of cleantech start-ups

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Abstract

In this study, business experimentation for sustainable value creation is explored through seven cleantech start-ups by applying the systemic combining approach. The findings reveal novel descriptions of six different business experimentation types. The study also advances our theoretical understanding of how the specific roles of learning, signaling, and convincing dominate each of the experimentation types differently and how each type of business experimentation has a distinct purpose. Furthermore, our findings propose how business experimentation types can be applied as a continuum as part of the cleantech start-ups' sustainable value creation process. Hence, our study contributes theoretically to our understanding of business experimentation for sustainable value creation and how the different types are applied in cleantech start-ups. We conclude our treatise with managerial implications and outlining fruitful future research avenues.

Keywords: business experimentation, sustainable value creation, sustainable entrepreneurship, start-up, cleantech

1. Introduction

Recent research has suggested and applied business experimentation to a sustainable business context as a key capability in the transition to sustainable business solutions and practices (Antikainen et al., 2017a; Weissbrod and Bocken, 2017; Bocken et al., 2019). Sustainability-driven ventures face, on top of normal entrepreneurial challenges, institutional challenges arising

from providing solutions not compliant to social, economic, or political institutional structures. Additionally, they often operate in nonexistent markets, creating a further layer of complexities leading to extra legitimization challenges (e.g., Hall et al., 2010). Hence, ventures focusing on sustainable value creation are in need of doing various kinds of business experimentation and piloting in their activities (Buhl et al., 2019). Therefore, the creation of sustainable value faces significant challenges as it needs to, by definition, be aligned and supportive of ecological, economic, and societal conditions involving multiple stakeholders (Mäkinen, 2020).

Business experimentation can be seen as testing variety of practices and products in uncertain environments to see what works and what does not (Bingham and Davis, 2012), and it has been recognized as an essential work method for companies to test and introduce radical sustainable innovations to existing markets (e.g., Antikainen et al., 2017b; Hildén et al., 2017; Weissbrod and Bocken, 2017). When business experiments are transdisciplinary, iterative, and participatory, as they need to be for sustainable value creation, they better enable common goal formulation and allow stakeholders to interactively develop the solution, as, for example, in climate governance–related experiments (Hildén et al., 2017). Hence we see business experimentation as deliberate, purposeful, and conscious testing (Murray and Tripsas, 2004).

Our empirical context, the cleantech sector, focuses on products, services, and technologies in the broad sectors of energy, transportation, water, and materials (Pernick and Wilder, 2007; Cumming et al., 2016; Giudici et al., 2019). Cleantech start-ups aim to create and deliver sustainable value by avoiding the use of non-renewable resources and/or to produce significantly less waste in their production and business than conventional start-ups (Pernick and Wilder, 2007). The unique aspect that sets the cleantech business apart from other industrial sectors is the way governments intervene with different regulations and policies as well as

incentives to develop business in the cleantech sector (Borghesi et al., 2015). Thus, in the cleantech sector, start-ups face particular strategic challenges, as they need to take into account multiple stakeholders including international environmental policies and regulations (Giudici et al., 2019) even more so than other sustainability-driven value creation efforts.

Hence, sustainability-driven innovative efforts for value creation in cleantech sector face situations where the roles of learning, signaling, and convincing (Bojovic et al., 2018) are crucial for their activities and legitimatization. Firstly, learning through experimentation needs to be both effective and efficient for sustainability-driven ventures due to resource scarcity and venture performance. Secondly, once the venture is learning attributes and cahracteristics of sustainable value–driven innovation and business models, it needs to signal these through experiments to its clientele and other stakeholders in a meaningful and attractive way. And finally, it needs to convince the stakeholders with experiments that the sustainability-driven value is present and attainable for all stakeholders. All of these together are used to solve the systemic challenges and opportunities sustainability-driven cleantech start-ups engage in, but existing studies do not shed light on the dynamics of these activities or types of experiments of value cration and business model formulation.

The sustainable business literature has recently widely discussed sustainable business model experimentation (e.g., Thomke and Manzi, 2014; Weissbrod and Bocken, 2017; Bocken et al., 2018), which is a natural continuation of the development of the business model concept that is used to describe new business ideas (e.g., Perkmann and Spicer, 2010). However, the actual creation and experimentation of business ideas with sustainable value has not been as widely scrutinized and only recently has stakeholder involvement in sustainable value creation been brought to investigation (Schaltegger et al., 2019). There is also still modest literature on

experimentation in association especially with start-ups' sustainable value creation (e.g., Shapira et al., 2017; Buhl et al., 2019), and generally even experimentation in new product development in start-ups (Frederiksen and Brem, 2017). In the extant literature, there are no studies that concentrate on the various types of experiments start-ups need to engage in as they are creating sustainable value. The emphasis in earlier research has been more on incumbents (e.g., Hart and Milstein, 2003), cleantech clusters (de Lange, 2016), and business accelerators speeding up the launch of start-ups (Stayton and Mangematin, 2019), not on sustainable value creation and experimentation in individual start-ups. More research has been called for specifically on different types of value and its creation in relation to stakeholders' demands (e.g., Schaltegger et al., 2019), especially in start-ups focusing on social, environmental, and economic objectives (e.g., Meyskens et al., 2010). In addition, studies of cleantech start-ups and their value creation and innovation has predominantly been done in the U.S., and more research has been called for in other national contexts (e.g., Doblinger et al., 2019; Sunny and Shu, 2019). Furthermore, recent literature has called for more research by interviewing start-ups to reveal their experimentation practices (Kuckertz et al., 2019) and in sustainable value creation this is imperative, as "sustainability value cannot be achieved through efforts of a single firm, but only in collaboration with external actors from wider systems" (Buhl et al., 2019).

In sum, current literature offers limited view on how experiments are used for sustainable value creation and how sustainability-driven ventures navigate challenges and complexities utilizing learning, signaling, and convincing. Hence, the overall research objective of this study is to provide new knowledge on how sustainable value creation is done with business experimentation in start-ups and what the role of learning, signaling and convincing is in these business experiments. Furthermore, our study focuses empirically on cleantech start-ups. All of

the selected start-ups already have an initial product, and they are at the stage of going to the market and growing and scaling their business.

The paper is outlined in the following way. Section 2 sets the theoretical background on business experimentation and sustainable value creation in cleantech start-ups, identifies the research gaps, and defines the specific research question. Section 3 presents the methodology, including the case selection and data analysis. Section 4 presents the results, and Sections 5 and 6 discuss the results and conclude with the contributions, limitations, and suggestions for future research.

