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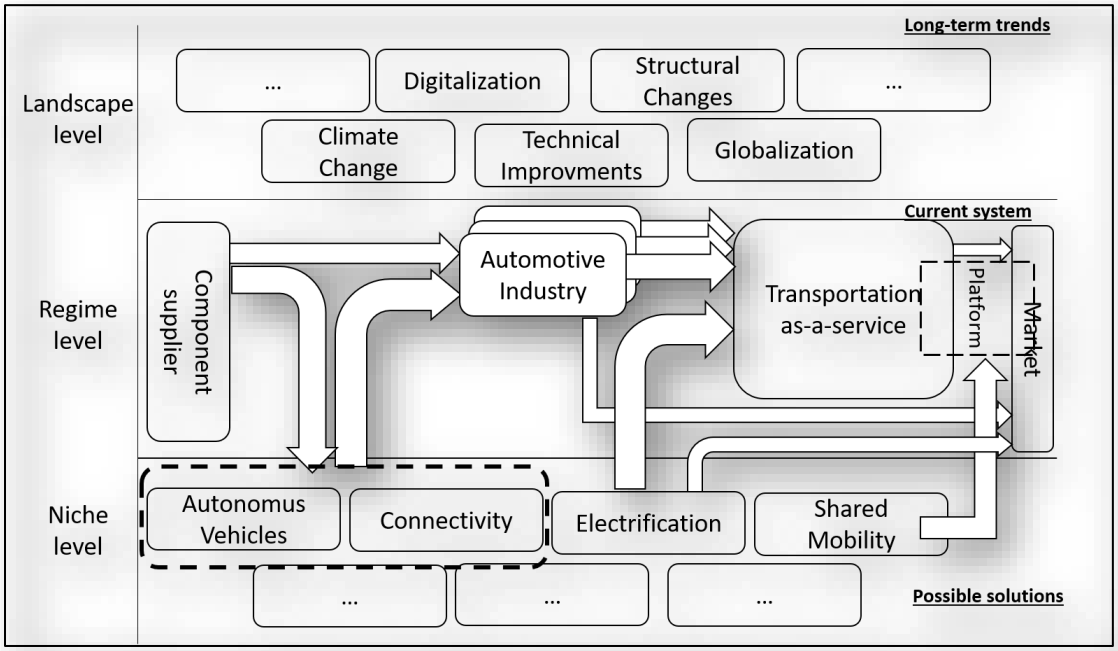

The role of innovation-driven SMEs in upscaling niche innovations within a regional context:

An investigation of SMEs developing new mobility solutions in Västra Götaland County

A Master's thesis at the Challenge Lab, Chalmers University of Technology

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Cover: [A dynamic illustration of "reconfiguration pathway" that represents transition for the current mobility system of Västra Götaland County; a detailed explanation of photo can be found in section 5.1.2. Photographer: Spiros Strachinis]
Göteborg, Sweden 2019

Preface

This master thesis is conducted in a sustainability-related theme at the Challenge Lab (C-Lab), Chalmers University of Technology. The master thesis process in Challenge lab is divided in two phases, I and II. For phase I, the framework of back-casting methodology was followed; which includes four steps based on the back-casting theoretical framework (Holmberg 1998, Holmberg and Larsson 2018). This framework works as a foundation for a better match between a proposed research problem and question from an academic perspective and sustainability problems that need to be addressed from a practical perspective, in order to move towards the envisioned future. More information about phase I is available in appendix A. In phase II, this study authors departed from the research question, reached at the end of phase I, by identifying the appropriate foundation of theoretical and empirical literature, research methodology approach, data collection procedures, analysis and discussion of the study's main findings. The following thesis structure is predominantly what have been implemented during phase II of the C-Lab.

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ABSTRACT

The issue of sustainability transitions of socio-technical systems (STS), despite being thoroughly discussed in literature, still has a lot of work to be further investigated, specifically from multi-level actor-based perspective. This study has a general aim to empirically investigate sustainability transition of mobility system of Västra Götaland County, by adopting theory of system innovations, put by Frank W. Geels, and a co-evolutionary approach of transition. As a system niche actor, Small and Medium Sized Enterprises (SMEs), that are innovation driven and developing new technological solutions, can be a source of disruptive and radical innovations, and hence a significant player in the process of sustainability transition in this regional context. In that regard, this thesis has the following overarching research question: what is the role of innovation-driven SMEs developing new mobility solutions in upscaling niche innovations within a regional context? To answer this question, the role of innovation-driven SMEs, located in Västra Götaland County, is explored by identifying their "*current*" and "*perceived*" roles, respectively. This study follows a qualitative strategy in which a comparative design is adopted. In addition, primary and secondary sources have been accessed to collect relevant data. In order to collect primary data, we identified population of innovation-driven SMEs developing new mobility solutions in Västra Götaland County, and then selected a sample of 9 SMEs to conduct semi-structured interviews. Primary data from 6 industry experts and researchers in the region were collected as well through unstructured interviews. SMEs were classified, under the comparative design, on four technological trends that have the potential to disrupt mobility systems and they are (a) autonomous vehicles, (b) connectivity, (c) electrification and (d) shared mobility. Results of SMEs population showed the existence of other technological trends that are not high-tech but service-based and sustainability-oriented, and they were included in the analysis. A qualitative thematic analysis has been conducted to decide on major themes of SMEs current and perceived roles based on findings of selected sample and industry experts. Accordingly, this study has found that SMEs current role is significantly and positively contributing to the system's transition towards sustainability. The latter role can be classified under three pillars; the creation and maintenance of specialized niches, forming symbiotic relationships with regime incumbents and undertaking active collaboration with various stakeholders on both regime and niche levels. However, current system bottlenecks represented into incumbents' inertia, as well as SMEs shortcoming regarding absence of sustainability-rooted strategies for scaling up their niche technologies, can put the whole transition process under risk of failure. That motivated SMEs perceived role based on their potential

of realizing disruptive effect of niche technologies. Again, by dividing such role into three interconnected sub-roles, SMEs have to adopt more co-innovation of their business models with relevant regime stakeholders, follow new forms of technology diffusion/scale-up rather than traditional business growth, and engage into more articulation of regime challenges and more direction of collaboration activities' goals. Lastly, VGR has a decisive role to assist SMEs scaling up their innovations, besides its traditional function to provide financial and mentoring support, by exerting more pressuring on regime influential stakeholders to open-up for real collaboration, and by the implementation of bridging policies that aim for more integrative innovation strategies between SMEs and regime incumbents.

Keywords: SMEs, Niche Innovations, Multiple-Level Perspective, Transition Pathway, Strategic Niche Management, Electrification, Autonomous Vehicles, Connectivity, Shared Mobility, Västra Götalandsregionen, Västra Götaland County, Sustainability.

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This thesis is an outcome of a long journey of ups and downs, ambitions and disappointments but with many inspiring “aha” moments!

We would like to send a BIG “thank you” to;

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Hani Elzoumor & Spiros Strachinis

Gothenburg, December 2019

List of abbreviations

Abbreviation	Meaning
AI	Artificial Intelligence
AV	Autonomous Vehicles
B2B	Business-to-Business
B2C	Business-to-Consumer
BMfS	Business Models for Sustainability
BRG	Business Region Gothenburg
C-Lab	The Challenge Lab
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CO_2	Carbon dioxide
EU	The European Union
EURO	The European currency
EV	Electric Vehicle(s)
FCV	Fuel-Cell Vehicle(s)
FEV	Full-Electric Vehicle(s)
HEV	Hybrid Electric Vehicle(s)
ICE	Internal Combustion Engine
IoT	Internet of Things
IT	Information Technologies
LSP	Lindholmen Science Park
M&A	Merger & Acquisition(s)
MLP	Multiple-Level Perspective
MVP	Minimum Viable Product
N/A	Not available
PHEV	Plug-in Hybrid Electric Vehicle
R&D	Research and Development
RIS	Regional Innovation Scoreboard
RISE	Research Institute of Sweden
SEK	The Swedish Kronor
SME(s)	Small and Medium-sized Enterprise(s)
SNI-code	Svensk näringsgrensindelning
SNM	Strategic Niche Management
SOI(s)	Sustainability Oriented Innovation(s)
STS	Socio-technical System(s)
TaaS	Transportation-as-a-Service
TMS	Transport Management System
VGR	Västra Götalandsregionen / Västra Götaland Regional Council
VTI	Vägtransportinsititutet
WCED	World Commission on Environmental Development

List of figures

List of tables

Table of Contents

1.Introduction

1.1 Background

1.1.1 Theoretical point of departure

The ***concept of sustainability transition/transformation*** has been heavily discussed under the realm of sustainability and sustainable development literature. In order to address what is meant by sustainability transition, it is of significant importance to start with the definition of "sustainability". Despite the various approaches and definitions put for the former concept, this thesis has adopted abroad definition formulated by the World Commission on Environmental Development (WCED) as; "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Later on, sustainability research has approached the concept from different perspectives; however, most cited definitions of sustainability are fundamentally based on three intersecting pillars or aspects (environmental, economic and social) that are fulfilling human needs and wellbeing. It is worth-mentioning that "sustainable development" as a process and "sustainability" as an outcome have been interchangeably used to reflect the same meaning (Schaltegger, Hansen et al. 2016).

Sustainability transitions are defined as "transformative changes" in which fundamental and transformative actions have to be undertaken to realize changes on a wide scale such as systems or sectors that serve specific societal functions or on the whole societal level. These kinds of transitions are not aiming to create incremental or marginal changes, but they are targeting to support radical, disruptive or substantial change in societies. Therefore, sustainability transitions are complex processes in which configurations of unsustainable systems are dismissed and replaced by more sustainable ones. In fact, sustainability transition scholars such as Frank W. Geels have developed many conceptual and theoretical frameworks that investigate and explain such complex transformative processes. For instance, in order to conceptually investigate and understand sustainability transitions on systems level, the concept of ***"system innovation"*** has been developed in literature, and it is usually defined as sustainable transformation of one of societal functions that takes place on a wide scale such as mobility, communication, housing …etc. (Geels 2005). A prominent theory of Multi-Level Perspective (MLP) of system innovation analyses how the structural formation of systems into three interlinked levels (landscape, regime, and niches) lead to a sustainability transformation process in which many actions and processes are taking place, co-evolving and reinforcing each other.

In that regard, it was argued by Geels (2004), Geels (2005) and Geels and Schot (2007) that ***system niches*** are the seeds of change, as they are "the locus of radical innovation". In fact, system niches are defined as protected spaces that are set up for the experimentation and development of new and radical technologies. It is argued by the last references, and adopted in this study, that such niches would lead to system innovation by utilizing windows of opportunity through scaling up innovations and linking with developments on higher system levels (i.e. regime and landscape). Geels (2004) stressed that involvement of actors is essential to accelerate the diffusion of radical new technologies into system regimes; however, there is still ***a literature gap regarding actor-related activities on***

niches of MPLs, and their effect to accelerate technological breakthroughs on higher system levels. Accordingly, more research is needed to reveal how niche actors navigate transitions, and to investigate actors-related patterns, including their modes and strategic interactions, in order to understand speed of diffusion and/or breakthroughs of new technological configurations that lead to system disruption and innovation.

On another note, ***Small and Medium-sized Enterprises (SMEs)*** play an essential role in technological niches. Many writings have referred to the pivotal role that SMEs are playing nowadays in innovation systems, especially regional ones, due to many factors; and that have created promising niche opportunities for them to step in (Smallbone, North et al. 2003). In addition, the last reference has classified SMEs according to their technological level and assumed that ***technology-driven SMEs*** would "create and maintain specialized niches" while they are developing their novelties and can be strong candidate to drive radical innovations especially in tech sectors and high-technology regions. Klewitz and Hansen (2014), in their systematic review of Sustainability-Oriented Innovation (SOIs) of SMEs, have argued that innovation-based and sustainability rooted strategies for SMEs would result into radical innovation, which have more influence to affect sustainability transformations on higher system levels. However, there is no enough literature that investigates the dynamics of SMEs role as niche-based actors into system innovation and sustainability transformations, specifically for scaling up sustainable radical technologies. Indeed, such dynamic role of SMEs has been reviewed from limited co-evolutionary perspectives such as interplay between SMEs and incumbent firms into creating and scaling up niche innovations, and from business model innovation perspective. However, more explorative research needs to be implemented from other theoretical co-evolutionary perspectives to ***understand dynamics of such SMEs role in scaling up niche innovations towards sustainability transformation of systems***.

1.1.2 Empirical point of departure

This study has a general interest of sustainability transition within ***the regional context of western Sweden***, and a specific interest of sustainability transition of ***"mobility system" inside Västra Götaland County***[1]. On a national level, there is an ongoing comprehensive work for a fossil-free Sweden. The goal is to make Sweden as a fossil-free country before 2045. On a regional level, Västra Götaland County is Sweden's second largest region in terms of population and is the hub for the automotive industry in Scandinavian countries. Regional authorities, represented into VGR, have taken an active role to reach fossil independency by the year 2030. In "Klimat 2030" report, published by Länsstyrelsen Västra Götalands län, the strategy is presented and described. Out of the four focus themes, one is related to mobility under the name "Sustainable Transports". The report proposes four different types of investments in this respective theme (VGR 2017);

- Sustainable everyday travel, where more people choose biking and collective travels

[1] Note that a list of terminologies is provided in appendix D, in which we briefly present/define main public authorities, companies and collaboration arenas that are mentioned in this study.

- Accelerate transition for fossil free vehicles
- Effective goods transportation
- Climate-friendly smart meetings and vacations

Västra Götaland Region has good prerequisites for the transformation. There exists dynamic private sector (i.e. innovative enterprises related to the transportation industry), strong knowledge centers, a dedicated public sector, and uprising collaboration platforms, that are committed to meet and solve society problems. The region has an ambition to become a role model for sustainable transformation, and this has been expressed through dialogs, meeting and reports from different actors inside the region. However, ***different stakeholders have different goals, interests and views*** towards achieving sustainable transport/mobility systems. For example, during an arranged meeting between this study authors and one of the actors in the public sector, economic sustainability was perceived as being used by incumbents to postpone the transformation for ecological sustainability. That was by arguing disruptiveness could make business models and products of incumbent firms obsolete, hence, many people would be unemployed, thus hurting economic sustainability.

Collaboration between actors in academia, government and industry to reach the goals for "Klimat 2030" is in the core of sustainable mobility transformation processes taking place inside Västra Götaland County. One example of an entity that support collaboration in Västra Götaland County is Lindholmen Science Park (LSP). LPS is located in a favorable position in one of Gothenburg's major business and academic areas, and it has worked, during the last 19 years, as a collaboration and network platform. At LSP, there exist several relevant initiatives and organizations for mobility transformation. The first one to mention is an incubator for startups that develop new mobility solutions; "MobilityXLab". MobilityXLab collaborates with six corporations, Ericsson, CEVT, Volvo Cars, Veoneer, Volvo group and Zenuity. Currently, it has a portfolio with 17 startups; the majority use some of the Artificial Intelligence (AI) technologies. Furthermore, the office for the testing arena of autonomous vehicles "AstaZero" is located in LSP. AstaZero is a perfect example where all three societal dimensions collaborate (i.e. industry, academia and government). It is owned by Chalmers University of Technology and Research Institute of Sweden (RISE) and gets financing from the public sector (i.e. VGR, Borås stad and European Union). Moreover, it collaborates with several industrial partners such as AB Volvo, Volvo Car Corporation, Scania. Outside Gothenburg city, Innovatum Science Park is one of the most active science parks located in Västra Götaland County in Trollhättan, where more than 140 companies are located and working. The park aims to strengthen business community in western Sweden through providing a constellation of services, most importantly, being a science center, driving development projects and incubating startups. Indeed, the park's incubator hosts startups developing innovative solutions related to food, mobility and energy.

On another note, ***several mapping reports*** have been produced by Business Region Gothenburg (BRG) analyzing landscape in western Sweden regarding developments of

new technologies covering companies working in mobility sector. Specifically, BRG has conducted cluster analysis and mapping reports about vehicles, electrification, AI, Internet of Things, Augmented Reality & Virtual Reality etc., partly or completely related to transportation and mobility. In addition, several business/professional international reports around transformation of mobility systems are available. ***Four disruptive technologies*** have been introduced mainly by industry experts, consultancy firms and interest groups and they are; autonomous vehicles (AV), connectivity, electrification and shared mobility (Arbib and Seba 2017, MCFM 2019). It is predicted that those technologies will completely re-shape and disrupt the future of mobility. Some reports have argued for the need to new institutional settings in order to realize the potential, and accelerate the disruptive effect, of such technologies.