2. Theoretical Background

In building the theoretical background for exploring the research question of the paper, we will first investigate the concept of business experimentation in start-ups. Secondly, we explore how sustainable value is created through business experimentation. Thirdly, we examine the concept of sustainable value creation in the context of cleantech.

2.1 Business experimentation in start-ups

Earlier research has found that turbulence in the business environment increases new ventures' propensity to experiment and increase their trial-and-error type of learning (Nicholls-Nixon et al., 2000). Thus, business experimentation is often used in attempts to control the operating environment to an extent that causal influence of certain activity can be explained with change in certain variables (Thomke and Manzi, 2014). Hence, it is paramount that business experimentation has a clear focus: if the experiment can be conducted, what can be learned from the experiment, and are the results usable in the venture? (Thomke and Manzi, 2014). This also

implies that learning is a key element of business experimentation, as stressed by Murray and Tripsas (2004) and Andries et al. (2013). Murray and Tripsas (2004) examine two ways in which firms can learn about their environments: *unplanned trial-and-error learning* and *purposeful experimentation*. The conscious, deliberate nature of *purposeful experimentation* differentiates it from *trial-and-error learning*, revealing the two opposite types of experimentation. Further, Bojovic et al. (2018) present a more detailed treatment of the forms of experimentation: *purposeful interactions* that are small-scale, potentially continuous experimentation with a limited amount of stakeholders or partners, and *experimentation projects,* which are large-scale, time-bound experimentation with engagement from multiple stakeholders. Here, they stress the different roles of learning, signaling, and convincing in these two forms of business experimentation. They argue that experimentation in the business modeling process plays an important role in expediting learning, and in signaling and convincing other parties of the business model, of the sustainability-driven value, and in general of the nascent firm's legitimacy.

Experimentation usually relates to technology, the market, or a business model (Murray and Tripsas, 2004), where experiments systematically conducted offer an excellent vehicle for understanding causalities (Bono and McNamara, 2011). For new ventures and start-ups it is natural to experiment in search of proper identification of their value proposition by trialing (Van de Ven and Polley, 1992). It may even be stated that new ventures or start-ups are series of experiments seeking to match solutions with problems and opportunities in the market (Curley and Formica, 2013). An important point for new ventures is the development of markets and customers (Blank, 2013) while the experiments are conducted. This way a venture can test various assumptions and parts of its business with different stakeholders. To test and experiment

an idea for a market opportunity, companies are encouraged to innovate the execution of the idea by experimenting with different approaches (Tuulenmäki and Välikangas, 2011).

However, experiments often require resources that start-ups do not have, cannot afford, or do not have time for, such as building experimental spaces or using time to explore with developers in imaginary settings. For start-ups, business relationship initiation and development needs to be worked on with experiments and in real customer settings already in the need identification phase initiating a limited amount of resources (Bocken et al., 2018). Conducting experimentation with a larger company customer often includes multiple phases that may help entrepreneurs to understand the needs of the customer better and to test their offerings (Aaboen and Aarikka-Stenroos, 2017). Hence, we view business experimentation as a deliberate, purposeful, and conscious testing of activities, processes, and offerings in value creation, delivery, and capture.

2.2 Sustainable value creation

Sustainable value creation has received growing attention over the years (e.g., Makadok and Coff, 2002; Surie and Ashley, 2008; Bruno and Bruno, 2018). Sustainable value can be seen as value arising from the integration of environmental, social, and economic issues within the firm's offering fulfilling customer needs (Chou et al., 2015). From the classical perspective, value is also derived from *value-in-use* and *value-in-exchange*. Here, *value-in-use* refers to customers'/end users' subjective perceptions of the value of a product or service, whereas *value-in-exchange* refers to the transformation of value-in-use into the monetary achievement of the company (Bowman and Ambrosini, 2000).

In the context of sustainable value creation, more scholars reframe the value construct, meaning that the one-dimensional shareholder logic of profit maximization is extended to more stakeholders and levels of attention (Pedersen et al., 2016; Schaltegger et al., 2016; Upward and Jones, 2016). In sustainable value creation ventures seek to reduce material consumption and pollution, increase level of transparency and responsiveness, decrease the size of human footprint, and incease inclusiveness of wealth creation and distribution (Hart and Milstein, 2003). Thus, actors and entities at all levels may benefit from the transformation of value-in-use into value-in-exchange, meaning that value beyond purely economic gains may also be captured on more levels (Lepak et al., 2007) and value creation takes place also during value delivery. Bocken et al. (2015) outline that sustainable value creation and delivery can be identified with the following elements: activities, resources, distribution channels, partners & suppliers, and technology & product features. In addition, Kuckertz et al. (2019) stress that a more holistic approach may be applicable in the context of sustainable/ecological start-ups; besides capturing value and earning profit, this also based on improvements created for the ecological environment and society as well as for customers (Abdelkafi and Täuscher, 2016). Thus, sustainable start-ups often put a priority on improving communities and the environment (de Lange, 2019), and incorporate the triple bottom-line logic of people, planet, and profit (Bocken et al., 2015; Pedersen et al., 2016). According to Gaddy et al. (2016), sustainable start-ups tend to be gamechanging. However, due to their capital requirements and associated higher risks, they are considered unique cases. Consequently, IT start-up firms receive less investor doubt compared to sustainable firms due to the successful history of IT as well as some resounding problems in clean tech, which represents a large part of the sustainable category (Saha and Muro, 2017).

2.3 Sustainable value creation in the context of cleantech

Cleantech as a concept has emerged to describe an economic sector in which activities are targeted at environmentally sustainable processes (Caprotti, 2016). The value creation rationale in cleantech start-ups has been described in earlier studies as differing from the prevailing conventional entrepreneurs, because the economic goal is more of an instrument for attaining additional important sustainable values, such as a positive environmental and social impact (Shane and Venkataraman, 2000; Dean and McMullen, 2007; Audretsch and Peña-Legazkue, 2012; Vuorio et al., 2018; Schaper, 2016). In addition, cleantech start-ups are competing against larger companies and incumbents who mainly work on process innovations within their environmental management systems (Hockerts and Wüstenhagen, 2010), while they are experimenting more with new radically innovative sustainable product designs. The innovations of cleantech start-ups tend to focus on environmental challenges that go beyond the potential customer requirements of conventional start-ups and require special expertise in the fields of environmental technology, environmental monitoring, and environmental policies (Cumming et al., 2016; Pernick and Wilder, 2007; Giudici et al., 2019).

Policy-oriented studies have found that cleantech ventures forming clusters involving multiple differing stakeholders indeed act as springboards for larger economic transformation toward green economy (Davies, 2013). Consequently, cleantech entrepreneurs can be seen as disruptors in the existing business ecosystems (Geels, 2011; Gibbs and O'Neill, 2014). However, the cleantech sector is still challenged as governments have not been supporting enough radical innovations to enable a transformation of business to become more sustainable and eco-friendly (Farinelli et al., 2011; O'Neill and Gibbs, 2016). This is also reflected in the way cleantech entrepreneurs/start-ups develop their business ideas from different perspectives than

conventional start-ups. In cleantech start-ups, business opportunities are found from current sustainability challenges and new sustainable innovations are created for areas where conventional solutions may be harmful to the environment (Farinelli et al., 2011). They also need to integrate sustainability into their business activities (Ciasullo and Troisi, 2013; Muñoz and Dimov, 2015). The new sustainability requirements necessitate that business practices are redesigned and experimented in the cleantech entrepreneurs' networks of different external stakeholders (Schick et al., 2002; Gast et al., 2017).

In existing research on cleantech and sustainability-driven value creation, Hart and Milstein (2003) have focused on incumbent companies with clean technology strategies for creating value by innovating solutions for social and environmental problems. In their cases, shareholder value was increased by the creation of sustainable value, but the incumbents did not necessarily take fully advantage of the sustainable business opportunities, instead focusing on the short-term solutions that are associated with their current products and current stakeholders. Furthermore, de Lange (2016) has researched cleantech entrepreneurs, but here the emphasis is more on cleantech clusters that are creating long-term sustainable value, instead of on analyzing the value-creation process and experimentation from an individual start-up's perspective. Kuckertz et al. (2019) suggest that identifying the sustainable impact of a start-up creating sustainable value and communicating it to its stakeholders and customers could contribute in the delivery of the created value. However, they have not looked closer at the way this is done by experimentation. This was not possible by looking at a database, and thus they have called for more research by interviewing start-up teams (Kuckertz et al., 2019). Stayton and Mangematin (2019) have studied the very early phases of product development and building a start-up from

the accelerator perspective, but have not looked at the activities with which start-ups extend their experimentation activities after the very initial product experimentation.

In sum, the research gaps in sustainable value creation through business experimentation stress the need for more research on the types of value creation and stakeholder demands in start-ups focusing on social, environmental, and economic objectives (Meyskens et al., 2010; Kuckertz et al., 2019). More research has also been called for outside the U.S. context (e.g., Doblinger et al., 2019; Sunny and Shu, 2019).

3. Methodology

Based on the above literature review and identified research gaps, we derive the following research question to be explored: *How is sustainable value creation done with business experimentation in clean-tech start-ups, and what are the roles of learning, signaling, and convincing in these business experiments?*

An exploratory case study research design was selected for this paper, ensuring a methodological fit between the research question and the status of prior theory (Edmondson and McManus, 2007). Case study methodology is suitable for acquiring rich, detailed data (Eisenhardt and Graebner, 2007) and for identifying emerging themes and patterns (Eisenhardt, 1989). It is appropriate for creating new knowledge about how and why events occur in situations with little theoretical background (McCutcheon and Meredith, 1993). The rationale behind the selection of the case study design was to explore the concept and practices of business experimentation and sustainable value creation across the selected cleantech start-ups of the case study. As the study of the paper is based on an abductive logic, the systematic combining approach was selected as the method for analyzing the data and research question of the study.

The systematic combining approach allows researchers to move continuously between the empirical world and a model world, thus enabling adjustment of the research issues and framework according to findings from the empirical world. There are two interwoven processes in the systematic combining approach: in the first part theory and reality are compared, and in the second part the research issues evolve and are redirected in order to investigate the relationships between the empirical world and theoretical concepts (Dubois and Gadde, 2002, 2014), which allows the overlap of data analysis with the actual collection of data (Eisenhardt, 1989).
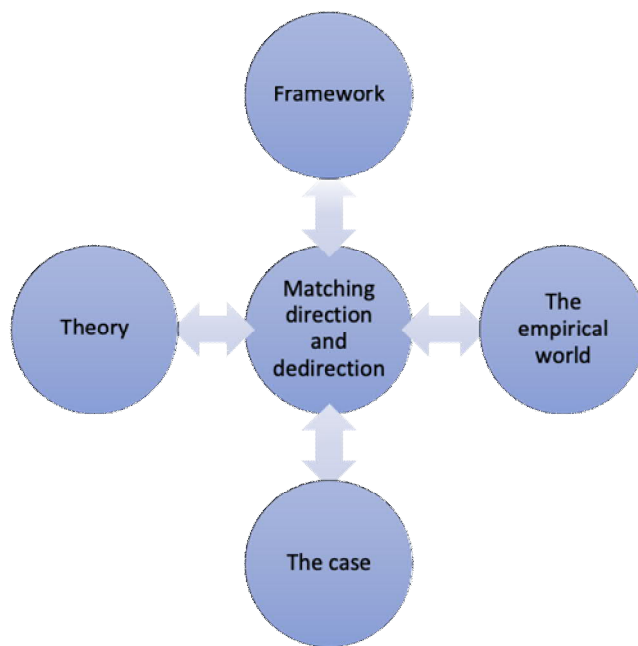
Source: (Dubois and Gadde, 2002).

Figure 1. The systemic combining approach

This approach is well suited for an iterative and non-linear research, where research activities are conducted by switching from empirical observations and theory several times to match the data sources, analysis, and theoretical framework (Dubois and Gadde, 2002, 2014). Thus, the systematic combining approach allowed the researchers to go between the different research

activities and match them after each interview to expand the understanding of the theory and empirical context. As the data set is only presented by seven start-up case companies, the methodology was ideal in exploring across these few cases the back-and-forth between the theory and practices of sustainable business experimentation in creating sustainable value.

3.1 Case selection

The cleantech start-ups in this study were selected from the global tech event called Slush, where founders of all types of tech start-ups and investors meet at a large tech start-up exhibition in Finland (Slush, 2019). The cleantech case companies included in the study were selected based on three case selection criteria:

1) They were start-ups as defined by Luger and Koo (2005, p. 19): they "did not exist before during a given time period (new), which starts hiring at least one paid employee during the given time period (active), and which is neither a subsidiary nor a branch of an existing firm (independent)."