Moreover, this thesis has a specific interest into ***the role played by SMEs located into Västra Götaland County*** towards its sustainability transition. In that regard, it is interesting to observe that VGR has taken an active role in supporting SMEs in several dimensions, with the purpose of creating a favorable SMEs environment towards the region's sustainable development, as expressed in its action plan for SMEs over the period 2016-2018 (VGR 2016). These dimensions are divided into two main aspects that include sub-areas of focus. The two main aspects are "business climate" and "innovation and market development", and in which sub areas include aspects such as funding, skills supply, procurement, knowledge transfer, and making new markets more available for SMEs. The second area for "innovation and market development" comprises knowledge transfer as a main sub-component. That is mainly to fill in the knowledge gap through networking platforms and closer collaborations between SMEs and knowledge centers such as academia, science parks, research institutes and industrial development centers. Knowledge transfer can be between SMEs and other companies in the same industry or other companies from the outside industry. In that regard, ***the region has a major role to facilitate knowledge transfer*** between both parties (i.e. SMEs and their knowledge providers).

Moreover, Västra Götaland County has one of the highest R&D expenditures as a share of national GDP, which makes it an innovation leader and placed among the top EU innovative regions, as suggested by the Regional Innovation Scoreboard (RIS) developed by the European Commission (EU 2019). However, such R&D is dominated by a few global companies that represent the majority part of the region's total R&D investments (VGR 2016). The latter reference assumes that such an unequal distribution of R&D business expenditures would make the region vulnerable when structural changes take place. Therefore, the region has identified a main goal to increase R&D investments in SMEs as well as to increase their ability to commercialize research and created knowledge. This is implemented, according to VGR, through providing innovative environments and meeting places for collaboration activities, such as science parks and testing arenas discussed above, which would enhance SMEs innovative capacity.

VGR also identified four major ***landscape/global trends*** that will continue to have a major impact on the entrepreneurship ecosystem in western Sweden. Two of them are digitalization and technical improvements which have increased the productivity in the manufacturing sector through automatization. This has fed into ***a major structural transformation***; less labor is needed to conduct operations. Indeed, workers have gradually moved from the manufacturing industries to the service sector. According to VGR (2016), employment in the region's manufacturing sector (with high productivity) has declined by 7% over the period (1993 – 2011), while the variable has increased 70% during the same period in the private sector, albeit in service companies. Today, SMEs create 4 out of 5 jobs in the region, making it the main source of equalizer during this transformation of occupation between sectors. To reduce economic and social unrest, policies aligned with the creation of new jobs are of importance for the region, thus giving their attention to SMEs. The two other landscape trends that disrupt the current system are globalization and climate transition. Again, the report assumes these two trends could make the established enterprises in the region vulnerable, however; the region also views this as an opportunity for innovation. Lastly, the report assumes that region's strategy "Klimat 2030" can open the door for SMEs to capture new business opportunities for ***sustainability-oriented innovations***, which would enhance their competitive advantage in the domestic and international markets. In fact, there are advantages of SMEs to be leaders for this change, mainly by introducing sustainable new innovations that will solve future challenges and satisfy demands, hence securing precious jobs. In other words, ***VGR aims for SMEs to take a significant role with the process of creating and managing upcoming sustainable innovations and help them grow within such process***.

In summary, Västra Götaland County is witnessing major transformative processes toward sustainability, with mobility in its core. However, such dynamic transformative processes include a lot of elements such as debates among stakeholders about regional sustainability strategies and optimal path of such sustainability transition, nature of interaction and collaboration among different types of stakeholders, the rise of collaboration arenas/platforms that aim to support new and radical innovations, in line with the suggested role that VGR has expected SMEs to play as a leader for introducing and managing sustainable innovations. All these elements provide ***an attractive leverage point for this study to do an in-depth investigation for the role of SMEs that are developing radical and sustainable new innovations aiming to transform mobility sector inside Västra Götaland County***.

1.2 Scope/Aim of the study and research question

This study aims to shed light on one of the main actors for leading sustainability transitions in a regional context; Small and Medium-sized Enterprises (SMEs). Based on theoretical point of departure, specifically from system innovation within the context of sustainability transitions, niche innovations brought up by niche level actors, including SMEs as a main stakeholder, have the potential to disrupt and transform unsustainable systems towards a more sustainable path. However, there is still a theoretical gap regarding the role of SMEs, as a main actor/stakeholder, on the niche level, in the process of upscaling niche

innovations towards sustainable transformation of systems. Based on empirical point of departure, within the regional context of western Sweden, a pivotal role is expected by SMEs residing in this region to significantly contribute in its sustainable transition, specifically in the light of VGR strategy of sustainable transport system. ***Therefore, this study is interested into investigating the case of SMEs located in western Sweden that are innovation driven. Such investigation is specifically regarding what role such entities play in accelerating and scaling up innovations in the context of regional transition towards sustainable mobility system.*** It is worth mentioning that in order to identify what is meant by "scaling up niche innovations", this study adopts Schaltegger, Hansen et al. (2016) co-evolutionary approach for scaling up niche business models towards sustainable transformations of markets. Accordingly, the concept "scaling up niche innovations" is defined by this study as the diffusion of sustainable innovative technologies by niche players (i.e. SMEs or other niche players) either through growth or other mechanisms such as replication or mimicry, in a co-evolutionary process that is characterized by high collaboration activities among niche actors as well as other stakeholders.

Accordingly, this thesis has the following overarching research question:

"What is the role of innovation-driven SMEs in upscaling/accelerating niche innovation within a regional context?"

Under this question, two more-specific research questions can be introduced:

- What is the *current role played* by innovation-driven SMEs in the mobility system within Västra Götaland County?
- What is the *perceived role to be played* by innovation-driven SMEs in the mobility system within Västra Götaland County?

Before proceeding, it is important to clarify why SMEs role is divided between "current" and "perceived" roles. As observed from theoretical and empirical points of departure, SMEs role is predominantly crucial to scale up niche innovations towards sustainable transformation of the region's mobility system, as an ultimate goal. To achieve such goal, this study assumes a perceived (i.e. a distinguished) role that is expected to be played by such niche players towards an agreed-upon vision of the region's transformation towards sustainability. Therefore, the latter role has not only to be perceived by SMEs entrepreneurs themselves but also other influential regional stakeholders such as VGR. Nevertheless, in order for this study to propose such role, it is crucial to understand, in the first place, what SMEs are currently doing within the region. That warrants the investigation of their "current role" in the mobility system of Västra Götaland County, as the first sub-question to be answered, under the current system's preoccupations/arrangements. In line with this, the regional development strategy of VGR is under development right now, therefore; regional authorities would be interested into potential areas of intervention for solving bottlenecks facing SMEs in the region. Indeed, the identification of bottlenecks that face SMEs in accelerating/scaling up their innovations is based on investigating the gap between the current role that such entities are playing and the perceived role that they are expected to play in the upcoming period based on their potential. Hence a more directed

approach, while deciding on the research method and designing interview guide for SMEs, can be implemented.

In order to answer this research question, the study follows a qualitative approach as its main strategy, in which a comparative design is adopted. In addition, it relies on primary and secondary sources to collect relevant data. The study has identified the population of innovation-driven SMEs developing new mobility solutions in Västra Götaland County. The criteria for identification and inclusion of "innovation-driven SMEs" in the population was theoretically based on the definition of "technology-driven SMEs" that Smallbone, North et al. (2003) has developed. The last reference has defined "technology-driven SMEs" as; the ones that keep updated with the latest technologies which would enable them to "create, maintain specialized niches" while they are developing their novelties; therefore, they can be strong candidates to drive radical technologies in high technology regions. In addition, the criteria for identification and inclusion of "innovation driven SMEs" into this study's population have been empirically based on the four promising technological trends, introduced by consultancy firms and industry experts, that have the potential to disrupt mobility systems, and they are: a) autonomous vehicles, b) connectivity, c) electrification and d) shared mobility. Primary data from selected industry experts and researchers within western Sweden were collected, in the beginning and during formation of population, through unstructured interviews. Afterwards, a sample of 9 SMEs were selected for the aim of answering the research questions through conducting semi-structured interviews. Therefore, it is crucial to mention that answering the overarching research question/two sub research questions has been implemented mainly from SMEs perspectives that have been involved in this study, in combination with some insights gained from the selected group of industry experts that have been strongly linked to the studied phenomenon. Qualitative analysis was undertaken later to decide on the major themes of the current and perceived role of SMEs. Based on such analysis, the study identifies bottlenecks facing SMEs while creating and accelerating/scaling up niche innovations. Reached conclusions are expected to have a contribution for VGR in terms of insights that regional authorities should consider in order to assist SMEs overcome barriers and scale up their innovations.

2. Literature

2.1 System innovation in the context of sustainability transitions

2.1.1 What is system innovation?

Over the last few decades, these has been a lot of innovations that led to substantial improvement in environmental efficiency on different, albeit relatively smaller, scales. That has resulted into positive impact on sustainability; however, such innovations did not achieve its desirable impact on a larger scale (Elzen and Wieczorek 2005). Therefore, there has been an increasing interest in creating wide-scale environmental efficiency that would require innovation to take place on higher levels (i.e. system/regime level), which would enable structural transformation of such systems. That kind of innovation is called system innovation, and aims to achieve sustainability transition (Geels, Elzen et al. 2004). That is why scholars of system innovation have given a special focus to the environmental aspect of system/regime transformation. In that regard, Elzen and Wieczorek (2005) argued for the need to build a solid knowledge base for sustainable system transformation as academic research is facing two major challenges. One is to develop a better understanding of transitions dynamics, and the other is feeding insights from such dynamics into formulating and implementing policies that would stimulate desirable transition paths.

In fact, the origins of system innovation go back to late 1970s when the definition of "technological regime" was developed by R. Nelson and G. Winter in 1977, as well as the concept of "technological paradigm" developed by G. Dosi in 1982 (Kemp, Schot et al. 1998). However, more tendency was toward using "technological regimes" in transition literature as a better concept than "technological paradigms" because of the former reference to the rules that are socially embedded into systems; such rules are well established and are not easy to dissolve or change. Therefore, discussion in literature of regime transitions and change, at that time was about system optimization rather than system transformation. Such optimization is dependent on two factors; engineers' beliefs and shared knowledge on one side, and beliefs of market needs/demand on another side. System optimization approach does not take into account the selection environments; or in other words, the institutional factors that rule economic and social environment.

Geels (2005) has defined system innovation as "large-scale transformations in the way societal functions such as transportation, communication, housing, feeding, are fulfilled". This study is concerned with sustainability transition of mobility systems/regimes, which is transition of one of societal functions as mentioned above (i.e. it is on a lower level than a transition for whole society and a higher level than transition on an organizational level such as firms) (Geels, Elzen et al. 2004). In system innovation literature, societal functions (including mobility systems) are also called socio-technical systems/regimes (STS), a concept that is raised by Geels (2004) by adding more actors and sets of rules to the "technological regime" concept developed by R. Nelson and G. Winter. Accordingly, system innovation is interchangeably called transition of STS (i.e. change from one social-technical system to another). Scholars such as (Geels, Elzen et al. 2004), Geels (2005) have identified salient elements of STS that go through transition processes. They are technology, industry structure (i.e. markets, maintenance and supply networks), cultural

meanings and values, regulations, infrastructure. In other words, system innovation is not only concerned with introducing new technological innovations, but also it comprises the introduction of new markets, regulations, infrastructure (on the supply side), as well as attitudes, norms, new users and practices (on the demand side). Elements of STS are, albeit heterogenous, connected into dynamic networks that are continuously reformed on multiple dimensions by activities of relevant social groups.

It has always been argued in sustainability literature that transitions always drive disruptive innovation (Hockerts and Wüstenhagen 2010). Therefore, system innovation causes disruption of prevailing technologies as well as their links to current markets/users, so it leads to structural/architectural changes of such systems. It is also characterized by multi-actor processes, which means that change includes interaction between actors within specific societal group as well as among different societal groups (i.e. system innovation is not initiated by a mere actor or driver). As this study is not only concerned with sustainable transition in automotive industry (as a single industry or sector), but also transition of mobility system as a societal function[2], which warrants the theoretical approach of system innovation. To elaborate, this study does not just investigate a specific industry, sector or technological knowledge, but it tries to understand change from a wider perspective that is characterized by complexity and coevolution.

System innovation has been approached from two distinct disciplines that provide a rich and more comprehensive view of such complex phenomenon. They are evolutionary economics and innovation studies in one hand, and cultural studies (i.e. sociology of technology) and history of technology on the other hand. Historical studies of system innovation indicate the gradual and long time span of such transformation, as it can take many decades of unfold desirable wide scale change (Geels, Elzen et al. 2004). That is because innovation systems are usually characterized by "stability", "path dependency" and "lock-in", which implies that new innovations are mostly incremental in nature (Geels 2004). These incremental innovations maintain and improve existing technologies and retain existing users. Although one reason for stability of existing system can be high investments undertaken by producers and too large built-in capital to write-off (Elzen and Wieczorek 2005). Another significant reason is that current systems are deeply embedded into society; they are adopted to people's lifestyles and prevailing institutional arrangements, which explains why new technologies may fail, in many cases, to achieve wide scale system transitions.

Kemp, Schot et al. (1998) have identified a number of binding factors that hinder sustainable transformation of socio-technical regimes. These factors can be summarized as technological, government and regulatory policies, cultural and psychological, market demand, production/supply, infrastructure and maintenance, expected undesirable effects of new technologies, which comprises the same elements for STS discussed above.

[2] That include mobility of people, goods as well as digital forms of mobility as will be more elaborated in the methodology section.

Therefore, Kemp, Schot et al. (1998) have indicated that radical technologies, necessary to create system transformation, take long development time to make significant changes in such factors embedded in the selection environment. However, it should be highlighted that system innovation or sustainability transition of STS, that would allow "competence destroying breakthroughs" to cause wider changes, are not planned and/or designed in advance, but they evolve as different actors interact and certain processes evolve over time. Therefore, there is a lot to learn about it from exploratory research that investigates such phenomenon in order to understand it over certain systems, regions and time spans.

2.1.2 Theories of system innovation and transitions of socio-technical systems (STS)

There have been many theoretical approaches that explain system innovation from different perspectives, such as point-source approaches, replacement approaches and transformation approaches (Geels 2004). This section is dedicated to discussing two prominent theories of system transitions that have been widely accepted and thoroughly reviewed in literature; Multi-Level Perspective (MLP) of system innovation and Strategic Niche Management (SNM) as the niche-based models of sustainability transitions. The criticism of MLP and niche-based models of regime transitions is discussed afterwards, with the introduction of transition pathways of STS.

2.1.2.1 Multi-Level Perspective (MLP): regimes, landscape, and niches

The Multi-Level Perspective (MLP) of system innovation has been introduced in literature order to better understand the complex phenomenon of system innovation (Geels 2005). Basically, any innovation system is comprised of three interlinked and interdependent levels, in which many processes and actions take place, co-evolve and reinforce each other. They are the micro level or "niches", the macro level or "socio-technical landscape" and the meso level or "regime" in between. MLP have stressed on the importance of interplay between the three levels to adopt wider institutional changes accompanied by the new technological discontinuities. Moreover, the three levels are positioned in a nested hierarchy (Geels 2004); that means niches are embedded into regimes which are, in turn, positioned inside landscapes. The following table no. 1 provides a detailed explanation for each level as suggested by Geels (2005) and Geels (2012).

Table 1: A detailed explanation for each level within the MLP of system innovation

The macro or landscape level	It includes all mega trends that function as background/external/exogenous variables such as macroeconomy, demographic changes, labor market conditions, natural environment, worldwide views, political culture and norms…etc. It also contains unexpected shocks such as wars, environmental disasters, acute changes in oil prices ..etc. It was argued that these variables could have a significant effect on channeling system transitions on the other two levels (regime and niche).
The meso or regime level	It includes the set of rules embedded in the current institutional arrangement of socio-technical systems. They can be summarized into seven dimensions: technology, user practices and application domains,

	symbolic meaning of technology, infrastructure, industry structure, policy and knowledge.
The micro or niche level	Protected spaces/incubation rooms that are prepared for experimentation and development of new technologies as "the locus of radical innovations". Niches have two fundamental aims.: (1) learning about desirability of the new technologies. (2) enhancing further development and accelerating the rate of application of such technologies (i.e. building social networks that enhance their development).