2) They had actual experiences with business experimentation. The start-ups participating in Slush were all divided into three groups according to the phase they were in: a) Working on a Product, b) Going to Market, or c) Growth & Scale. With this criteria we only focused on the cleantech start-ups from the categories "Going to Market" and "Growth & Scale."

3) They had demonstrated successful sustainable value creation and delivered sustainable solutions/products/services successfully to or together with customers, which implied that convential (non-sustainable) start-ups were excluded.

Based on further analysis of the current status of the start-up at the end of 2018, we confirmed that each company was still viable and in business, and that they had an active website and

records on finances. This resulted in seven viable start-ups that could be interviewed for the present paper.

3.2 Data collection

In each of the seven case studies, data was collected via documentation studies and qualitative, semi-structured interviews with informants responsible for the business experimentation and value creation activities of the company. For each of the start-ups, all publicly available information and documentation on the Internet was studied. This included the start-ups' websites, reports and background information provided by the Slush team, and available start-up data in open company information databases to verify that the start-ups were active and in operation at some level even if they did not have recurring revenue streams. As all the case companies were start-ups, the number of informants was rather limited, ranging from 1 to a maximum of 7 employees across the selected case companies. The data were collected through informants from the seven cleantech start-ups with in the roles of CEO, COO, CFO, and Account Manager (see Table 1), as they were the ones with knowledge of their business experimentation and sustainable value creation practices. The specific sustainable value created by the case company is also stated in Table 1.

Table 1. Case companies and informants

Case ID	Informants	Stage of the start-up	Cleantech sector	Sustainable value created by the start-up
C1	CEO	Going to market	E, T & A	Analytics solutions for monitoring the status of the environment
C2	Account Manager	Growth and scale	T & A	Facilitating the adoption of EVs with the help of a unique service platform

C3	CEO and CFO	Growth and scale	E, T & A	Energy-efficiency in power transmission solutions
C4	CEO	Growth and scale	E	Specialized analytics solution based on AI
C5	COO	Going to market	E, T & A	Specialized technology easing adoption of EVs
C6	CEO	Growth and scale	E, T & A	Technology for reducing CO2 emissions
C7	CEO	Going to market	E, T & A	Facilitating the adoption of EVs with the help of a unique solution

*Note: In the fourth column of the table, "Cleantech sector," the appreviations stand for: E=Energy, T=Transport, A=Automotive, EV=Electric Vehicle, AI=Artificial Intelligence.

The primary data were collected through exploratory interviews with the help of a semi-structured interview guide focusing on the motivations, initial ideas, business experimentation, and value creation activities and stages in the development of the sustainable business. The semi-structured interviews took approximately 1.5 hours and were conducted in Jan–Feb 2019 with the selected informants and cleantech start-up case companies. The majority of the interviewees were founders or members of the founding team, and only one of the respondents had joined the team at a later stage. In the interviews, the research objective was first described and the interviewees were then asked to describe the value they created to customers, society, and the environment; customer collaboration; stakeholders; their organization, resources, distribution channels, partners, and suppliers; and cooperation with research institutes. All the interviewees were asked about the initial idea for developing their business and how the idea was developed through business experimentation, testing, and piloting. The interviews were all recorded, then transcribed and validated by the interviewees.

3.3 Data analysis

Each interview was coded deductively while using the frameworks by Bojovic et al. (2018) and Murray and Tripsas (2004) on the business experimentation and Mäkinen et al. (2020), Buhl et al. (2019), and Kuckertz et al. (2019) on the sustainable value creation, in looking for evidence of how sustainable value was created through business experimentation activities. Following the methodology of Gioia et al. (2013), we engaged in a second analysis where we coded inductively, looking for patterns that could explain how start-ups apply business experimentation in their sustainable value creation in understanding the interplay between business experimentation and value creation in cleantech start-ups. Intercoder reliability, which is the term used for the extent to which independent coders evaluate a characteristic of a message or artifact and reach the same conclusion (Tinsley and Weiss, 2000), was conducted between three people: the interviewee, who had conducted the interview sections and data collection, and two other researchers that had not been actively involved in the data collection and interview process.

Table 2 portrays the data analysis of mapping first-order concepts based on the quotes from the interview sessions about how business experimentation is supported, organized, and managed across the seven case companies, and the derived second-order themes stating the core antecedents of the different ways of conducting business experimentation in leading up to the aggregated dimensions of the six individual types of business experimentation in creating value as identified through the data analysis.

4   Results

In mapping and categorizing the data on how business experimentation was performed at the start-up case companies, six different business experimentation types were identified using the Gioia methodology, as explained in Section 3.3. Table 2 illustrates the mapping of first-order

concepts based on the quotes from the interview sessions, and the derived second-order themes on the different ways of conducting business experimentation in leading up to the aggregated dimensions of the six individual types of business experimentation. These types can be divided into internal and external experimentation types and are explained in detail below. Below Table 2, each of the business experimentation types (4.1–4.6) are each explained more elaborately and in relation to their internal and external qualities. The findings revealed that each of the seven case companies applied all of the seven business experimentation types, and it appered that the start-ups applied the business experimentation types as a sort of continuum in their business experimentation process, which is explained in Section 4.7.

Table 2. Data analysis

First-order themes	Second-order themes	Aggregated dimensions
"We are a five-person company, of course we use a lot of use a lot of subcontracting." (C1) "Our contract manufacturer…also became a minor shareholder." (C5)	Subcontracting	NETWORK BUSINESS EXPERIMENTATION (see 4.1 below) **Networks driving business experimentation and value creation**
"We have our shareholders…none of them gets paid." (C2) "I used all my networks …, and also the co-founder's to get required type of stakeholders involved." (C4)	Paid and unpaid resources	
"We have very powerful names (owners) who are invested in our company and willing to win with us." (C3) "We have a marketing professional, who has her own company, and she's kind of acting as our marketing manager." (C6)	Create and engage the internal and external networks for value creation	
"We hadn't that money to make those prototypes and test them in our lab, so, our customer buys project, and then we go with our prototype to…demonstrate something." (C3) "Everything can be done, first we have to sell it."	Sell demo and fail fast	

(C4)		SELLING BUSINESS EXPERIMENTATION THROUGH TRIALING (see 4.2 below)