Figure 1: A dynamic illustration of multi-level perspective of system innovation by Geels (2005)

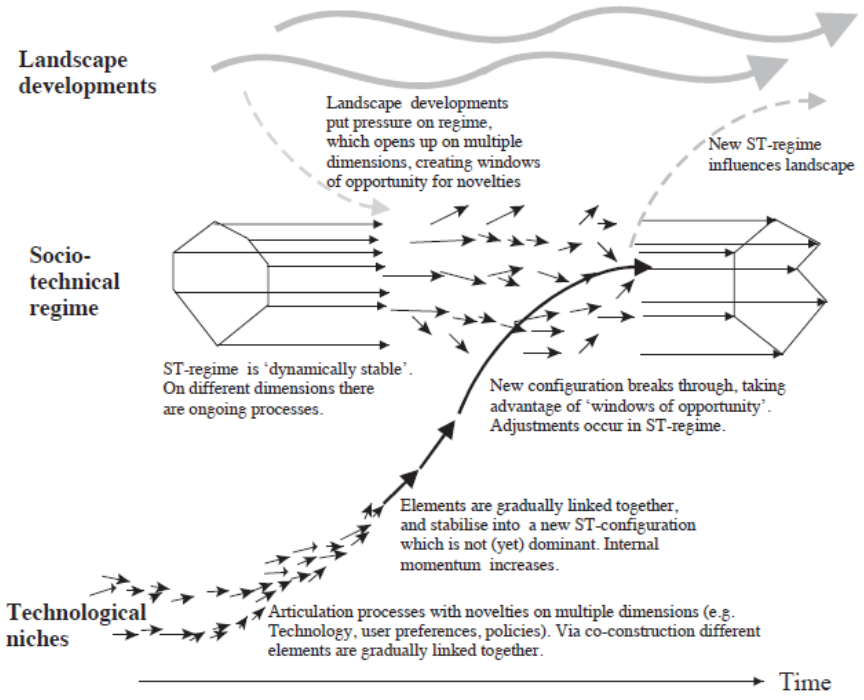


Figure no. 1 illustrates the dynamic process of system innovation from a MLP, as developed by the last two references. Geels (2004) assumes that system innovation is predominantly initiated at the niche level. As shown in figure no. 1 above, new technical configurations that are successfully incubated on a niche level find their trajectory path by linking up to the meso and macro levels. Along the way, linking up new configurations with the different aspects on regime level would result into larger changes on the higher system levels. Although a lot of highly potential configurations are incubated in protected niche spaces, very few ones succeed to achieve regime transformation on a wider scale later. In fact, Berkhout, Smith et al. (2004) has mentioned a number of growth determinants for new technical configurations, that include: degree of effectiveness of protection and nurture within niches, scope of application for niche technologies in new setting (i.e. to what extent the new configuration solves a bottleneck in the incumbent regime), and compatibility of new configurations with current technological regimes. The last

determinant has raised many questions regarding the relative degree of change that can be considered as transformational when the degree of compatibility is very high.

Geels (2005) and Geels (2004) have discussed patterns of new configurations breakthroughs from niches to regime level in an MLP. The former reference assumes that success of wider diffusion depends on linking developments in niche level with ongoing processes on regime and landscape level (i.e. external circumstances that provide windows of opportunity for radical novelties). There are also internal drivers that function as windows of opportunity for niche innovations such as technical improvements and increasing returns of adoption. Although improvement in price/performance ratio (i.e. internal drivers) is one important factor, other socio-technical and social external factors still play crucial role, albeit not comprehensively discussed in innovation literature (Geels 2005). The former reference has indicated three distinguished patterns of technological breakthrough from niches to regime and landscape levels.

First, radical innovations are accumulated at the niche level; they do not happen suddenly or at once. They are gradual and follow subsequent steps. In that regard, learning processes at niche level include, at its core, testing novel configurations with users, and by building that experience, new technical forms and functionalities of such novelties are explored and validated. This process would lead, at the end, to the stabilization of rules, which means the creation of new dominant design and articulation of new users' preferences.

Second, innovations at niches follow co-evolutionary pattern by linking to other technologies. Interlocking, interrelatedness, and co-development of multiple technologies become recently a main theme in technology diffusion research. In this regard, there are four ways in which emerging niche technologies co-evolution can take place. A new technology can:

(1) Be a complementary to existing technologies, especially when the former one faces a lot of constraints in its functionality.
(2) Be a technical addition or hybridization, as new and old technologies can create a kind of symbiosis link.
(3) Follow sequential accumulation; when a technology catalyzes an existing regime to open up and hence provides an opportunity to an upcoming technology to link up on a later stage.
(4) Exchange some elements from other competing technologies.

Third, involvement of actors is an essential pre-requisite to stimulate and accelerate diffusion of new technologies on higher levels of MLP systems. Indeed, active involvement and support from related actors can help newly emerging technologies to link up and reinforce each other. That would enhance the creation of new opportunities that would lead to regime change. It is important to mention that actors' involvement is a non-linear process which includes both accelerations and slowing down. That process affects strategic interactions between actors as well. Scholars have been able to study actors-related activities in case studies by investigating micro activities of actors' practices on a local

level (Geels 2005). On a later study, Geels and Schot (2007) have defended MLP model from critics and indicated that although it is a global model, which describes and analyses transition process from a macro/holistic perspective (i.e. outside-in approach), MLP is also designed to allow analysis from an actor/local based perspective (i.e. inside-out approach). However, the focus on actors related activities can be more elaborated by single case studies. That warrants aim of the study, its research question and its exploratory nature of investigating the role played by an essential actor in technological niches "SMEs" by upscaling such technological breakthroughs that have the potential to transform mobility system in western Sweden.

2.1.2.2 The process of nice formation: Strategic Niche Management (SNM)

Background and definition of SNM: Kemp, Schot et al. (1998) have introduced the concept of Strategic Niche Management (SNM) in the regime transition literature. The concept comprises the creation and management of niche spaces for highly potential technologies. The importance of SNM relies on the famous assumption of system innovation literature: transformational changes in innovation systems can be initiated from niche level because they are the rooms for radical novelties (Geels 2004). Practices developed by niche players/managers, when adopted on a larger scale, would have a more amplified effect that could lead technological regimes to transform. Accordingly, transitions of socio-technical regimes suggest a crucial role to be played by niches and entrepreneurs/system builders in such complex process. In strategic niche management or "niche-based model" of regime transformation, niche actors who are transition managers protect what they believe as desired technological configurations, so that such configurations have the opportunity to develop and prosper on a later stage. Then they can replace and/or transform current environmentally unsustainable regimes.

Specifically, niches are important to prove the technical viability of, secure financial assistance for, and form "constituency" around the new-born technologies. In other words, niches provide space for learning processes, and institutional connection and adaptation that are crucial for accelerating such novel technologies. Accordingly, regime transitions require niche proliferation as a core element in such process, hence, Kemp, Schot et al. (1998) has introduced the concept of SNM as "the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology". Geels (2004) has indicated that experimentation processes in protected niches are precarious (i.e. reconfiguration processes of new technologies on niches are, to a great extent, unorganized and coincidental; they can go in many directions and lose momentum). That would require more work from niche actors to support it as well as articulating its rules.

Steps and processes of SMN and formation: Kemp, Schot et al. (1998) and Kemp, Rip et al. (2001) explained in detail the five steps of SMN. These steps should not be seen as

sequential; but overlapping, interconnected and feeding into each other. They can be presented as follows,

The choice of technology: a technology that could be supported by a SNM process is one from outside the current technical regime and has a high potential to solve a persistent problem at an acceptable cost level.

The selection of an experiment: it is the selection of an appropriate setting for developing and testing the new technology. In other words, it is the selection of the most appropriate space, such as a specific geographical location or a business application, in which the technology advantages are maximized, while its disadvantages and disruptions are minimized.

The setup of experiment: it is the most difficult step as it includes choosing the right policy mix that maintain the balance between the protection and selection pressure on the new technology. Indeed, high focus on protection and low focus on selection can lead to reverse results in terms of very expensive failures. On the opposite side, high selection pressure with little protection can lead to undesirable path dependencies for the new technology.

The scale up of experiment: it is related to the choice of the right policy mix to promote the scale up of successful experimentation of a new technology.

The breakdown of protection: this is done when protection is no longer needed as the technology does not show desirable results. It is also needed when niche manager wants to fully consider selection pressure. However, this step should be done in a controlled manner in order not to negatively affect involved companies and developers.

In addition, Kemp, Schot et al. (1998) have highlighted three processes that constitute niche formation. First, *coupling of expectation*; which is the process of translating expectations and promises of the developed technologies to other actors by engaging into collaboration activities that substantiate such expectations primarily to market users/adopters. That is because actors vary according to their interests, capabilities, believes/values as well as expectations. In that regard, regulators as well as public authorities can have a crucial role in supporting (or impeding) niche technologies if they are (or aren't) successfully engaged into this process (Elzen and Wieczorek 2005). Second, *articulation process*; specifically, the articulation of the above-mentioned barriers for regime transitions, as well as possibilities to overcome them (i.e. articulation of technology design specifications, its side effects, and users' needs/requirements). Articulation is undertaken through experimentation as presented in the steps of SNM. Third, *network formation*; and that is for new actors developing the disruptive technologies. In this regard, government can step and assist in forming such networks as other prevailing actors would not be interested into taking the initiative and spreading respective technologies that may threaten existing ones. These networks should represent potential users/adopters of new ideas as they are the main receivers of development outcome and primary source of feedback over the SNM process.

Characteristics of SNM and formation: It is crucial to mention that SNM is undertaken by more than one actor who can perform as "niche managers" such as governmental agencies, local municipalities/authorities, non-governmental organizations, private companies, interest groups and/or independent individuals. The number and collection of involved actors differs from once case to another, albeit it is a collective action process than a single-actor one, and it is not implemented in a systematic or coordinated manner. Kemp, Schot et al. (1998) and Kemp, Rip et al. (2001) have highlighted the role of government in SNM as an enabler, facilitator and process manager of niche formation, rather than a regulator of it. Elzen and Wieczorek (2005) indicated that this facilitating role is concerned, in the first place, with fostering knowledge transfer and affecting patterns of collaborative relationship among involved actors. Different government levels can have different roles in SNM. For instance, a local government can facilitate networking activities and information exchange (i.e. be a network manager), while a regional or state government can co-sponsor projects that need to scale up and formulate supportive macro-policies.

SNM has to be perceived as facilitating, rather than a modeling, factor of regime transitions, yet it is a steppingstone in this process. Moreover, government's policies are one component among many other factors that form its multi-actors' perspective. The success of strategic niche formation and management is dependent on the status of current regime (i.e. its structural problems and changes) as well as on the processes within the niche itself. Both factors are determining the patterns and path dependences of niches development. Therefore, success of SNM is not granted; because of the unexpected factors from the selection environment that can alter the attractiveness of a new technology. That is why it is key to support technologies that have high improvement potentials, several applications, as well as ample cost reductions.

Accordingly, Kemp, Rip et al. (2001) consented with the above-mentioned literature of sustainability transition of STS that niche managers cannot completely predict transition paths of regimes in a certain desirable direction as SNM is coevolutionary in nature; there is no linear causality between its processes and their expected outcomes, and there is no clear cut distinction between its public and private spheres. However, SNM is not completely unpredictable as it comprises guidance for paving transition paths in order to increase the probability of their desirable direction. That's why sustainability transition cannot be fully controlled but it can be affected and direct its developments over adequate, and relatively longer time periods (Brown, Vergragt et al. 2004). Lastly, to create a desirable transition, a critical mass should be created; experiments should have adequate size and time span in order to achieve learning economies and intended institutional change. Kemp, Schot et al. (1998) have noticed that experiments for new technologies in transportation sector are implemented on a small scale and on a short time period, therefore, a significant risk was demonstrated for losing all created knowledge from such experiments when they are done.

2.1.2.3. Criticism to MLP and niche-based theories of regime transitions and the development of transition pathways

Berkhout, Smith et al. (2004) have argued that existing theoretical explanation of system transformation, especially MLP approach, is predominantly niche-based, as they place too much emphasis on niches to create regime transitions. In other words, theoretical foundation of regime change has focused on linking activities on the niche level and finding trajectories to direct new technological configurations towards executing deliberate transitions. Particularly, Berkhout, Smith et al. (2004) have criticized F. W. Geels's MLP theory of system innovation as it does not provide a solid explanation of how new configuration on the niche level would "link up" to the incumbent regime level in the process of creating wider regime transformation, as F. W. Geels explained it as "haphazard and co-incidental" process.

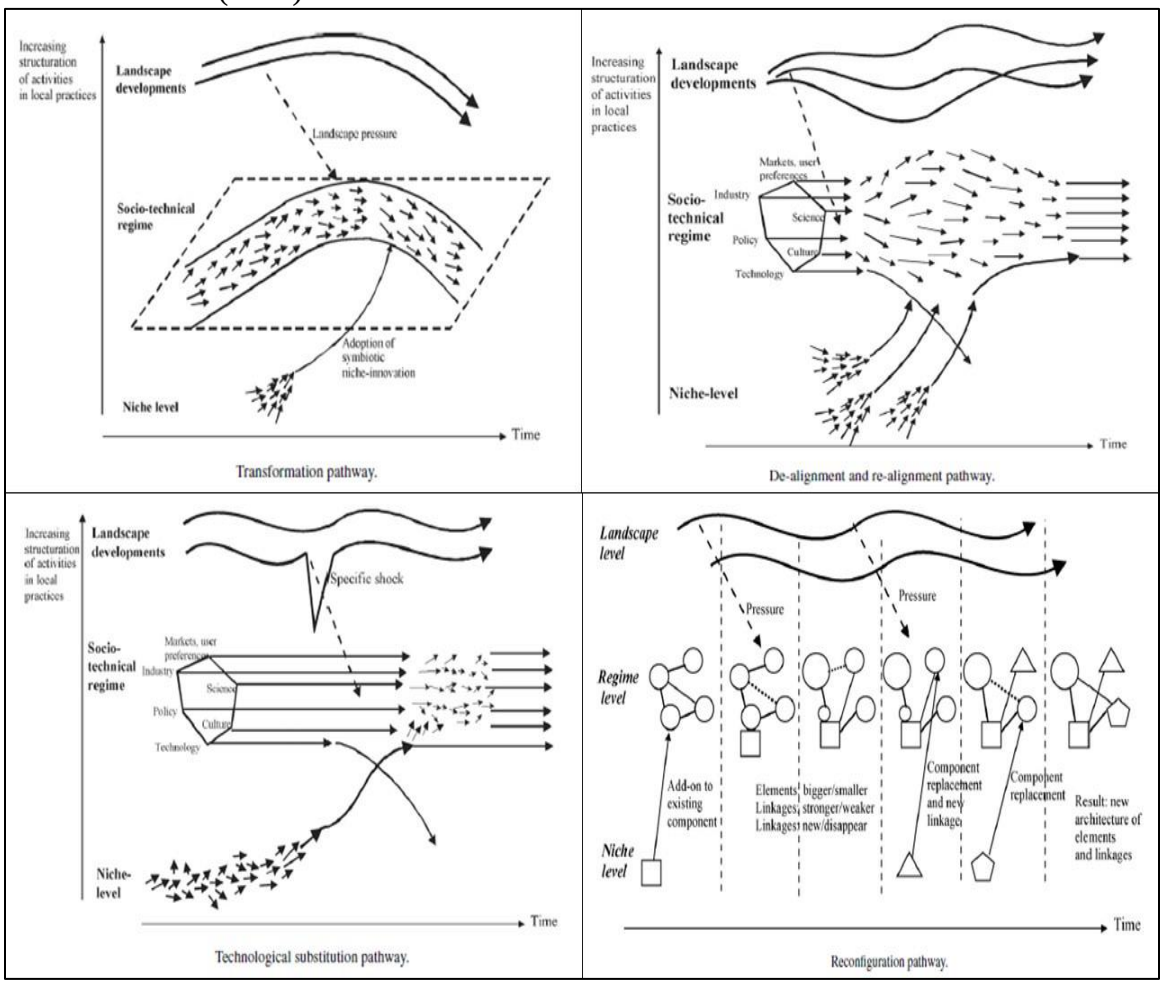
Geels (2004) explained that changes in the landscape such as economic fluctuations and demographic megatrends can perform as a source of tensions in socio-technical regimes, but with no further explanation of how such tensions arise and create windows of opportunities to "link up" with niche radical novelties. In fact, it was argued by Berkhout, Smith et al. (2004) that some observations and historical examples of regime transitions have indicated to the top-down direction of initiating change. Macro-level processes can put regimes under selection pressure that would stimulate change. Therefore, transitions are not only taking place through the bottom-up niche-regime technological breakthroughs with the aim of creating a new, or upgrading an existing, social function. For instance, new institutional, economic, political, social and cultural settings on the landscape can stimulate innovation on the micro-niche level, hence drive larger transformation on the meso-regime level. And that would have a crucial factor of creating bottom up opportunities from niche level for linking up to higher levels. So, the question arises: how can the top-down processes would create bottom-up opportunities for radical innovations to link up?

In response to criticism on MLP framework, Geels and Schot (2007) have developed a typology of four transition pathways based on alignment of developments within and between the multiple levels. Nevertheless, the four pathways are highly differentiated with respect to *timing* and *nature* of multi-level interactions. Regarding *timing*, it is the time when landscape pressure takes place on the regime level. This pressure can happen while niche innovations are or are not fully developed and ready to break out to regime; and that would result into different transition pathways. In fact, Geels and Schot (2007) have mentioned four indicators for stabilization of niche innovations and their readiness to scale up on regime level. They are: (1) the establishment of a dominant design as a result of cumulative and continuous learning processes. (2) the establishment of support network by powerful related actors. (3) significant techno-economic improvements (i.e. price performance ratio) with expectations for further improvements. (4) the spread of technology in a market niche that can count to 5% of market share.

Regarding *nature of interaction*, landscape pressure as well as niche innovations can have either reinforcing or disruptive relationships with regimes. Landscape reinforcing

relationship with regimes would not lead to regime transition, while a disruptive relationship might create necessary pressure for regime change. Niche innovations, in many times, have a "competitive" relationship with existing regimes, and in such cases, the former aims to replace the later. In some other instances, niche innovations can form symbiotic relationship with regimes, and in this case, the former would be adopted by the later as "add-on competence enhancing" technologies that aim to improve regime's performance and solve its problems.

Figure 2: A graphical illustration of the MLP four transition pathways as developed by Geels and Schot (2007)



Accordingly, the four transition pathways can be presented as follows:

a) *Transformation pathway*: moderate landscape developments exercise pressure on regimes, and that happens in early phases of disruptive changes taking place in the landscape level. Regime actors, in turn, re-orient/ modify the direction of their innovation activities, while niche innovations cannot take advantages of such developments because they are not sufficiently developed. In this path, outsiders such as pressure groups and movements, entrepreneurs, activists, exert pressure on regime insiders. The later tends to neglect negative externalities and problems that the regime

faces. When pressure happens, regime actors re-adopt innovation paths and their development trajectories in a gradual magnitude. In addition, niche innovations would function as symbiotic add-ons to existing regimes without any restructuring/disruptive effects.

b) *De-alignment and re-alignment pathway*: landscape would exert large, sudden and frequent pressures on regime that suffers from persistent structural problems. That cause regime actors to lose trust in the prevailing regime's developmental path, and that can be seen in declining R&D investments in sustaining innovations. That will also cause the de-alignment of prevailing regime and creation of a gap and an opportunity for radical novelties to fill in. On the niche level, radical innovations may not be ready to penetrate regimes; as they are not fully developed. So, they enter a co-evolution process in which multiple niches compete to evolve and gain resources in conditions characterized by high uncertainty and experimentation. Eventually, one niche innovation manages to gain momentum and be the dominant design, break out and create the re-alignment path of regime.

c) *Technological substitution pathway*: in this path, there is much pressure from landscape developments. At the same time, sufficiently-developed radical innovations are located in, and ready to break out of, the niche level. Accordingly, such radical innovations would replace the existing regime when landscape pressures on regime are enough to initiate transition. Interestingly enough, regime level can be relatively stable, but facing small problems, however; regime actors think that such problems can be solved by sustaining innovations. Therefore, regime actors do not pay much attention to radical innovations happening on the niche level. When landscape shock takes place and initiates transition, niche innovations diffuse to bigger markets through more niche accumulations. This path is characterized by sever competition between incumbent regime firms and new actors; as they both enter a power struggle. In this struggle, incumbent firms would try to defend themselves by improving existing technologies (i.e. the sailing ship effect) but they usually fail at the end. This path is also characterized by "technology push" as new innovations replace/substitute old technologies, leading to the downfall of traditional regime incumbents, wider regime changes, and the emergence of new STS.

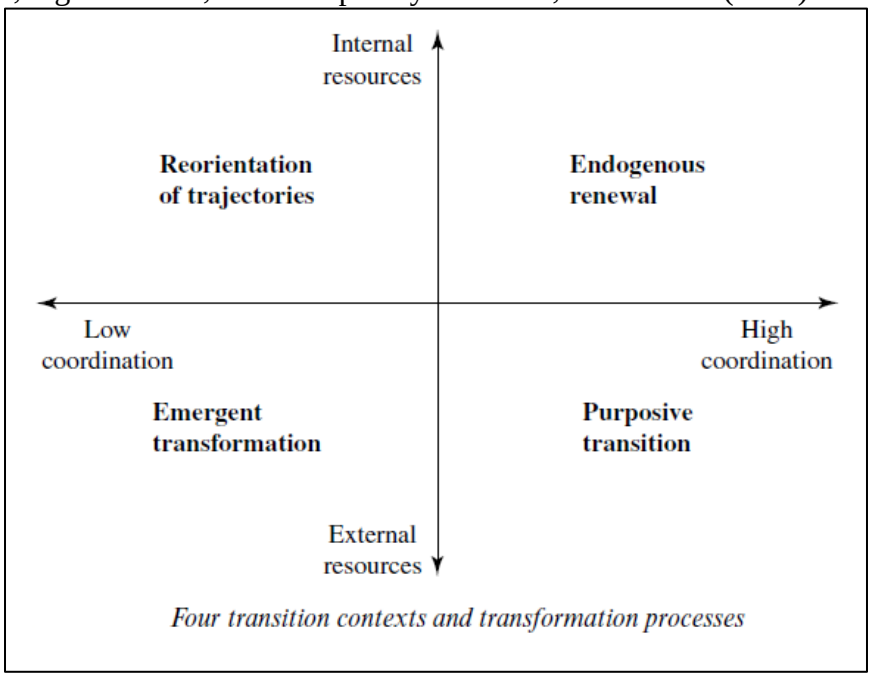
d) *Reconfiguration pathway*: in its first phase, this path resembles transformation pathway as niche innovations form symbiotic relationship with regime that adopt such technologies to solve its local problems. That process is usually driven by economic considerations such as increasing performance efficiency. However, on a later stage, the adopted innovations would lead to more adjustments on the regime level, as supported by new waves of pressure from landscape developments. Regime actors learn more about niche innovations and they "explore new combinations" between old and new technologies' elements. That in turn would open new windows of opportunities for more adaptation of niche innovations, which would result in more

changes and reconfigurations on the regime level. It is important to highlight that this pathway is different from transition pathway as a reconfiguration path would imply fundamental changes in the regime basic architecture. In addition, transition is initiated because of the interaction among multiple technological configurations (i.e. component innovations), and not a single technology, that are developed and distributed among many STS. Lastly, regime actors would survive in such transition path, while niche innovations would compete and serve as "component suppliers" to regime actors.

Figure no. 2 above shows a graphical illustration of MLP four possible transition pathways. Moreover, Geels and Schot (2007) argued that, in a dynamic presentation of transition pathways, when landscape pressures continue in the form of disruptive change, transition can take a particular sequence. It would start from transformation then to reconfiguration, and at this stage, regime actors would continue to exist, while niche players would be complementary add-on suppliers to existing regime actors. Transition can turn to be substitution or de-alignment and re-alignment if landscape pressures become more disruptive, and regime changes seem to be insufficient to solve its challenges. In such case, regime incumbents lose faith in existing technologies and eventually collapse. The breakthrough of new niche players would determine the resulting pathway (either substitution or de-alignment and re-alignment) according to its development status (either sufficiently developed or not).

Alternatively, Berkhout, Smith et al. (2004) have suggested another projection for transition contexts as presented in figure no. 3 below. As shown from the figure, transition contexts are depicted on two dimensions; one is the level of coordination among regime actors (i.e. either transformation is highly organized/coordinated/intended on the regime level or it is based on unintended outcomes of actors' interactions). The second dimension is the availability of resources such as capabilities, knowledge ..etc. (i.e. either transformation is dependent on internal regime resources or external resources that are not within regime outreach). It was assumed by Berkhout, Smith et al. (2004) that availability of internal resources would cause change to be incremental/gradual in nature. While if change is characterized by lack of internal resources and adaptation of external resources, then transition would experience more disruptive and major structural changes.

Figure 3: Transition contexts based on level of coordination among, and availability of resources to, regime actors, as developed by Berkhout, Smith et al. (2004)



As presented in figure no. 3, the four transition contexts can be summarized as follows; (1) *endogenous renewal*: regime actors are executing deliberate regime transformation, as a result of outside pressure using its own resources. That would result into incremental innovation that is shaped by regime actors and accumulated over time. (2) *reorientation of trajectories*: unexpected shock originated either from inside or outside regime would push regime actors to respond and initiate change in a very uncoordinated manner by using its own resources. (3) *emergent transformation*: it is initiated by outside uncoordinated pressures on regime level, in which outside actors from other industries such as small firms and university research facilities step in and develop unconventional solutions. These solutions can be disruptive in nature and would initiate major changes later. In fact, Berkhout, Smith et al. (2004) argued that Information Technologies (IT) are an excellent example of disruptive technologies that can function in different technological regimes and cause emergent transformation. (4) *purposive transition*: which is highly coordinated and deliberately executed, however; it reflects a set of interests from outside regime boundaries. In many cases, purposive transition represents the broad spectrum of societal expectations and interests. Berkhout, Smith et al. (2004) indicated that the last form of transformation (i.e. the purposive transition) is the most likely one to create a successful transition management because it would imply a successful negotiation process among different societal actors, inside and outside regime, on the agreed-upon vision that is deliberately executed and guided by them.

2.2 Role of innovation-driven SMEs in upscaling niche innovations

This second part of literature is reviewing innovation-driven SMEs, as the focus actor of this study for scaling up niche innovations to achieve sustainability transitions. It is crucial

to highlight that there is no adequate literature tackling role of SMEs in scaling up niche innovations. However, many scholars have been investigating the uprising role of SMEs in regional innovation systems, various types of SMEs innovation activities, sustainability dimensions/aspects of SMEs innovations, relationship between SMEs and other niche players that introduce radical innovations, and accordingly, the role of business model innovation in the core process of upscaling niche innovations towards achieving sustainability transformation, which will be reviewed in this section.

2.2.1 Rise of SMEs as a main actor in regional innovation systems

Nowadays, SMEs are playing a pivotal role for promoting economic growth and innovation in many regions worldwide, especially within the European economies. In fact, SMEs have formed 99% of all businesses inside the European Union (EU), provided over 85% of newly created jobs, and constituted two thirds of total private sector employment over the last five years (EU 2019). Smallbone, North et al. (2003) have discussed the increasing importance of SMEs inside EU different regions since the beginning of 1980s, from an economic perspective, both on the supply and demand sides. On the supply side, many factors have contributed to this phenomenon, most importantly; new technological changes, development of knowledge-based activities, a reduction in the minimum optimal scale of production, tendency of larger firms to undertake cost reduction strategies, increased outsourcing and contracting out to smaller firms, and the structural shifts between manufacturing and service sectors. According to the previous reference, *all these factors have created promising niche opportunities for SMEs to step in*. In fact, many of these factors have changed the nature of relationship between different firm sizes in which smaller firms pursued to act as suppliers for fewer larger firms, the final producers, in many industrial clusters. Smallbone, North et al. (2003) claimed that such new structures have enhanced regional competitiveness and innovation capacities in many EU regions.

Due to big discrepancies among SMEs regarding technological level, they have different roles in relation to innovation. Accordingly, Smallbone, North et al. (2003) mentioned that some references had made classification of SMEs based on their technological level; (a) technology-driven SMEs, that keep updated with latest technologies, (b) technology-following SMEs, in which technology is important but it does not have to be updated to the frontier, and (c) technology-indifferent SMEs; that have very low investment levels in technological equipment. Moreover, as creating competitive advantage is the core of innovation activity, Smallbone, North et al. (2003) has argued that *technology-driven SMEs developing proprietary novelties would seek to "create and maintain specialized niches" as they create their own competitive advantage*. However, such innovation process requires substantial resource commitment that can be quite challenging for new companies, therefore a significant financial and external technical support is needed in such cases to maintain the firm's own resource base.

2.2.2 Role of SMEs in regional innovation systems

In general, there is unclear and undecisive conclusions for role of SMEs in innovation systems, specifically regarding nature of their innovation activities, types of available

resources to them, their engagement within innovation networks. In fact, Klewitz and Hansen (2014) pointed out that innovation in SMEs can takes place in many degrees, due to the different levels of innovation capacity within SMEs. That is why, Tödtling and Kaufmann (2001) have investigated, in a prominent study, the role of SMEs in regional innovation systems, as part of a large European research project "SMEPOL survey", in which they have concluded SMEs to play an essential role in such systems. The former reference has reviewed SMEs innovation activities by investigating nature/type of innovation (incremental/disruptive, product/process/organizational), dedicated resources of SMEs innovation activities and external networking activities of SMEs. Before first reviewing Tödtling and Kaufmann (2001) findings for types of innovation undertaken by SMEs, it is important to highlight the difference between product, process and organizational innovation, as defined by Klewitz and Hansen (2014). The three types of innovations can be interlinked and conducted simultaneously especially by technology-driven SMEs;

- *Product innovation*: it is directly linked to modifying/improving specifications of the firm's offering or changing the bundle of its products/services by introducing new offerings through the adoption/development of new technology(ies).
- *Process innovation*: it is directly related to improving quality, and increasing efficiency, of production and delivery of firm's current offering such as cost reductions and introduction of cleaner production methods through the adoption/development of new technology(ies).
- *Organizational innovation*: it is directly related to the introduction of new managerial formats and reorganizing the prevailing managerial structures that address people and work routines within the firm.

Regarding nature of innovation, Tödtling and Kaufmann (2001) have pointed to the debate in literature whether SMEs innovation is incremental or radical in nature. In fact, empirical findings show that SMEs play a bigger role in incremental innovation; however, in high-tech sectors and technology regions, **SMEs can be a strong candidate to drive radical innovation** (Smallbone, North et al. 2003), if some preconditions are fulfilled. These conditions are: availability of strong R&D institutions, venture capital firms, spin-off companies and technology networks. Kaufmann and Tödtling (2003) has highlighted two innovation strategies by SMEs; defensive and offensive innovation strategies. SMEs are predominantly following defensive innovation strategies such as focusing on niches, cost cutting, increasing the quality and redesign of traditional products, other than offensive strategies such as expanding to new mainstream markets. However, more offensive strategies are found in R&D intensive SMEs.

Regarding available resources to SMEs, Tödtling and Kaufmann (2001) have argued that SMEs have fewer endowments of internal and external financial resources as well as compatible human resources (with technical and managerial skills, and/or time); which lead to crucial consequences. On one note, limited resources would affect SMEs abilities to "scan, identify and respond to opportunities and threats" surrounding them; as they

usually have less ability to influence and shape their external environment (Smallbone, North et al. 2003). That warrants the different path of innovation strategies undertaken by SMEs compared to those adopted by large ones because of the higher levels of uncertainty and barriers to innovation faced by them. On another note, SMEs conduct lower level of R&D activities than larger firms. However, empirical findings show that SMEs are relying more on human resources than financial resources while conducting innovation activities compared to larger firms. In addition, more people are working on innovation activities in SMEs in relative terms in comparison with larger firms; that suggests more resource intensity for conducting innovation activities in SMEs. It is important to highlight that lack of financial and human resources are not the sole, albeit main, barrier for technology-driven SMEs to innovate. In other words, many technology-driven SMEs are suffering from other challenges repressing innovation that are not usually recognized, underassessed and/or overpassed such as innovation cooperation, strategic deficits, lack of market information and organizational weaknesses (Kaufmann and Tödtling 2003).

Regarding networking activities, Tödtling and Kaufmann (2001) argued that SMEs innovation process is characterized by involvement, with other external actors, in interactive learning networks through which knowledge is created from and exchanged within inter-organizational and intra-organizational interactions. Knowledge is gained by SMEs in two forms; codified (i.e. through formal R&D) or tacit (learning by doing and interaction such as production, logistics, marketing …etc.). In most cases, SMEs innovation activities are more reliant on tacit knowledge transfer as they usually build "informal, face-to-face and trust-based" type of relationships with stakeholders and partners. In addition, SMEs build external relationship mainly with business partners in their value chain such as suppliers and customers. In fact, customers are SMEs' main innovation partners; they are very crucial for SMEs to guide their innovation activities. On the contrary, SMEs exhibit very low collaboration with knowledge providers (i.e. science, technology and training institutions such as universities and research centers), and collaboration within joint innovation projects is much less frequent, and sometimes rare. Tödtling and Kaufmann (2001) indicated that SMEs relationship with their business partners is rigid and very costly to change, as it would imply losing accumulated knowledge within the firm. In fact, some references pointed out a concern that is usually raised by SMEs managers and technologists about intellectual property protection especially if larger partners in collaboration networks would take over their developments (Smallbone, North et al. 2003). Nevertheless, the firm's technological level is a decisive factor for its ability to collaborate with outside stakeholders; the higher technological level, the more tendency to collaborate with science and technology entities.

Accordingly, Tödtling and Kaufmann (2001) concluded that SMEs resource limitations/obstacles would be solved by integration into networks of regional innovation systems, despite SMEs' low capacity and tendency to engage into, and conduct collaboration activities within, innovation networks. In fact, regional context is very important to SMEs because of the short geographical distance and more concentrated networks that would allow tacit knowledge transfer compared to larger contexts such as

national or international networks. Therefore, SMEs innovation activities are regionally-concentrated than other types of firms. However, such regional orientation can be a major disadvantage to SMEs as it may lead to "regional lock-in" (Kaufmann and Tödtling 2003); SMEs may not have access to adequate collaboration opportunities due to lack of innovation partners and limited market potentials in some regions. Accordingly, regional innovation networks are a necessary but not sufficient condition to stimulate SMEs innovation activities (Kaufmann and Tödtling 2003).