Business experimentation used for selling and value is created and delivered through demos and trialing |
| "We provided for them…this learning area… They paid the original price, but all the repairs and all the corrections has to be paid by us then." C6)

"We had to do this kind of bold thing, and that way fail fast." (C2)

"What could be considered as a failure? What if we a little bit failed, but it turns out some kind of success at the end. Even though you fail something, it doesn't mean you have to lose entirely to the issue." (C4)

"Of course there are minor hiccups… They happened because we have overlooked something or forgot to do some order on time or that kind of things. And you learn." (C5)

"We have made small error judgments sometimes, of course. You have to pay your learning money sometimes but, nothing to tip us over." (C7) | Learning through failing | |
| "We didn't know these markets beforehand very well, that what would be the exact requirements that these customers might have, so we kept the device quite flexible in a sense that it's configurable." (C1)

"Most of the customers, they really don't have any idea what they actually want." (C7)

"I'm quite a MacGyver so usually, if I meet the problem we tailor something up for the customer." (C4) | Experimenting with value creation | |
| | | |
| "They give us a vehicle that they want to use and then we fit it with our technology and then they test it." (C2)

"Very, very close collaboration with customers" (C3) | Open business experimentation with customer | CUSTOMER-DRIVEN BUSINESS EXPERIMENTATION (see 4.3 below) |
| "We did all kinds of prototypes." (C5)

"When the pilot starts and we come up with the problems that we couldn't foresee beforehand" (C7) | Pilot drive experimentation with customers | |
| "Quite strict requirements and compliance against the requirements" (C1)

"…you can see the difference how the people think | Requirements drive business experimentation | **Business experimentation aimed at specific or open-ended customer ideas or requirements in creating value** |

about technical things in different parts of the world. For example, the standard for the Japanese origin, it's very straightforward, very simple and precise enough to do. And then the European version, it's like any decision-making in EU, there are so many players that have had their own small influence in it so it's pretty hard to follow…" (C6)		
"(We are)…making those simulations in University of Tampere." (C3) "Three out of four, we were still studying" (C6)	Collaborations with universities for specialist knowledge	
"Very close collaboration with the service provider and the authority" (C1) "We need to understand the legal requirements." (C2)	Deep understanding of service and legal requirements in creating value	SPECIALIST BUSINESS EXPERIMENTATION (see 4.4 below)
"Five of our friends are testing the device and telling us feedback." (C7) "Three of the four founders, they had know-how on the electrical engineering, about the programming." (C6) "A specialist in our team is working all the time and thinking what we can secure in our…" (C4)	Specialist knowledge sought for business experimentation across internal and external network	**Specialist driving business experimentation in creating radically new value**
"We very soon found out that this is not a business, and expanded the scope." (C5) "I's actually the same product, same technology, it can be used the same set of basic technologies can be used in other markets as well" (C1) "We made…an announcement of some IPR for the university about it and thought that this would be interesting to develop further." (C7)	Creating value by expanding technology scope	TECHNOLOGY SCOPE BUSINESS EXPERIMENTATION (see 4.5 below) **Expanding the technology scope of business experimentation**
"As a company we're purely focused on technology." (C6) "Our device it's very versatile, and you can use the same technology to, make a fixed installation in a ship" (C2) "Ae are trying the new technology. And then we developed the basic technology." (C3)	Technology as the main driver of business experimentation	
"For me it's important that whatever I do, people	Intrinsic values drive	SUSTAINABLE VALUE-

	sustainable business development	DRIVEN BUSINESS EXPERIMENTATION (see 4.6 below)
benefit from it." (C2) "Each of us want to save the world." (C5) "I wouldn't be doing this, this long time, if it wasn't for the greater good." (C6) "I really do feel like we're helping people, switching to electric mobility." (C1)		**Business experimentation driven by intrinsic values and "better world" motivations**
"The founder drives an electric vehicle for the last 15 years, and he's really into that." (C2) "The biggest drive I have, why I have been doing this, is doing better." (C6) "In big picture, it's about saving the planet." (C3)	Continuous long-range focus on creating greater good	
"We're a politically charged team." (C6) "Our product itself is part of a big political battle." (C4) "I don't know if you've seen the news… And this is something that shows that there's more people interested in cleaner solutions." (C7)	Business experimentation as a political battle	

Note: the codes C1, C2, C3, C4, C5, C6, and C7 indicate which case company the quote comes from to ensure traceability and provide evidence for the validity of the results.

4.1 Network business experimentation (internal)

Network business experimentation entails an internal business experimentation process driven by the internal organization in combination with the networks of the internal and external competences and collaborations. These collaborations include a wide range of different stakeholders and networks (e.g., powerful industry profiles, customers, service providers, competitors, and freelance employees). However, the collaboration in this business experimentation process is driven from the inside of the organization, and thus the potential inertia and lack of competences internally influence the results of the business experimentation. This type of business experimentation does not require unique specialist knowledge or highly

technological skills and is not only focused on customers. It is typically rather incremental, but it needs internal and external networks to include the requested knowledge, buy-in, engagement.

4.2 Selling business experimentation through trialing (internal)

This business experimentation type emphasizes the internal processes of business experimentation speeded up by selling demos and failing fast through trialing. Hence, this experimentation emphasizes internal connections to necessary partners and convincing all these partners. Here adjustments are done through internal learning-by-doing and learning-by-failing processes. The start-up experiments with value creation through an internal process based on the demos sold to the customers or other stakeholders and then conducting experimentation afterward.

4.3 Customer-driven business experimentation (external)

Customer-driven business experimentation is carried out in an exploration of how to create and co-create value together with and for the customer, as customers' needs, knowledge, and even lack of knowledge/awareness drive the learning and value creation process of the start-up's business experimentation process. Hence, this experimentation is directed toward convincing customers of the sustainable value of the cleantech start-up offerings. If a customer has clear needs for the kind of value creation the business experimentation should provide, then the business experimentation is tailored and rather fixed, whereas with unclear requirements the business experimentation is an open learning process together with the customer. Thus, the focus here is only on the customer and their needs. The customers' needs drive the business

experimentation, so the value created is typically not radically innovative, as the customers' imagination/requests/ideas appear to set a limit of the innovation level.