2.2.3 Sustainability aspects of SMEs innovations

Many references have argued that SMEs innovate differently for sustainability. Sustainable innovations is usually defined as the introduction of innovations that have a positive impact, or at least neutral or less harmful impact, on the environment. Klewitz and Hansen (2014) have conducted a large systematic review of available literature to investigate "Sustainability-Oriented Innovation" SOI of SMEs, which is defined as integrating societal and ecological aspects, alongside economic aspect of sustainability into the three types of SMEs innovation activities; product, process and organizational innovations. That is based on the role widely-accepted in literature that SMEs significantly contribute into sustainable development. Therefore, Klewitz and Hansen (2014) have investigated SOI of SMEs by reviewing the three types of innovation practices as well as their strategic sustainability behavior. The former reference has discussed, in detail, sustainability dimensions in the three types of innovation practices and found that SOI of SMEs requires a more integrative approach; SOI implies an interactive process among the three types of innovations (i.e. product, process and organizational innovation) simultaneously. In addition, SMEs strategic sustainability behavior can take a wide spectrum from resistance (on one polar as extremely negative), to innovation-based and sustainability-rooted innovations (on the other polar as extremely positive). Interestingly, it has been found that innovation from triple bottom line, that considers the three aspects of sustainability (i.e. economic, social and environmental) is still an under-researched area in literature compared to eco-innovation (i.e. innovation that considers economic aspect only), which is the most prevailing in literature.

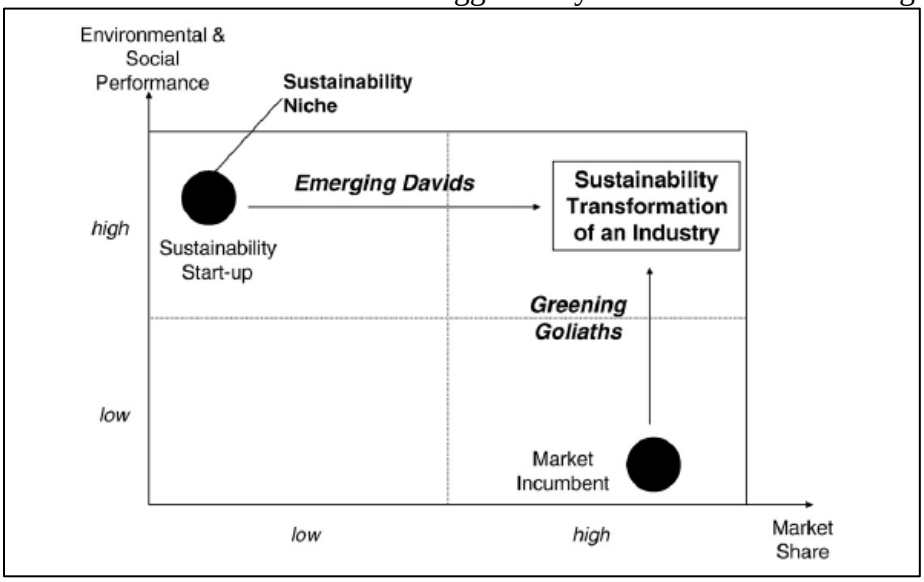
The introduction of SOI by SMEs can be either in niches or mass markets and can be incremental or radical in nature. *In that regard, innovation-based and sustainability-rooted strategies for SMEs would result into radical innovations. In fact, SMEs radical innovation strategies have more influence to affect transformation towards sustainable developments on whole sectors/industries and larger system scales* (Klewitz and Hansen 2014). Moreover, there is a growing trend in literature that addresses SMEs radical innovations to solve sustainability challenges (i.e. sustainable entrepreneurship). This branch is investigating entrepreneurial firms that discover and exploit economic opportunities through developing explicitly radical/disruptive SOIs in niche markets in the first place, and then spread to mass markets on a later stage, that would initiate sectoral/industrial transformation by achieving better societal and environmental status (Hockerts and Wüstenhagen 2010). In that regard, the diffusion of, and scaling up, SOIs is essential for transformation towards sustainability. Nevertheless, Klewitz and Hansen (2014) stressed

on the involvement in external multi-actor networks such as research institutions (i.e. knowledge networks), governmental organizations (i.e. regulatory networks) and business partners (i.e. value chain network). Collaboration with external stakeholders is argued to be an essential element in sustainable development as it enhances SMEs capacity in stimulating their radical innovations and deal with their SOI multi-dimensional aspects. In general, SMEs capacity for innovation is dynamically affected by interactions between their "competences, strategies and networking relationships" (Klewitz and Hansen 2014).

2.2.3.1 Interplay between SMEs and incumbent firms in creating and scaling up niche innovations towards sustainability transformation

In general, many references have argued for the superior role that SMEs play in introducing innovations, especially radical ones, over other types of business organizations such as large incumbents. That is because SMEs enjoy unique characteristics not found in other business organizations such as agile/lean organizational structure, flexible managerial practices, and not being stuck with prevailing practices or product offerings. For instance, Klewitz and Hansen (2014) have argued that SMEs agile structure and entrepreneurial style of management make them better positioned, than larger incumbents, to introduce radical SOIs within niches, despite many obstacles they already face. However, despite the leading role given to SMEs in introducing radical SOIs to achieve sustainability transformation, some references have pointed to the interplay between new entrants (including SMEs) and existing incumbents to achieve such transitions. As the former would develop the radical innovations and sustainability strategies while the later would adopt them and introduce them into mass markets, therefore having a significant role in achieving sustainable transformation of mass markets (Schaltegger, Hansen et al. 2016).

Figure 4: Co-evolution of sustainable new small firms and old incumbents towards sustainable transformation of industries as suggested by Hockerts and Wüstenhagen (2010)



In that regard, Hockerts and Wüstenhagen (2010) have introduced a co-evolutionary conceptual framework in which they have suggested roles for both new entrants, including

startups and small companies (i.e. emerging Davids) and old incumbents (i.e. greening Goliaths) into achieving larger industrial transformation towards sustainability (i.e. sustainable entrepreneurship). This model is based on a dynamic perspective of innovation studies in which different firm sizes play different roles in phases of transition and they dynamically interact over time to achieve such transformation. The framework is presented into four consecutive steps as follows. *First*, in an early stage of transformation, emerging Davids would introduce "disruptive sustainability innovations" due to their superior capabilities of product innovation and their equal evaluation of social and environmental, alongside economic, aspects of sustainability. *Second*, on a later stage, pioneering incumbents with large market shares and more valuation for economic, than other, aspects of sustainability would react to competition from new Davids by catching up quickly. The former mimics the latter's innovations after proving market success through introducing corporate sustainability initiatives and bringing such innovation into their main distribution channels. Engagement of large incumbents is crucial in this stage as they can bring such innovation initiatives to higher levels of industrial transformation due to their market power, better equipment of financial resources, higher R&D levels, and superior capabilities of process innovation. *Third*, on the next stage, as sustainable transformation of markets evolves, more sustainable startups, that are more business-oriented and funded by professional investors, would step in. These startups combine superior product innovation of emerging Davids with strong process innovation of greening Goliaths. *Forth*, in the last stage when sustainable transformation becomes mature, main market brands enter the process of adopting niche innovations by developing more process innovation, as they start to realize the growing threat of startups as well as the highlighted market opportunity in front of them. At a certain point, scaling up and spreading niche innovations would be on the expense of depth of sustainability qualities. Therefore, at this stage, new Davids would emerge again to create newly "high-end market niches", hence the transformation cycle starts over again. The above figure no. 4 shows the co-evolution model of both new small companies "emerging Davids" and established incumbents "greening Goliaths" for industrial sustainable transformation.

It is important to highlight that co-evolution of both types of firms (i.e. greening Goliaths and emerging Davids) is a pre-requisite to achieve sustainable transformation rather than evolution of one firm type alone. Therefore, such industry transformation has to consider "partnering" and/or "a complementary strategy" between these two types of firms to push transformation further in its desirable path. In addition, it is argued by Hockerts and Wüstenhagen (2010) that radical new Davids must have a growth strategy to "broaden their impact on a wider market". In other words, radical emerging Davids have to aim for mass market transformation rather than staying on niches, otherwise their innovations would be considered incremental rather than disruptive. However, in some cases, such firms may fail to grow and reach mass markets or may prefer to stay in niches rather than to scale up.

2.2.3.2 Business model innovation at the core of scaling up niche innovation towards sustainability transformation

Schaltegger, Hansen et al. (2016) indicated that relevance of "business model" have started to gain more importance in "sustainable entrepreneurship" literature. The last reference has referred to the definition of business models as "the design or architecture of value creation, delivery and capture mechanisms" employed by the firm, and it introduced the concept of Business Models for Sustainability (BMfS) in which generated value proposition is creating an economic value while "maintaining and/or regenerating the environmental and social capital" beyond the firm's boundaries. In fact, research has thoroughly investigated the specific characteristics of business models for "sustainable niche market pioneers". As literature has mostly focused on how sustainable niche players integrate sustainability principles into the core of their business models. For instance, there are multiple cases in which radical innovation can be realized through *business model innovation*, especially with newly established SMEs, by integrating sustainability into core business through conducting changes on the three levels of innovation activities (Klewitz and Hansen 2014). However, there is no enough evidence for the dynamic role of business models in upscaling sustainable niche innovations to mass market (i.e. how such models help small niche players to grow and/or influence others to create mass market transformation), or even in upgrading those of firms operating in conventional markets.

Therefore, Schaltegger, Hansen et al. (2016) have introduced a co-evolutionary framework of business model development/innovation for both pioneering sustainable niches and conventional mass market players, in which dynamic development of business models is crucial to achieve sustainable transformation of markets. The last reference has relied on Hockerts and Wüstenhagen (2010) model represented in figure no. 4 to decide on direction of business model development for both players (i.e. sustainable niche SMEs and mass market incumbents), as both types of firms start from very different positions regarding sustainability and this have important implications for their business model innovation. Accordingly, business model of sustainable niche players is expected to face many challenges in the process of upscaling niche innovations and introducing them into mass markets, which would be the same situation facing mass market incumbents. Interaction/interplay between the previously-mentioned two players is crucial to achieve desirable transformation towards sustainability in such dynamic co-evolutionary process of business model development. Moreover, it is argued by Klewitz and Hansen (2014) that interaction with external stakeholder networks would lead to the introduction of new business models by niche players. Therefore, innovation-driven and sustainability-rooted SMEs are rebuilding their business models on the three pillars of sustainability (environment, society and economy) through extensive interaction with external stakeholders/actors and collaboration beyond the firms' boundaries.

In their co-evolutionary framework, Schaltegger, Hansen et al. (2016) have suggested three evolutionary processes and four pathways to spread sustainable business models into mass markets. The three evolutionary processes are: variation (the introduction of various business models and organizational forms), selection (the elimination of unsustainable

models and the positive selection of sustainable ones by market, societal and political forces), and retention (the continuation and diffusion of sustainable business models by both SMEs and incumbent firms). Retention of sustainable models can be achieved through the four pathways: growth, replication, merger and acquisition (M&A), and/or mimicry. Therefore, scaling up niche innovations through growth is not the only way according to this co-evolutionary process to achieve mass market transformation, as the diffusion of sustainable niche innovations can take other forms in which other niche players are essential in introducing, developing and/or combining such forms of diffusion in the transformation process.

2.3 Policy implications for regional public authorities in supporting sustainable transformation of STS and role of SMEs in upscaling niche innovations

There is no doubt that managing transitions can be a difficult, albeit not impossible, process. As it may be implied from previous analysis, sustainability transitions are very complex processes; they are multi-actor, multi-factor and multi-level processes (Elzen and Wieczorek 2005). Nevertheless, policy support has a pivotal role in the diffusion of radical technologies and acceleration of system innovation processes (Geels 2005). That is why policy makers have become increasingly keen to influence, rather than steering, system innovation into favorable direction in order to create a desirable sustainability transition. In fact, that have gained momentum since mid-1980s, as part of sustainable development agenda on many levels of policy making; local, regional, national and international (Berkhout, Smith et al. 2004).

2.3.1 For supporting sustainable transformation of STS

One policy approach mention by Geels, Elzen et al. (2004) is "policy network model" which apply sharing mechanisms in decision making processes among the multiple interdependent actors that have different and noncoherent beliefs. On another note, based on the multiple factors included in MLP of system innovation, it should be realized that policy for sustainable transition has to be directed not only towards the economic incentives for customers/users (such as regulations and taxes), but also towards the prevailing norms, believes, expectations and infrastructure. Kemp and Rotmans (2004) suggested that many policy cycles have to be applied over different phases of transition which enable adjustment, feedback and continuous learning from uncertain changes especially within transition in transport and mobility systems. In addition, changing believes and norms is defined by Brown, Vergragt et al. (2004) as high order social learning; it is the most difficult type of learning and key for transition towards sustainable mobility system. That is because any successful transition towards more sustainable systems require interaction between new technologies and societal and cultural changes, which would stimulate the cultural acceptance of such novelties (Elzen and Wieczorek 2005). In that regard, legitimation of radical novelties would evolve as they would link up to cultural values and social norms. In turn, that would attract more resources to invest, and entrepreneurs to work for their further development.

In addition, according to MLP of regime transformation, accelerating successful configurations from niches to higher levels must follow pre-identified goals or "visions" (Berkhout, Smith et al. 2004). In other words, the objective of transition management is to navigate/drive niche-regime dynamic processes according to a specific vision of sustainable systems. For instance, a vision for sustainable transport/mobility system would not just state the issue of lower levels of CO_2 emissions, but also the issue of more accessibility and livable cities (Elzen and Wieczorek 2005). The last reference has stressed on the importance of actor engagement into a process of "vision building and learning". Accordingly, experimentation on niche level can provide an excellent opportunity for learning about viability of such a transformation vision, possible paths to its realization and revising mechanisms for further development. Therefore, vision for transformation is always under review in the process of transition management; where niches can have a significant role to review and develop.

Counter wise, vision for transformation have a significant role in creating protective niches. In that regard, it is important to align expectations and build needed support regarding the proposed vision for transition. That is in order to attract necessary resources and build momentum for aligned interests as an essential step in transition management. For instance, social interest for pursing a certain transition vision needs to get embedded into the institutional arrangement of the landscape "macro" level, such as market and regulatory signals, before they become effective into transition process at regime and niche levels. Nevertheless, policy makers should be aware that it has always been a difficult task to set policy agenda/options towards creating a clear vision that is viable and acceptable by all engaged social actors, specifically on the niche level. That is because such actors represent a wide spectrum of divergent, and sometimes, contradicting interests. Accordingly, it is crucial for policy makers to be more reflective, specific and explicit about the role and effect of such divergent interests in the process of building support and aligning expectations of policy visions; for the successful implementation of transition management (Berkhout, Smith et al. 2004). Lastly, policy makers should keep in mind the fine-tuned interplay between niche main actors, specifically between new small firms and old incumbents, towards achieving sustainable transformation of industries, by not just focusing on actions undertaken by one actor and neglecting the other (Hockerts and Wüstenhagen 2010). In other words, an effective innovation policy has to leverage dynamic interaction (in terms of cooperative as well as competitive relationship) between the two firms' types.

2.3.2 For supporting SMEs in upscaling niche innovations

Kaufmann and Tödtling (2003) and Smallbone, North et al. (2003) have suggested that an SME regional innovation policy has to address their main challenge of "limited internal resources" with a clear identification of their "expressed needs" (i.e. those that are explicitly expressed from SMEs managers and owners) and "latent needs" (i.e. those detected after a systematic evaluation of the firm's status), and that can be done in through a number of channels. First, a regional innovation policy can provide adequate sources of knowledge and innovation-related information (i.e. market and technology information)

for SMEs, as windows of opportunities, in order to enhance their monitoring capacities. These sources have to be well-structured, organized, updated and presented in an easy and convenient way, and they would display, at the same time, available innovation support and ways to access them, as many SMEs show interest to access such support, but they lack enough information for how to access it. These sources should also show value of collaboration activities, which are undervalued by SMEs in many instances. That can be done through the dissemination of stories for successful innovation cooperative projects and raising awareness for innovation barriers that SMEs usually don't recognize or surpass. In that regard, Kaufmann and Tödtling (2003) recommend technology centers to function as such sources of knowledge, and they can perform as "gate keepers" to intermediate communication between SMEs (through trust-based informal links with them) and extra sources of information and innovation partners within or outside the region.

In addition, an SMEs regional innovation policy and its supporting instruments should be directed, not only to co-funding product or technology development, but also for commercialization of new products. Such policy has also to support SMEs to easily access venture capital to fund riskier R&D activities. Most importantly, regional innovation policy should be more focused on increasing networking capabilities for SMEs through stimulating and accelerating collaborative projects between SMEs and other network partners. In order to do so, an effective innovation policy has to enhance manpower capabilities in SMEs for innovation management (Kaufmann and Tödtling 2003). Lastly, such policy should consider developments outside the region's boundaries that would support innovation activities inside it, especially for those linked to SMEs growth and internationalization strategies.

3. Methodology

3.1 Research strategy

The choice of research methodology for a social study has to be problem driven, and not methodology driven, in the sense that employed method to the investigated social problem/phenomenon has to help the researcher to answer its proposed research question (Flyvbjerg 2006). Hereby, this study adopts a **qualitative research strategy** by incorporating **an abductive approach** between theory and research. Following a qualitative approach in this study goes in line with the main pre-occupation of qualitative research, as suggested by Bryman and Bell (2015). According to the former reference, adopting a qualitative research strategy is much preferred when it is crucial to see reality through eyes of subjects under investigation as social subjects can interpret/explain their surroundings and assign meaning to their environment. Therefore, social phenomenon would be explained from perspectives of people involved in the study. Moreover, qualitative research puts a significant emphasis on description and context. In other words, such research is concerned with descriptive details as well as thorough explanation of studied topic, and that is undertaken in a direct relation to settings/context in which the respective phenomenon is taking place. Indeed, that warrants the explanatory nature of this study for investigating the role of innovation-driven SMEs within the regional context of western Sweden.

Moreover, describing a social phenomenon using a qualitative strategy provides a sense of process to research, in terms of dealing with a phenomenon as a series of interdependent elements, events and patterns (Bryman and Bell 2015). Such research strategy goes in line with the main theoretical approaches adopted in this study for investigating the role of innovation-driven SMEs in upscaling niche innovations (i.e. MLP and SNM). Both theories stress on the co-evolutionary nature of system innovation and emphasize that sustainability transitions are complex messy phenomena comprising many actors, processes and actions that reinforce each other (Geels 2012). Lastly, a qualitative research strategy provides flexibility/limited structure while deciding on research design, data collection methods and analysis. For instance, such strategy enables researchers to ask general rather than specific research questions, and to flexibly design interview guides/questions so that interviewed agents can have a complete freedom while revealing their own perspectives of the phenomenon under investigation. In that regard, this study has deliberately put a general research question for "investigating the role" of a particular niche actor "SMEs" from two perspectives; current and perceived ones. That enabled us to flexibly design the interview guide for interviewed SMEs with general/open-ended questions, as well as to follow unstructured interview guide with the industry experts included in this study. That has also strengthened the underlying goal of this study of obtaining a better and deeper understanding of the phenomenon of upscaling niche innovation by SMEs from the own perspective of involved social agents.

On another note, an abductive approach has been followed in this study due to its interpretive nature. As Bryman and Bell (2015) claims, abductive approach usually fits interpretive research as it involves "a dialogical process between theory and empirical

phenomenon". To elaborate, this study has relied on system innovation within the context of sustainability transition, role of SMEs in regional innovation systems and sustainability aspects of SMEs innovation as the main theoretical approaches, as well as empirical insight from western Sweden, for studying the relevant phenomenon. However, there exist major shortcomings and gaps in theoretical literature as well as lack of empirical insight from regional context of western Sweden, which warrants a deeper investigation of the studied phenomenon. For instance, Schaltegger, Hansen et al. (2016) claims that there is a lack of empirical evidence for the dynamics of co-evolutionary process between SMEs and other players in the process of upscaling niche innovations from a business model perspective.

Accordingly, it was clear to observe that available literature does not comprehensively address the role of SMEs developing niche innovations and does not deeply probe into dynamics of such role in the process of scaling up such innovations towards sustainable transformation of systems. That makes qualitative approach of this study not purely inductive since there is available theoretical and empirical literature of the studied phenomenon, but it is more of an abductive or "interpretive research". In other words, this study would follow a dialogical process between available literature and its empirical findings. Such approach has provided us with more flexibility in terms of choosing the most appropriate/best explanation of the investigated topic based on our own interpretation of collected data. As a result, such dialogical process would lead to a better understanding of the studied phenomenon instead of relying on pre-understanding and non-comprehensive theoretical foundation.

3.2 Research design

The research design followed in this piece of research is **case study, with a comparative design** between the investigated cases. Bryman and Bell (2015) have put a comprehensive definition of "case study" and explained in detail under what conditions it is appropriate to use such research design in order to match its research strategy and main problem/question. Case study can be defined as an intensified analysis of a single case in which a researcher represents detailed features of the studied unit of analysis. A case is an "object of interest in its own right" as the researcher undertakes an in-depth investigation of it, in its unique natural context, so that s/he can form "an advanced understanding of viewpoints and behaviors of studied social actors" (Flyvbjerg 2006). The last reference hence stated that case study, as "a narrative inquiry", is the best approach to understand a particular phenomenon from its participants' perspectives. In other words, case study approach is an excellent source of "context-dependent knowledge" for a nuanced understanding of social reality, as it allows both an understanding-oriented and an action-oriented perspective. In that regard, applying a case design in this study is expected to significantly help us answer the two sub-research questions for the current and perceived roles of SMEs by highlighting the major bottlenecks that hinder innovation-driven SMEs to play their perceived role based on their potential. As by investigating the phenomenon under focus, we would be able to detect deep causes of bottlenecks facing SMEs and their consequences instead of just providing a superficial description of the common problems SMEs face and how occasionally they take place. Flyvbjerg (2006) also argued that policy

interventions/suggestions are better formulated with a "typical case narrative", which is assumed to validate this study's insights for what regional authorities can consider in helping SMEs overcome barriers and scale up their innovations.

In addition, **comparative design/multiple cases approach** is becoming more popular in business research nowadays, as it is an extension of single case analysis. Instead of just focusing on one case, a researcher extends analysis to two or more cases in a comparative approach. In other words, a category of multiple/collective cases are compared for the sake of better exploration/understanding of a specific phenomenon. Such comparison would enable us to detect the commonalities and contrasts across cases, which can allow for a theoretical reflection when analyzing the findings.

It is of significant relevance to highlight advantages of using a comparative design in this respective study. First, a comparative design would still enable us to shed light on the unique/special features each studied case, which would not discount from its in-depth quality compared to a single case approach. Another advantage of multiple case study approach is that it improves theory building because comparison makes a researcher stands on a better position to decide under what circumstances a theory will or will not hold. Hence, a comparative design can be used to refine or refute existing theoretical framework rather than building entirely-new theories from scratch. During such process, analysis of comparative cases can suggest new concepts that would fill in gaps of current theories or even contribute to the new emerging theoretical frameworks. Accordingly, in our study, a comparative design would be significantly helpful, while analyzing findings, to admit new concepts that would fill in the gaps of theoretical and empirical literature regarding SMEs-related activities and dynamic role on niche level in the process of upscaling niche innovations within the regional context of western Sweden's mobility system.

On the other hand, comparative design has its own major disadvantages that may negatively affect our study. First, it may overlook the delicate details of each case, in order to keep focus on the general context and allow for cases to be contrasted, and that might undermine the idiographic approach of case research. Therefore, multiple cases have to be well-structured since inception by clearly stating areas of comparison, which can be a difficult and tricky task and imply a less open-ended approach of case research. Second, using a case study design in general can undermine external validity/generalizability of research results, as well be shown later in section 3.4 of this study limitations. Indeed, many scholars have lessened the generalizability as a goal of case study research. For instance, Flyvbjerg (2006) have refused the call to generalize or even summarize case studies; as good cases have to keep their narrative entirety. Instead focusing on particularization, other than generalizability, of results, is the strength point of this research type. Particularization, as the case study main goal, is the focus on the deeper understanding of unique features and case complexities. However, multiple case design can mitigate the problem of low research quality due to lack of external validity, as the inclusion of more than once case provides a broader spectrum of various cases, hence; a better insight on the investigated phenomenon.

On another note, it is great significance to highlight that comparative design has been chosen for the SMEs selected sample as they would be classified according to the four disruptive trends of mobility systems. In fact it was argued by Sprei (2018) that the three trends of electrification, shared mobility, and autonomous vehicles have the potential to disrupt automotive industry as well as transportation and mobility system in general. Nevertheless, the greatest disruptive potential lies into the combination of those technologies as some can steer the others towards more sustainable transformation of mobility systems. That further motivated the comparative design of this study to understand the general relationship and potential effect between different SMEs under each technological trend. However, this study, as mentioned in the introduction, considers four technological trends that have the potential disruptive effect on mobility systems, by adding one technological trend in addition to the above-mentioned three; connectivity (Arbib and Seba 2017, MCFM 2019). In addition, the level of analysis in this comparative study is the firm/organization level (i.e. SMEs) and level of observation (i.e. with whom we have collected relevant data) are individuals; managerial personnel/entrepreneurs in top management team (CEOs, co-founders, CFOs ..etc.).

3.3 Data collection and analysis method

3.3.1 Framework for population identification

3.3.1.1 Setting definitions for the study main concepts.

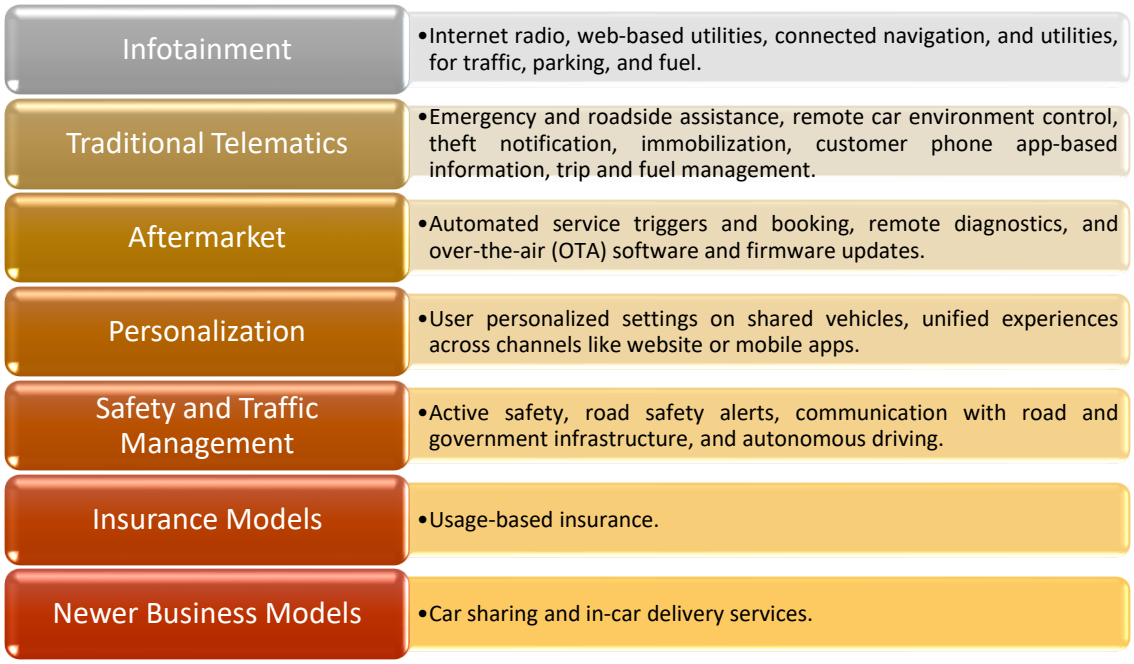
In this phase, we have decided to set definitions as a very beginning step before identifying the population of innovation-driven SMEs developing new mobility solutions inside western Sweden. Starting with geographical location, it was clearly set that we would search for SMEs located within Västra Götaland County. A second step was to identify criteria for companies that are developing new mobility solutions. Two issues have been raised regarding this. The first issue is how to define what we shall mean by "**mobility**" or "**mobility system**", so that we can decide if an SME can be classified under this population or not. Therefore, we started to define "mobility system", as mentioned in literature section, simply as a system that serve the societal function of mobility in the regional context of western Sweden. Then we have decided to adopt, for research purposes, a holistic definition of "mobility" that is much inclusive and broader than what transportation system and/or automotive industry can be defined. In fact, we argue that mobility is not just about transportation because it is nowadays more about "having access" to modes of transportation. More precisely, mobility is movement and accessibility to different modes of transportation that have to be affordable, safe and compatible to time (Fortunati 2018), and that involves mobility of people (i.e. personal mobility), goods/freight, and services. Therefore, this study includes digital/IT business solutions within different forms of mobility solutions.

The second issue is to define what we mean by "**new mobility solutions**". In that regard, defining "new mobility solutions" is directly linked to how we identified "innovation-driven SMEs" As mentioned in the introduction, defining what we mean by "innovation-driven SMEs" is theoretically based on the definition of "technology-driven SMEs" developed by Smallbone, North et al. (2003). Accordingly, the focus in this study is on

SMEs that develop mobility solutions related to the four "frontier" technological trends that have the potential to disrupt mobility systems (Arbib and Seba 2017, Sprei 2018, MCFM 2019). In order to have clear criteria of inclusion and classification of SMEs under these four respective trends, we have tried to define each one of them as follows:

Autonomous Vehicles (AV): In this trend, we refer to technologies of self-driving vehicles (either partially or totally), that can navigate and control driving process without human intervention. Hence, we include all SMEs that are developing new enabling technologies of self-driving vehicles under this category.

Figure 5: List of connectivity enabled features/applications as developed by Kavanaugh (2018)



Connectivity: That technological trend is related to the online/internet-connectivity features of vehicles. In this study, we have adopted Kavanaugh (2018) definition of connectivity as a disruptive technological trend to redefine mobility systems. In fact, the last reference has stated the expansion of scope and complexity of connectivity features and enabled applications in the last two decades. That's why, we have considered his classifying list of connectivity enabled applications as criteria to include SMEs that develop new mobility solutions under this category, as shown in figure no. 5 above.

Electrification: The concept of Electric Vehicle (EV) is not considered a new technology, as the development of electric propulsion has already started since the beginning of the 20th century, however; the Internal Combustion Engines (ICE) have dominated vehicles propulsion since then (Sprei 2018). The concept of electric propulsion has been revived, and extensively tested, again as a potential disruptive technology that may be able to replace ICE. Dijk, Wells et al. (2016) have stated many versions of electric propulsion that may have the potential to replace ICE, and that include: Full-Electric Vehicle (FEV), Fuel-

Cell Vehicle (FCV), Hybrid Electric Vehicle (HEV) and the Plug-in Hybrid Electric Vehicle (PHEV). Accordingly, this study considers SMEs that develop new technologies/solutions in relation to the above-mentioned forms of electric propulsion.

Shared mobility: In this study, we have adopted Sprei (2018) definition of shared mobility as "transportation services that are shared among users". The last reference has mentioned various forms/modes of shared mobility either as vehicle-based sharing (such as station-based sharing, free floating, bike sharing …etc.) or ride-based sharing (such as carpooling and ride hailing). The last reference has also argued that it is becoming more challenging to identify boundaries for shared mobility because the introduction of new innovative services makes such boundaries blur between this respective trend and other technologies disrupting mobility. Nevertheless, we have been reliant on Sprei (2018) classification of shared mobility modes as criteria to include SMEs developing new mobility solutions under this respective category.

SMEs definition and criteria for inclusion

On another note, it was of crucial importance to highlight how we defined SMEs as a business organization and set criteria for their inclusion in our population. Indeed, we have relied on the European Union (EU) definition of SMEs, as stated in the European Commission website (EU 2019). It is worth-mentioning that EU definition of SMEs goes in line with adopted definition by the Swedish government. Accordingly, in order to include an SME in our population, it must:

- Be a registered Swedish company.
- Be located in Västra Götaland County.
- Have less than 250 employees.
- Not more than of 25% the company assets are owned (solely or jointly) by a larger firm (Tödtling and Kaufmann 2001).

In addition, firms can be classified either micro, small or medium sized according to the number of employees and the company's annual turnover/balance sheet as follows:

- Less than 10 employees – micro firm with an annual turnover or balance sheet total less than or equal to €2m.
- 10 – 49 employees – small firm with an annual turnover or balance sheet total less than or equal to €7m.
- 50 – 249 employees – medium-sized firm with an annual turnover less than or equal to €50m or balance sheet total less than or equal to €43m.

Lastly, we would advise to refer to the introduction and literature sections, to review how we have thoroughly set the other crucial definitions applied in this study. As the adopted theoretical and empirical approaches have affected our subjective criteria to include SMEs into our setup population, most importantly what we mean by "innovation-driven" and "scaling up niche innovations".

3.3.1.2 Meeting with industry experts in Västra Götaland County

The next step was to organize and conduct *unstructured interviews* with experts from different relevant industry backgrounds in Västra Götaland. The main purpose of such interviews was to gain better insights of the studied phenomenon, and to get the needed help for the formation of this study's methodological choices. Accordingly, table no. 2 below shows the name, professional title, organizational affiliation of interviewed experts as well as date of meeting. As shown from the table, seven meetings were conducted in total (one expert is interviewed twice), with 3 experts are from Business Region Gothenburg, one independent consultant, one university innovation advisor, and one research analyst.

Table 2: List of meeting with industry experts in Västra Götaland County

Name	Position and organization	Date of meeting
Per Gyllenspetz	Independent Consultant, Curve Navigator, Concept Design and Transportation Strategies	12th of February 2019
Bo Norrman	Innovation advisor at Chalmers Innovation Office, Chalmers University of Technology	15th of February 2019, 19th of February 2019
Erik-Wilhelm Graef Behm	Area & Investment Manager ICT, Business Region Gothenburg	13th of March 2019
Lars Bern	Area responsible – Cluster & Innovation, Business Region Gothenburg	22th of March 2019
Magnus Karlström	Analyst – Swedish Electromobility Center, Chalmers University of Technology	10th of April 2019
Per Österström	Head of Automotive and Transportation Clusters & Innovation, Business Region Gothenburg	24th of May 2019

It was deliberate to choose those 6 experts from different organizations and backgrounds as we assumed that having different professional and academic backgrounds will imply different types of knowledge gained from them. That would enable us to discover different aspects/perspectives of the studied phenomenon and to decide on a better approach of data collection and analysis, hence; answering research question. The approach of selecting those 6 experts was methodologically based on "snowball sampling". That sampling technique is usually defined as starting with an initial small group of people/individuals

that are relevant to the study's research problem/question(s), and they in turn propose other participants "that have the experience and characteristics relevant to research", and so on (Bryman and Bell 2015). Accordingly, when we started expert meetings, the second interviewee in the above table no.2 "Bo Norrman" has suggested other potential/candidate experts to interview in order to learn more about mobility system and regional developments in western Sweden. And later, other interviewed experts suggested other related experts for us to meet.