4.4 Specialist business experimentation (external)

Another business experimentation type identified in the study is *specialist business experimentation*. This type of business experimentation is highly dependent on the unique specialist knowledge of (internal) external stakeholders, as their unique knowledge is a prerequisite for developing radically new value/offerings. Consequently, relations and collaborations with universities and research institutions and specialist knowledge gained from internal and external networks become important antecedents of this business experimentation type. The specialist knowledge, competence level, ownership, and active engagement of the stakeholder in the business experimentation process are used in creating radically new and sustainable value. This business experimentation type is radically innovative and therefore only invites in stakeholders based on their specialist knowledge to create new, sustainable value.

4.5 Technology scope business experimentation (internal)

This business experimentation type is highly driven by technology and technological scope and what is internally possible to accomplish through internal technological knowledge and resources. This business experimentation type does not focus on customer needs, but rather on what technology can potentially do. It is therefore aimed at radically new innovation. However, where *specialist experimentation* goes beyond the boundaries of the company, *technology scope experimentation* stays within the company using the internal competences of and technology

drive/interest of internal employees. This business experimentation type was not the most common among the seven case companies, but could be viewed as "pet projects"—lacking a business aim or customer, but still experimented with due to the intrinsic technology drivers of the internal organization.

4.6 Sustainable value-driven business experimentation (external)

This business experimentation type is unique to start-ups, as the aim and primary driver of this business experimentation is the creation of sustainable value and offerings that saves the world and benefits society. The driving force is political and represents intrinsic values of "doing good" for the external world. Consequently, the outlook is long range and on radical innovation in creating value through "out-of-this-world" solutions for saving the planet. As what is considered sustainable value is defined and driven by society and external stakeholders, this business experimentation type is viewed as external. However, the motivation is intrinsic and highly connected to the values and political stance of the individual.

4.7 A continuum of business experimentation

The findings also revealed that the seven case companies applied all of the six business experimentation (BE) types - in combinations, and as a continuum to accommodate to specific customer characteristics or lack of internal resources/competences in the specific business experimentation activities. However, an overarching BE type or mindset was present among all the seven case companies in their experimentation processes, namely "sustainable value-driven business experimentation" with the emphasis on 'doing better for the greater good' as stressed by this quote: "*I wouldn't be doing this, this long time, if it wasn't for the greater good.*"

The start of the BE continuum was explained by one of the informants stating, "First we search our own network," where the business experimentation processes of the cleantech start-ups typically start by experimenting internally with their networks (*network business experimentation*). In the cases where the competences are sufficient (and "the customer [does] not really know what they want") the case companies would pursue the BE type "selling business experiementation through trial and error" in trying to experiment their way to a project/solution suitable to the customer. However, if the suggested solutions presented to the customer was "*not found to be a business*" and too good to "dump," the case companies would go for the BE type "technology scope business experimentation," trying to develop the cleantech technology even further and into a business that would potentially interest the customer or other customers/segments as well.

Another pathway of business experimentation would start, if the customer knew (exactly) what they wanted experimented. In these cases the companies would approach the customer through the BE type "customer-driven business experimentation," tailoring the BE to the specific needs and requirements of the customer. Yet, if the case companies' capabilities were not sufficient to accomplish these tasks and live up to the customer requirements, the cleantech company would go further to the BE type "specialist business experimentation," seeking external specialist capabilities in solving the specific experimentation tasks identified and requested. Consequently, the case companies use the BE types as a continuum, which can be illustrated in the following manner in Figure 2.
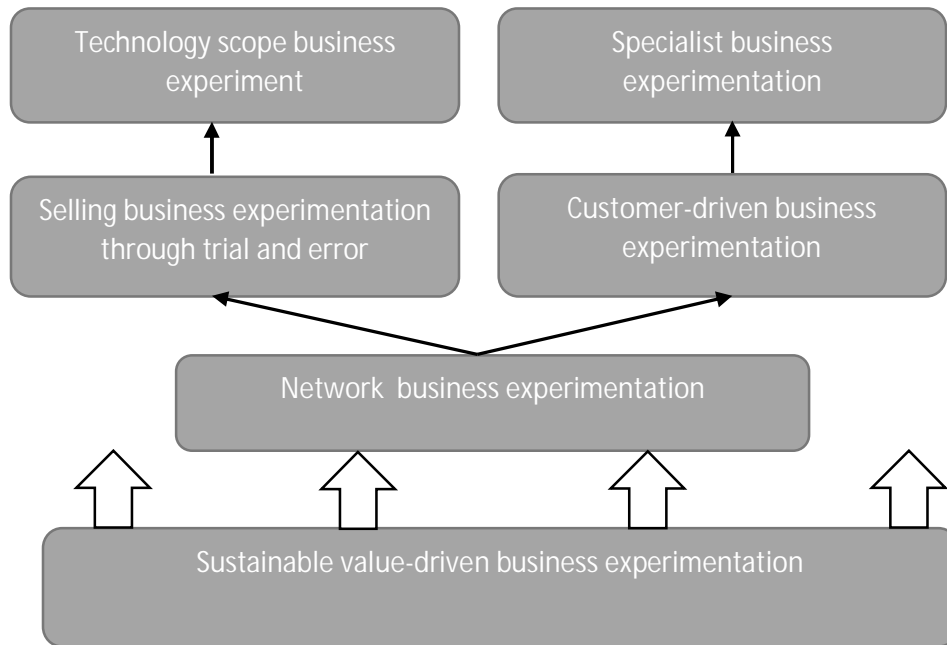
Figure 2. The continuum of BE types

5. Discussion

This study derives six different types of business experimentation of cleantech start-ups and in Table 3 below the findings of how the roles of experimentation—learning, signaling, and convincing—defined by Bojovic et al. (2018) are presented for each of the six business experimentation types.

Table 3. The role of experimentation across the six business experimentation types

Internal experimentation	Role of experimentation	External experimentation	Role of experimentation
Network business experimentation	Learning: - about own competences - about needed competences in the network	**Specialist business experimentation**	Learning: - specialist skills from others - needs, wants, preferences
	Signaling: - giving professional image of competences - capability to learn		Signaling: - willingness to cooperate with specialists and universities
	Convincing:		Convincing:

	- trustworthiness - technical expertise		- cooperation skills - specialist network
Selling business experimentation through trialing	Learning: - what are the key selling points	**Customer-driven business experimentation**	Learning: - customer requirements
	Signaling: - needed functionality in solution		Signaling: - willingness to listen to customer
	Convincing: - solution has the sustainable value - needed competences are in place		Convincing: - willingness to find common understanding and adapt solution
Technology scope business experimentation	Learning: - getting feedback on the fit of the technical solution	**Sustainable value-driven business experimentation**	Learning: - using sustainability in reaching new targets
	Signaling: - technical quality, know-how		Signaling: - sustainable motives of the business
	Convincing: - technical adaptability and functionality		Convincing: - showing that sustainability could be a selling point for this solution

Through our study, we confirm that learning is an inherent role of experimentation, as described in earlier research for example by Murray and Tripsas (2004) and Andries et al. (2013). Similarly, as noted above, all the types of experimentation have some elements of all the roles identified in Bojovic et al. (2018). However, we find that different types of experiments have differing emphasis on roles, i.e., there is a dominant role for each business experimentation type (see Table 4).