On another note, the choice of unstructured interviews, as a data collection method with industry experts, was the best fit to these meetings mainly because of its flexible structure. As Bryman and Bell (2015) argues that such type of interviews is similar to informal conversations, as they can be formulated on just one single question. The conversation can flow freely according to the interviewee's interest as well as the interviewer interactions with the points that seem worthy to follow up. In that regard, we have approached meetings/interviews with such experts by starting with a general narrative about our background, study focus, research question, and suggested approach for answering it. In addition, the choice of unstructured interview approach in this stage was mainly to discover the regional context of mobility system in western Sweden, which was a relatively unknown topic for us with no much pre-occupations. Due to the rich knowledge background of experts, it was crucial for us to probe into the investigated topic from their own perspective and get better insights about it from their own points of view. In other words, unstructured interviews were appropriate in this stage as we have started it with a holistic approach to answer research question rather than a detailed structured analytical approach.

Moreover, we have voice-recorded all experts' interviews, taken thorough notes during them, as well as partial transcribed main points/most relevant parts highlighted by interviewees later. That have proven useful for us, as we have reached some preliminary findings that assisted us further in the next steps of data collection and analysis. It is important to highlight that some experts' meetings were conducted before population identification, while some were implemented during interviews with selected SMEs sample. With one exception, meeting with Per Österström was conducted after finishing primary data collection from SMEs and we have done a full written transcription of his interview for the purpose of data triangulation.

Accordingly, we can summarize the main outcomes of expert meetings as follows. **First,** such interviews helped us to collect practical knowledge necessary for the study in its early phase, more specifically for putting criteria of inclusion and setting up the population of innovation-driven SMEs. **Second,** expert meetings were significantly helpful to decide on the best approach to select SMEs sample for interviews, as the main source of data collection to answer research question, as well as to suggest a better design of SMEs interview setup, specific topics and proposed questions to be raised within such interviews. Potential online and offline sources of targeted population were revealed and recommended by some experts. Furthermore, some handpicked companies were mentioned as interesting,

which we have considered as potential "critical cases" in our study. Some experts have also provided us with contact information of relevant personals inside selected SMEs, and some others have given recommendation of other industry and research experts to contact. **Third,** expert meetings have revealed insights about which stakeholders exist in the region and their collaboration activities with SMEs, through reports that were made available to us from them. That have helped us to get a broader understanding of the regional context, in terms of activities and goals of different stakeholders. **Forth,** these meetings made us better elaborate and distinguish between on what experts and stakeholders already know today and what they wish to learn more about. **Fifth,** expert meetings have confirmed many of knowledge gained through other sources. For instance, many mega/landscape trends, that have been highlighted by VGR as affecting regional sustainable transformation, were verified as essential and closely linked to this study's investigated phenomenon. In addition, many of expert meetings have confirmed/verified the four technological trends assumed in this study to disrupt mobility systems, and they have provided reports that summarize situation within the region's business landscape in relation to some of these disruptive technologies. Interestingly, one expert who works closely with VGR has confirmed that its strategy aims to support SMEs contribution towards transformation of regional transportation system, particularly through speeding up transformation and creating new job opportunities. Lastly, more information of expert meetings can be reviewed in appendix B, as we provide more detailed presentation of main discussion outcomes for each individual expert meeting.

3.3.2 Population identification

3.3.2.1 Data collection, filtering and population classifications

Data collection: When we started at this stage, we have revised all information accessible to us from the interviewed industry experts. In fact, meeting with Erik-Wilhelm Graef Behm and Lars Bern from Business Region Gothenburg (BRG) gave us valuable advice regarding strategies of searching for SMEs at online and offline sources, mostly databases and reports. In addition, they have also advised us that following traditional search techniques/methods for companies online such as searching using SNI-code (svensk näringsgrensindelning) would not result into a comprehensive list of companies that can be potentially included. That is because such methods would imply traditional classifications which are not able to detect and include some IT companies directly linked/related to mobility or transportation sector. That's why we have followed a manual handpicking approach for searching, reviewing and selecting SMEs to be included from different online sources that gather companies' information in specific industries. That have resulted into over 350 companies being gathered and processed before filtering and classifying them based on SMEs criteria stated above (i.e. location, size by EU standard definition and technological trend). It is worth mentioning that data was collected from 8 different web sources and they are:

- One online transport fair: Transportmässan i Göteborg
- One collaboration platform of Artificial Intelligent (AI) enabled technologies for mobility: MobilityXLab

- Two university business incubators: GU Ventures and Chalmers Ventures
- Two private incubators: Innovatum Science Park startup incubator (Innovatum Startup) and Borås Inkubator
- Business Region Gothenburg (BRG) clustering and mapping reports
- One governmental innovation program (Almi)

Furthermore, additional companies that were previously known or mentioned to us through Challenge Lab team/network were also added.

Data filtering: The filtering was done in sequences/steps. The first filtering step was based on location. All companies that are registered outside of Västra Götaland County on "allabolag.se" were excluded. The second filtering step was based on size; companies that have 250 (or more) employees and €50 million (or more, with one EUR was rounded to 10 SEK) as turnover were also excluded. The third filtering step was for checking the company's innovativeness (i.e. being innovation driven). In order to know if companies could be classified under any of the four technological trends mentioned above, we have looked on the company website and all its other available resources for description of its business solution/offering. In addition, we have evaluated innovativeness of companies based on the three types of innovation developed by Klewitz and Hansen (2014); either as product, process organizational innovation, or a combination of the three. Therefore, criteria for inclusion/exclusion in this phase was quite subjective and up to our own evaluation as researchers. During this process, more data were added to the database, including year of establishment, contact information (website, email, phone number, contact person …etc.). At the end of this phase, 39 SMEs were left on the dataset/list to form our population.

Data population classifications: Afterwards, a classification of the dataset has been done to distribute SMEs over the four technological trends according to the above-mentioned criteria set for each respective trend. In fact, we have found that some SMEs failed to be classified under any of these four trends. However, we strongly argued that they can still be evaluated as innovation-driven according to the innovation types developed by Klewitz and Hansen (2014). Therefore, companies that work outside these four technology classifications were classified as "other". Moreover, we added, to the final list, the geographical location of companies within Västra Götaland County, turnover, number of employees and year of establishment to have a comprehensive picture of identified population, as well as to allow for some analytical insights, as being done in the results section below. Lastly, it is worth-mentioning that inclusion of last two sets of information (number of employees and year of establishment) was inspired by methodological approach of Hockerts and Wüstenhagen (2010) for classifying companies based on size and age.

3.3.2.2 The final population

The final SMEs population comprises 39 companies that can be presented in the following table no. 3. The first column represents technological trend where 32 SMEs fall within one of the four technological trends included (9 within AV, 7 within Connectivity, 9 within

Electrification, and 7 within Shared mobility), while 7 SMEs are following other technological/innovation trends. The other columns represent other data input collected during previous stages. It is important to highlight that last column for turnover is representing the last figure available for it online, mostly either in 2018 or 2017.

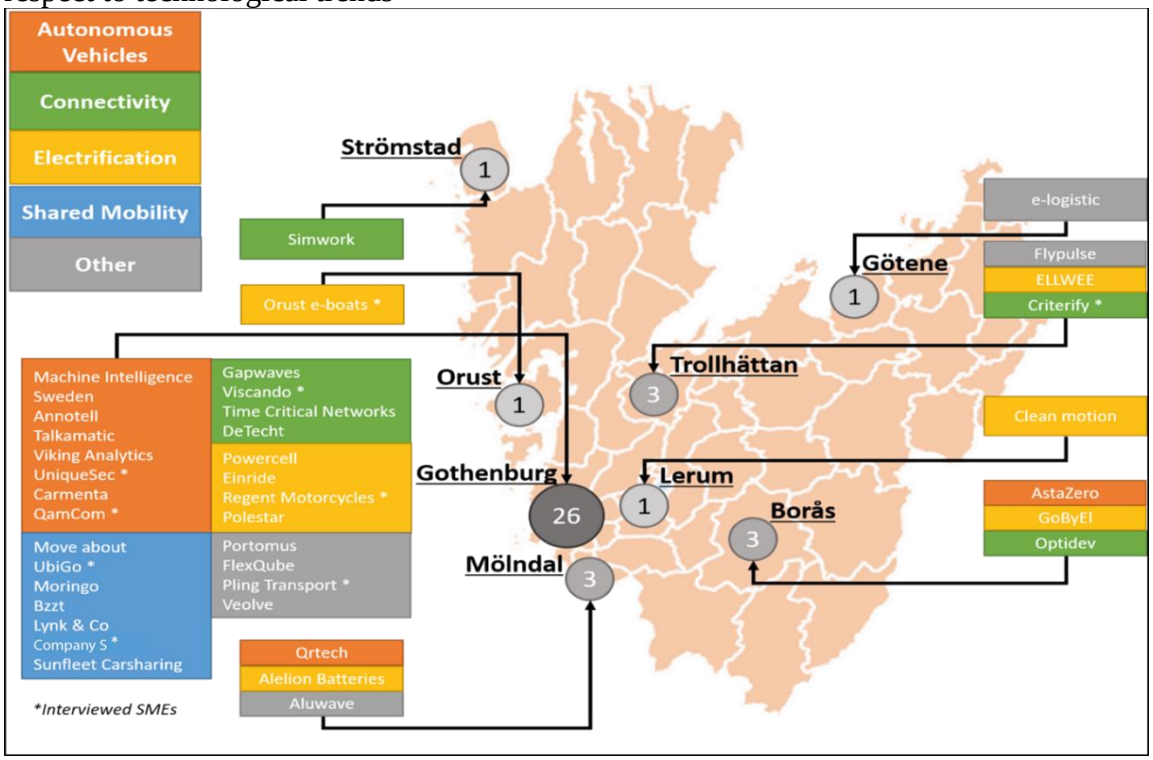
Table 3: Final population of innovation-driven SMEs within mobility system of Västra Götaland County

Technology type	Source	Name	Location	Established	Number of employees	Turnover (tkr)
AV	BRG	AstaZero	Borås	2010	18	100241
AV	BRG	Qrtech	Mölndal	1995	80	121 904
AV	BRG	Qamcom	Gothenburg	2001	250	285000
AV	MobilityXLab	Machine Intelligence Sweden	Gothenburg	2017	5	543
AV	MobilityXLab	Annotell	Gothenburg	2018	8	-*
AV	MobilityXLab	Talkamatic	Gothenburg	2009	9	2 728
AV	MobilityXLab	Viking Analytics	Gothenburg	2017	8	267
AV	MobilityXLab	UniqueSec	Gothenburg	2013	4	3700
AV	MobilityXLab	Carmenta	Gothenburg	1994	81	119 390
Connectivity	BRG	Time Critical Networks	Gothenburg	2008	4	2 513
Connectivity	Chalmers Ventures	DeTecht	Gothenburg	2018	2	-
Connectivity	Inovatum	Simwork AB	Strömstad	2013	-	1 282
Connectivity	Inovatum	Criterify	Trollhättan	2017	2	350
Connectivity	MobilityXLab	Viscando	Gothenburg	2012	9	6 500
Connectivity	MobilityXLab	Gapwaves	Gothenburg	2011	9	8 559
Connectivity	Transport Mässan	Optidev AB	Borås	2015	61	139 929
Electrification	AstaZero	Einride	Gothenburg	2016	14	7
Electrification	BRG	Clean motion	Lerum	2010	9	5 384
Electrification	BRG	ELLWEE	Trollhättan	2016	2	8 610
Electrification	BRG	GoByEl	Borås	2004	39	319 031
Electrification	BRG	Powercell	Gothenburg	2008	32	46 670
Electrification	BRG	Alelion Batteries AB	Mölndal	2006	13	141 444
Electrification	Inovatum	Orust e-boats	Orust	2014	-	76
Electrification	Other	Polestar	Gothenburg	2003	82	395918
Electrification	Other	Regent Motorcycles	Gothenburg	2018	3	-
Shared mobility	BRG	Move about	Gothenburg	2007	7	9 885
Shared Mobility	Drive Sweden	UbiGo	Gothenburg	2014	4	500
Shared Mobility	Inovatum	Moringo	Gothenburg	2015	7	321
Shared Mobility	Other	Bzzt	Gothenburg	2014	6	2 498
Shared Mobility	Other	Lynk & Co	Gothenburg	2016	-	-
Shared Mobility	Other	Company S	Gothenburg	2017	15	11200
Shared Mobility	Other	Sunfleet Carsharing	Gothenburg	1999	38	166 250
Other	BRG	Veolve	Gothenburg	2015	7	5 966

Other	Chalmers Ventures	Aluwave	Mölndal	1997	75	102 137
Other	Chalmers Ventures	e-logistik	Götene	2006	26	39 759
Other	Chalmers Ventures	Portomus	Gothenburg	2007	-	6 440
Other	Inovatum	Flypulse	Trollhättan	2016	3	616
Other	Transport Mässan	FlexQube AB	Gothenburg	2010	-	127
Other	Other	Pling Transport	Gothenburg	2012	15	1 400

(*) means unavailable information after searching for all available sources

Figure 6: Locational distribution of SMEs population within Västra Götaland County with respect to technological trends



In addition, we have visually presented the locational distribution of SMEs population within Västra Götaland County in figure no. 6 above. As it is visualized from the figure above, there is a high concentration of SMEs located in the city of Gothenburg (26 out of 39) of the investigated SMEs, representing 67% of the total population. The rest is distributed over seven other locations, where the three biggest (i.e. Trollhättan, Mölndal and Borås) have three SMEs each from the population. Moreover, it is observed that SMEs classified under shared mobility technological trend are only presented in Gothenburg city, while SMEs in electrification technological trend have the greatest geographical spread over the region. Lastly, as it is shown from the above-mentioned figure, a color code has been given to each technological trend, which will also be applied to the selected SMEs sample in this, as well as upcoming, section(s).

3.3.3 Selection of SMEs sample

3.3.3.1 Type of sampling

The next step was to select the SMEs sample by which we would be able to collect main data for the purpose of qualitative answering of research question. In this study, we have decided to adopt a purposive sampling approach. According to Bryman and Bell (2015) purposive sampling is a non-random technique of sampling in which study participants are not randomly selected. By using purposive sampling, a researcher gains adequate access to the studied units of analysis (i.e. organizations, documents, individuals) that have a direct reference to research question. Therefore, not adopting a random sampling approach in this research is not because of technical constraints, but it was a deliberate choice of us because we want to sample the studied participants in a strategic way so that the selected sample is strongly linked to research problem and question(s). Purposive sampling is further motivated to be followed in this study as it is usually used when a researcher needs to sample cases that differ in key characteristics (i.e. stratification of investigated cases). In fact, we claim that investigated SMEs in this study are stratified into 5 classifications (i.e. the four technological trends plus one additional classification for all technologies outside the previous four ones), which would support an enriched analysis of commonalities and variations among the different investigated cases. In addition, we have followed what Bryman and Bell (2015) have called " a priori purposive sample", as it was clearly set, from the beginning, the criteria by which we would select participant SMEs to collect data necessary for answering research question.

On another note, we had to decide on the most appropriate sample size, which was a tricky decision for us. That was also highlighted by Bryman and Bell (2015) argumentation for the best sample size, as one of the difficult decisions to take while conducting qualitative research. A qualitative researcher has to achieve a delicate balance in this regard. On one side, as comparative design is adopted, more cases are encouraged to be interviewed in order to provide an adequate depth of analysis. On another side, time and resource limitations would be the main hinders for being generous to interview more cases. However, as a rule of thumb, sample size has to allow for the minimum level of "convincing conclusions". Accordingly, we have targeted to select around 8-10 cases by equally representing each of the 5 categories in our comparative design. To achieve our target, we have planned to approach most of SMEs in the identified population, as most of them were recognized as valid to be included among the sample of critical cases.

Besides, it was argued by Bryman and Bell (2015) that it is crucial to design request/call for interviewing in an attractive way to prospective interviewees in order to have a favorable response from them. In this regard, we have approached companies mainly through emailing them asking for a short interview, and by including a prepared short presentation of our research project that comprises background of C-Lab, purpose and scope of the study, general information about the suggested interview, and why this study would be beneficial for them and their respective company. We have been targeting the top management team of interested companies, therefore; we have been focusing/directing our

communication to either the company's CEOs, founder or one of co-founders. If none of the previously-mentioned personnel were available, we turned research/interest for persons with the highest helicopter perspective for the company. That is because the suggested personnel are expected to have a broad understanding of the company/organization's overall strategy, its offering(s), collaboration activities, and an overview of the main activities happening either internally or externally and affecting the company. In addition, in order to find the most suitable personnel, the digital professional network "LinkedIn" was used, and later referred to when searching for contact information of targeted personnel through the company's communication channels.