Table 4. Experimentation types and the dominant roles of experimentation

Internal business experimentation	External business experimentation	Dominant roles
Network business experimentation	Specialist business experimentation	**Learning** Internal: understanding and developing own

		skills
		External: obtaining feedback from stakeholders
Selling business experimentation through trial and error	Customer-driven business experimentation	**Convincing** Internal: Perusading partners to engage with the start-ups External: Persuading customers to test the solutions
Technology scope business experimentation	Sustainable value-driven business experimentation	**Signaling** Internal: Demonstrating sustainable value internally and to partner External: Signaling sustainable value and good intentions to society

Network business experimentation is mostly about learning the level, limits, and needs of competences, while externally oriented *specialist business experimentation* is about learning expectations of others toward own skills and competences. In contrast, *selling business experimentation* is convincing partners to engage in collaboration through experiments by showing and enhancing the capabilities of the start-up, and the *customer-driven business experiments* are convincing customers with their own guidance and requirements specifications in leading experimentation. Finally, *technological scope business experimentation* is about showing technical quality and level of know-how in order to demonstrate sustainable value, whereas *value-driven business experiments* are outward-directed sustainable value showcases signaling green motives and sustainable values of the start-up.

In studying how sustainable cleantech start-ups use business experimentation in creating, delivering, and capturing sustainable value, a number of the key activities and factors were identified. The first finding of our analysis relates to the first aggregate dimension: *Networks*

driving business experimentation and value creation. It was evident from all seven cases that the start-ups' extensive network of close stakeholders across sectors and industries as well as their access to flexible, ad hoc, and often unpaid resources was a necessity for the start-ups to create and deliver sustainable value. This corrolates well with existing findings of importance of outside resources and networks (e.g., Aaboen and Aarikka-Stenroos, 2017; Bocken et al., 2018). However, this factor may be even more critical among sustainable/cleantech start-ups and entrepreneurs, as when inventing radically innovative, sustainable business solutions user needs and wants are inherently difficult to conceptualize (Buhl et al., 2019). Also, completely new (and maybe not yet invented) competences, knowledge, and technologies are often required from the cleantech's networks in providing competitive solutions beyond existing (unsustainable) offerings. This is well in line with findings of Giudici et al. (2019) in that local network of actors having access to technological knowledge increases likelihood of establishing cleantech start-ups, albeit our findings shows that start-ups need to have capabilities to utilize these resources as well. Specifically for cleantech start-ups, the capability to access resources of stakeholders in a large network is important as cleantech start-ups face difficulties in raising financing. This is due to, e.g., capital intensity, technological risks, scalability issues, and existing requirements (Cumming et al., 2016).

A further finding obtained from the second aggregated dimension, *business experimentation used for selling and value is created and delivered through demos and trialing*, revealed that the cleantech start-ups would apply a shortened and ad hoc business experimentation process. The study showed that cleantech case companies would "jump" or "skip" phases and activities to speed up the business experimentation process in close collaboration with stakeholders, following the effectuation-logic described by Sarasvathy (2001).

They also attempt to ensure fast failure by selling demos and do not spend time and resources on building prototypes first. This is also very in line with Lean Startup methodology (Ries, 2011). However, the benefits of speed and not spending/locking in resources for prototyping apparently outweighed the arguments of involving users being difficult (Janssen and Dankbaar, 2008) or arguments for increased costs of acquiring customer information (Jeppesen, 2005).

The third aggregated dimension, *business experimentation aimed at specific or open-ended customer ideas or requirements in creating value*, revealed an experimentation process almost solely driven by the customers' requests and knowledge *or* recognized lack of knowledge of needs. The dimension takes us to an explorative process driven by trialing that is well in line with existing literature on business experimentation (e.g., Thomke and Manzi, 2014; Weissbrod and Bocken, 2017). The existing prescriptions are often built into premises of identification of the purpose of an experiment and planning up changes to be made in trials.

The fourth aggregated dimension identified in our study showed how *specialists drive business experimentation in creating radically new value*. The collaborations of the case companies were carried out with various stakeholders like universities, service providers, and even competitors to get access to highly complex specialist knowledge in pursuing the various technological opportunities to fit or exceed the needs and expectations of the customers. The mixed specialist backgrounds of the founders was one key factor in having access to a wider range of knowledge and competences, and thus being able to create "new" value and develop more radically innovative sustainable solutions targeting the customers' objective, but also going beyond existing and unsustainable offerings. This is a key feature of cleantech in that it creates value for multiple stakeholders, not just for the start-up venture, which has traditionally been seen as a risk by financiers (Cumming et al., 2016). In contrast, our findings show that the

cleantech start-ups can engage stakeholders in value co-creation and create value with and for various stakeholders, in line with findings in importance of network resources in innovation ecosystems literature (e.g., Adner and Kapoor, 2010) and with the contemporary views extending business case from mere financial aspects toward including ecological and social aspects (e.g., Schaltegger et al., 2019).

The fifth aggregated dimension, *expanding the technology scope of business experimentation*, addresses the need of cleantech start-ups to build bridges between their sustainable value creation and their technology-driven business experimentation in creating truly new, yet sustainable/green business innovations. The technology driver of the cleantech start-ups is key in constantly searching for new and unexplored technology pathways supporting the importance of local technical knowledge spillover (Giudici et al., 2019).

The final aggregated dimension supports and elaborates on the previous dimension by underlining the uniqueness of cleantech start-ups pursuing business experimentation for sustainable value creation. The findings from all the seven cases showed that business experimentation is driven by intrinsic values and political "better world" motivations. This finding is critical in understanding the difference between conventional/non-sustainable and sustainable start-up as the sustainable value-driven business experimentation is unique to the context. Making the world a better place and making others benefit from the value created is the intrinsic driver of this type of business experimentation. Consequently, the sustainable way that value is created, delivered, and captured also over the long range is critical for this type of business experimentation. Hence we find that the cleantech start-ups in our sample indeed have the intrinsic sustainable business case development at their operations, which has been stated to be an inate feature of this firms in this sector (Caprotti, 2016).

Additionally, our findings suggest that the business experimentation process of cleantech start-ups proceeds in a certain logical continuum starting from sustainable value-driven and network business experiementations and then following two differing paths, with emphasis on either internal or external experimentations. When needs and solutions can be devised to fit well together with external stakeholders and customers, customer-driven and specialist business experimentations follow, while when further trialing is needed for matching needs-solutions selling and technology scope business experimentations follow. These findings are in line with Bocken et al.'s (2018, p. 83) view on experiments during the innovation process and this continuum with types of business experiments defined refines the role business experiments have during the innovation process. Furthermore, this continuum proposes that the strategic decision-making in cleantech start-ups is more nuanced and logical in using business experimentation, beyond simple trial-and-error learning that is so prominent in existing literature describing start-ups' managerial decision-making processes (Nicholls-Nixon et al., 2000).

In general, besides the types of business experimentations that cleantech start-ups use, our results contribute to the theoretical perspectives on network resource involvement in start-ups' sustainable value creation and how experimentation is used by cleantech start-ups to engage various stakeholders, as called for in earlier research (Schaltegger et al., 2019). We develop more nuanced understanding of different types of experiments for sustainable value creation, continuing recent research on use of stakeholder involvement and network resources (e.g., Musiolik et al., forthcoming). Furthermore, we extend the existing literature in general on how start-ups—and, in our research context, cleantech start-ups—use experimentation in creating sustainable value (e.g., Shapira et al., 2017; Buhl et al., 2019). Our exploration is well in line with existing research on the roles experimentation has on start-ups (Bojovic et al., 2018) but it

confronts existing understanding in that different experiments have different purposes for sustainable value creation.

6. Conclusion

Our study contributes theoretically in extending a more nuanced understanding of business experimentation by deriving six different types of business experimentation that cleantech start-ups use for creating sustainable value. We find that these six types, namely *network business experimentation*, *selling business experimentation* through trial and error, *technology scope business experimentation*, *specialist business experimentation*, *customer-driven business experimentation*, and *sustainable value-driven business experimentation*, are used by all of our case companies and as a continuum. Each type of experimentation is dominated by a certain role, i.e., these types of experiments have distinct purposes for the cleantech start-up in sustainable value creation. We confirm that purpose of learning is an inherent role of experimentation, as described by earlier research, but at the same time our results show a much more nuanced and formulated picture of the role of signaling and convincing in the sustainable value creation in cleantech start-ups. These core findings support recent trends on emphasizing stakeholder involvement in sustainable value creation beyond economic concerns (Schaltegger et al., 2019) and increased user involvement (e.g., Abrell et al., 2018. Furthermore, our findings extend the understanding of engagement of network resources in sustainable value creation in different types of business experiments and what role these business experiments play in creating sustainable value for start-ups. Indeed, fundamentally our contribution to the business experiments research stream is that there are different types of business experiments for different purposes, which also paves a way for fruitful research agendas for future studies.

6.1 Managerial implications

The managerial implications of the study constitute a typology of six business experimentation types for managers to pursue individually and/or as a continuum in creating sustainable value for and with their stakeholders. The typology allows managers to "tailor" their business experimentation to the specific context, needs, or requirements of the customer, while expediting learning and signaling and convincing other parties of the sustainability-driven value and legitimacy of the start-up. Managers of cleantech start-ups can create competitive advantages by bridging the need for sustainable value creation through expanding the scope of technology-driven business experimentation and by applying their intrinsic "better world" motivations in expanding business experimentation for sustainable value creation.

6.2 Further research and limitations

Future studies could investigate if there are other types of experiments and could also dive deeper into for what purposes different business experiment types are used. The different use of experiments in start-ups' sustainable value creation reflects recent discussion on the centrality of choice that entrepreneurs must make between various options in pursuing their entrepreneurial strategy (e.g., Gans et al., 2019). In response, future research could investigate why and how business experiment types influence entrepreneurial choice making or vice versa. The limitations of the study also constitute opportunities for further research. For one, case study was small and focused on one industrial sector, cleantech. Consequently, further research could explore the six BE types and how and when they are used through a larger and quantitative study, or through a

comparative study of cleantech start-ups versus conventional start-ups in exploring the role of sustainable value creation in business experimentation.

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APPENDIX

1. **INTERVIEW GUIDE / 3rd version**

Questions used in the JCP Call on Business experimentation for sustainability (Submission deadline: March 31, 2019)

See call text:

https://www.journals.elsevier.com/journal-of-cleaner-production/call-for-papers/business-experimentation-for-sustainability

1. What initial idea started the development of your sustainable business?
    (who/what inspired you to start your business? What were you hoping to solve?)

2. How do you provide benefits/value through your offerings to:

    a. customers,
    b. society and
    c. the environment?

3. Who are your customer segments and what are your relations with them?
    (e.g., close – we co-create, they provide input and ideas for our products
    or not close – we just collect complaints and information)
    a. How willing are the targeted customers to take the new product/service in use?

4. Who do you work together with? What types of stakeholders do you work with?

5. How is your business being created/developed in practice? (this value created?)

    a. Through which activities? How loose is your organization? Do you work with
        volunteers? How do you attract them? (Have you encountered Smart Money?)
    b. What resources do you use and need to provide this value?
    c. Which distribution channels?
    d. Which partners & suppliers?
    e. Which technologies and product features?
        i. How much of the product development is focused on hw and how much
            on sw?
    f. Do you have cooperation / joint projects with research institutes/universities?
    g. How has regulation impacted your business?

6. How does the company make money and capture other forms of value (branding, data
    etc.)?

7. What do you experience as the main benefits and (internal and external) barriers of
    working with CleanTech and sustainable offerings compared to traditional/non-sutainable
    offerings/business?

8. What specific challenges/obstacles are there in the cleantech sector / in developing
    business for more eco-friendly products?

9. How have start-up events helped your start-up? E.g., Slush. Has the municipality helped your start-up? How have business angels possibly helped your start-up?

10. What is the main difference in your view between cleantech start-ups and start-ups in other sectors?