3.3.3.2 Data collection method for the sample

In order to align with the qualitative strategy of this respective study, we have decided on the qualitative semi-structed interviews with the selected SMEs sample as the main data collection method. Bryman and Bell (2015) have summarized the main advantages of qualitative interviewing that go in line with this study strategy and design. Most importantly, such interviewing approach provides more flexibility to us, as it can capture the interviewee's whole perspectives and answers by considering his/her detailed and rich answers. In addition, following a less rigid structure of interviews would enable interviewees to ramble/go off to tangent points based on his/her point of view of what important/significant issues to be raised in relation to the discussed topic. Therefore, such flexible structure would enable us (i.e. interviewers) to access new insights as well as to move through suggested schedule/guide by asking follow-up questions or restate questions to get elaborations and touch on interesting discussions during interviews.

On another note, the choice of semi-structured interviews for SMEs data collection was mainly because of trade-off it provides between having a general structure/more focus on one side, and flexibility of qualitative interviewing on the other side. In fact, as this study adopts multiple case studies as its design, semi-structured interviews are argued to be a very suitable data collection method as some structure would be needed in order to allow for a minimum level of comparability between cases. Besides, having a clear focus and approach of how research question should be studied/answered would naturally favor a semi-structured interview for data collection, which would make it easier for us, under time constraint, to interpret and analyze obtained data in the following sections. So that, while preparing interview guide as will be shown in appendix C[3], we were able to identify specific topics of discussion as well as suggested questions to cover in these respective topics (i.e. having a pre-set focus before approaching SMEs interviews). Nevertheless, we were allowed as interviewers not to follow a strict outline/schedule during the interview, and to cope with interviewees interest within these pre-set focus topics.

3.3.3.3 The final sample and interview settings

The final sample: In total, 9 of the SMEs from population were interviewed. For the rest 30 companies, 11 declined, 17 did not reply to our preliminary request for engaging into

[3] A detailed elaboration on the development steps of SMEs semi-structured interview guide is available at appendix C.1.

the study/conducting a short interview, and 2 were not reachable (no contact information was found either for top management team or general contact info.). The sample size represents roughly 23% of the total identified population; 2 SMEs each of the four technological areas (i.e. AV, connectivity, electrification and shared mobility), and one SME in the "other" classification. The following table no. 4 shows the list of interviewed SMEs along with technological classification, year of establishment, number of employees and last available figure of turnover. As shown from table no. 4, it is worth-noting that one interviewed SME in "shared mobility" technological trend has chosen to be anonymous in the study, therefore it was renamed as "company S". Moreover, we have created a code for each company, as presented in last column, and that will be used for reference purpose to individual SMEs in upcoming sections. It can be also clearly shown from table no. 4 that QamCom is the only company that is positioned far away from the rest of selected sample. That is in terms of year of establishment (in early 2000s), compared to other companies that were established in 2012 or later, as well as number of employees (250), to make it on the frontier of a medium-sized enterprise, compared to other companies that are either small or micro. The same magnitude is also found with respect to the last figure available to company's turnover.

Table 4: List of selected SMEs sample for semi-structured interviews

Company Name	Technology	Year	No. Of Employees	Turnover (in thousand SEK)	Code
UniqueSec	Autonomic Vehicles	2013	4	3700	A1
QamCom	Autonomic Vehicles	2001	250	285000	A2
Criterify	Connectivity	2017	2	350	C1
Viscando	Connectivity	2012	9	6500	C2
Regent Motorcycles	Electrification	2018	3	-	E1
Orust e-boats	Electrification	2014	1	76	E2
Company S	Shared Mobility	2017	15	11200	S1
UbiGo	Shared Mobility	2014	4	500	S2
Pling Transport	Other	2012	15	1400	O1

On another note, as it can be shown from table no. 5 below, most interviews were conducted with either a CEO, a founder/a co-founder, with a length of 60 minutes on average per interview. Six SMEs conducted interviews as face-to-face, while the three others preferred to conduct it over phone due to difficulties in physical reach out. Although it may seem that telephone interviews are more convenient than face-to-face interviews, it has its own costs in terms of technical difficulties. That include low quality of respondent's recorded voice, besides not well-receiving the interviewee's implicit reactions (i.e. the way

an interviewee receives questions and provides answers) such as body language, impressions ...etc. As shown from table no. 5, the three phone interviews were with Orust e-boats, UbiGo and Pling Transport. One telephone interview was conducted twice, as we have requested from the CEO of Orust e-boats to have a follow up interview to clarify on some other topics not raised during the first telephone interview. However, all other interviews (face-to-face and telephone) were conducted once.

Table 5: Title of interviewee, interview type, date and length for each respective SME

Name of SME	Title of Interviewee	Type of interview	Date of Interview	Interview length
Viscando	Co-Founder	Face-to-face	April 16th	63 min
Regent Motorcycles	Co-Founder	Face-to-face	April 22th	44 min
Criterify	Co-Founder	Face-to-face	April 18th	67 min
QamCom	CEO & Founder	Face-to-face	April 15th	70 min
Orust e-boats	CEO	Telephone	April 17th, May 10th	34 min (15 min & 19 min)
UbiGo	CEO & Founder	Telephone	April 24th	65 min
Pling Transport	Sales Manager	Telephone	April 18th	37 min
UniqueSec	CEO & Founder	Face-to-face	April 12th	37 min
Company S	Business Development Lead	Face-to-face	April 8th	49 min

Interview settings: After an SME would confirm its participation in the study, and agree to hold an interview with us, the suggested interview guide, shown in appendix C.2, is sent to the prospective interviewee at latest two days before the interview date. So that s/he can have a quick review on, and be familiar with, the suggested interview topic and questions in each respective section.

All interviews were conducted within quiet places, either within the companies' physical location or within the C-Lab premises. In the beginning of interview, we would briefly introduce ourselves; what we do and what our study is about in simple words. We also elaborated on the overall goal of study and why we chose to include the interviewee's company in the study, hence the main goal behind respective interview (i.e. getting a better understanding of how new innovations can penetrate traditional transportation system and transform it in western Sweden). In that regard we have stressed on the sole academic use of data provided in the respective interview. We have also asked the respective interviewee to give us a quick feedback/evaluation of the way we approached his/her respective company, and if he/she has any clarifications before we start. In addition, we have

requested from all interviewees to voice record the whole interview for the sake of conducting a full written transcription later. We gave the option to all interviewees if they would like to skip any question and/or keep any piece of information anonymous (i.e. company name, name/title of interviewee person ...etc.).

In general, most interviews went smooth according to the pre-set interview guide, however; that did not bind us to be flexible with what the interviewee preferred to focus on. For instance, in some circumstances, we felt it is necessary to depart from the scheduled flow of questions and ask new ones based on the interviewee's views. In some other circumstances, we used silence or short pauses between questions/sections as a kind of prompt to let interviewee reflect and elaborate more on his/her provided answer, as suggested by Bryman and Bell (2015). In some telephone interviews, we had to re-formulate some questions and make them simpler as they seemed almost not clear to interviewees due to absence of face-to-face interaction. That have helped us later, as mentioned before, to adjust interview guide, hence, having a more comprehensive guide in next interviews. At the end of each interview section, sometimes, we provided a summery "catch all" of the main points that interviewee has given for the main "must know" question for that respective part. At the end of each interview, we thanked the interviewee for participation in the study, and offered to send the whole transcribed interview and final thesis draft to him/her for the purpose of verifying obtained data and providing their feedback if necessary.

3.3.4 Data transcription and approach for analysis

Data transcription: For the purpose of having high-quality and deeper analysis, all SMEs interviews were voice-recorded and full-transcribed in high detail. That resulted into approximately 9 hours of audio-recorded material and more than 70 pages of transcribed text, which have been processed and analyzed in the later stages. In addition, we have taken small notes, during interviews, so that we can refer to important topics (i.e. key points highlighted by interviewees) while we are conducting transcription. These small notes were used by us to mark new interesting points introduced by respective interviewees that can be highlighted later in results and discussion sections. This approach of conducting full-written transcription to SMEs interviews has its own advantages in terms of overcoming memory limitations especially when a lot of details are provided in an interview. In that regard, more attention can be devoted to have a deeper discussion, and keep intact with interviewee, instead of taking notes most of the time that may not be fully accurate (Bryman and Bell 2015). That would also imply more transparency in terms of having the original data materials (i.e. the interviewee's own wordings), hence; having a more thorough investigation of discussed topic and removing all possible sources of misinformation. However, a major disadvantage of this approach is that it is time consuming (i.e. an hour of recorded material resulted into 6 hours of transcribing time on average). Therefore, in order to make a balance between research needs and the limited amount of available time, we have decided to just fully transcribe SMEs interviews (as well as one expert interview for data triangulation purpose). Lastly, we have been doing full transcription as soon as an interview is done with an SME, therefore; such full transcription put our feet on the ongoing

analysis very early in the research process. That gave us a big advantage for being aware of upcoming themes that we can focus more on the next interviews, as suggested by Bryman and Bell (2015).

Approach for analysis: This step has been implemented after finishing the process of data collection and transcription. In fact, we have adopted "**thematic analysis**" as the main analytical approach of this study, and we define it as: the extraction of main/key themes through identification and analysis of patterns in obtained data. This definition is based on Bryman and Bell (2015) explanation of what "a theme" is about in qualitative data analysis. Accordingly, the main developed themes for the SMEs current and perceived roles, in the discussion section below, are mainly developed "categories" of such roles after a thoughtful review of data transcripts. Such categories/themes are directly linked to the phenomenon under investigation (i.e. scaling up niche innovations into the regional context of sustainable transformation of mobility system), as well as this study's research questions.

Moreover, the development of such categories/themes have been implemented in a structured process of "coding" primary data obtained from interviews. The coding process have been taking place over two stages. In the first stage, we have developed general "interview-centered" codes/labels that are very close to obtained data, and in many instances, linked to important quotations by interviewees. That was after a careful reading of interview transcripts and taking preliminary notes of possible general data categories. The resulting codes in this stage were mixed between predetermined codes (codes that are directly linked to theoretical foundation of this study), and emerging codes (i.e. codes that are coming from data with no theoretical predetermination). In that regard, it is important to highlight that we have been using NVivo, a software tool for qualitative data analysis, for the purpose of identifying initial codes (i.e. pre-determined and emerging). That validated the abductive approach of this study as we have been going back and forth between the different concepts, dimensions, and themes of investigated literature and new emerging concepts, finding interconnectedness between codes and seeing them as dimensions of a broader phenomenon (Gioia, Corley et al. 2013, Bryman and Bell 2015). This stage stopped after familiarizing all data obtained from purposive sample (i.e. the 9 semi-structured interviews). In the second stage, we started to combine these codes, both manually and using NVivo software, and categorize them into major themes under two main divisions:

(1) SMEs current role: Under this division we combined and categorized codes related to what SMEs are doing in the meanwhile under the current regime/system's pre-occupations (i.e. rules, structure, settings…etc.)
(2) SMEs perceived role: Under this division we combined and categorized codes related to what expected role to be played by SMEs based on their potential in reference to theoretical/empirical literature and interviewees own perspectives.

In this second stage, a continuous review/refinement of suggested themes has been implemented by combining them and visualizing relationship with each other and relevant theoretical concepts in literature. In fact, we have treated ourselves as "knowledgeable agents" who are multiple level thinkers to identify the most appropriate themes under the above-mentioned two main divisions, as suggested by Gioia, Corley et al. (2013). That is by continuously asking ourselves if the suggested themes are significantly describing/explaining phenomenon under investigation.

Lastly, we believe that thematic analysis is the most suitable tool/option for qualitative data analysis in this respective study for two reasons. First, thematic analysis enabled us to base data in a suitable theoretical understanding, hence; a theoretical contribution is expected to be made by introducing new emerging themes/concepts in relation to literature in context and corresponding research focus. Second, such method of analysis made it easy and flexible for us to fit/align with research strategy, design and data collection methodology of this respective study. In fact, thematic analysis made it more convenient for us to identify/extract codes based on obtained primary data solely under time and resource constraints of this study. However, there are some major disadvantages of using thematic analysis that must be highlighted. Most importantly, it is still considered an underdeveloped method of qualitative data analysis as it has few rigorous descriptions of what steps/procedures should be followed, however; this has changed since recently. Moreover, a lot of criticism has been put on coding as it leads to lose context in which data was generated, therefore; contextual social setting is under risk of being lost (Bryman and Bell 2015). The last reference also highlights another problem of coding; data fragmentation, by ignoring the narrative flow of interviewees' stories. In that regard, we tried to hold a narrative flow of obtained primary data from interviewed entrepreneurs and experts while presenting and analyzing the main findings in the results and discussion sections below.

3.4 Sources of misinformation and study limitation

3.4.1 Physical, time and data limitation

Physical and time limitations: This thesis has a geographical limitation of western Sweden; the focus is the regional context of Västra Götaland County. Despite of that, we have faced physical distance barrier; we could not always choose to travel significant distances in the region to conduct SMEs interviews. To overcome this barrier, we were flexible with the method of conducting interviews, as mentioned before, either as face-to-face or telephone. This, together with the fact that most relevant companies are in Gothenburg, lead to a concentration of data from the city of Gothenburg. Indeed, out of nine conducted interviews, two SMEs were located outside of Gothenburg. On the other side, such variations of conducting the interviews (i.e. face-to-face/telephone and in the C-Lab premises/SMEs physical location) would imply imbalances of obtained data from each individual case, which could have significant negative implications while conducting analysis. For instance, visiting company's physical location/office would enhance our understanding of studied phenomenon by observing the workspace environment and getting some demonstration of the company's prototypes. Such opportunity was not

available for SMEs that chose to conduct interviews via phone or by coming the C-Lab premises. One way to limit such negative effect of interviews variation is by being aware of it, and by collecting additional secondary data to minimize the gap between interviewed SMEs. Due to time limitations, this study has a special focus on sustainability transformation within one socio-technical system only (i.e. mobility system). That is besides, in the process of population identification, we have relied more on available Swedish online resources and databases, as well as recommendations from industry experts, compared to other secondary data source. Lastly, more experts have been reached out; however, they fell short to participate in the study due to the same reason.

Data limitation: This study has faced a major data limitation for identification of SMEs working within mobility system. That warrants our methodological approach for adopting a broad definition for "mobility". Therefore, while identifying SMEs population, we included businesses that operate inside transportation sector as well as IT companies developing digital solutions that have direct application into mobility/transportation sector. In addition, the two terms "mobility" and "transportation" have been used interchangeably in search engines and databases to access resources and secondary data essential for population identification. Another major deficit of data availability is for some variables/figures in SMEs population, specifically for most recent numbers of employees and company's turnover. In fact, data collected for turnover and number of employees are from year 2017 for the companies that were not interviewed. That could create some uncertainty, whether such companies are still considered as SMEs or not, if most recent figures are significantly different from those of 2017. Because the limit of generating 500 million SEK (as turn-over) or having more than 250 (as employees), is still quite high, that was considered as a good argumentation for not excluding the rest of non-interviewed SMEs from the identified whole population.

3.4.2 Validity and reliability of the study main findings

A major limitation of this study is validity and reliability check for its main findings, discussions and reached conclusions, which is a direct result of its strategy; qualitative approach. **First, regarding reliability**, it can be claimed that replication of this study or its methodological choices are hard to implement. In general, it is difficult to test for reliability of qualitative study because of poor documented procedures and unstructured nature of qualitative data. In addition, the interpretation of collected data is influenced by the "subjective learning of researcher" (Bryman and Bell 2015). Therefore, we have tried to solve this problem by providing a clear and detailed description of the study's main methodological choices. In addition, a careful documentation of data collection and analysis procedures has been done for this study through recording either manually in research memos and notebooks or digitally in transcripts and coding software "NVivo".

Second, regarding validity, Bryman and Bell (2015) have mentioned three main considerations to validate qualitative research when case study design is followed, and they are: construct validity, internal validity and external validity. **For construct validity**, the last reference indicated that it is hard to check for this type of validity as one can hardly

develop valid operational constructs from qualitative data/case studies, therefore; initial codes check for themes emerged from data analysis cannot be fully validated. Admittedly, it is hard to check for construct validity in this study due to its explorative rather than generalizability purpose. In other words, based on the non-generalizability characteristic of case studies, qualitative data obtained from studied cases are not meant to represent the whole population which make it difficult to hold construct validity. Accordingly, we tried to reduce the risk of invalid coding in this respective study by matching major themes coming from primary data with the main constructs/themes found in theoretical literature. In addition, we have relied on "triangulation" by following more than one data collection method in order to decrease subjectivity of developed themes while conducting qualitative data analysis. Primary data collection has been conducted from 9 semi-structured interviews with SMEs over 5 classifications and 5 unstructured interviews with industry experts, as well as secondary data sources from online documents, reports and databases.

For internal validity, this study cannot fully stand on strong grounds to insure an acceptable level of this validity type for its main findings. However, we have managed to improve this study's position for internal validity by following Yin (2014) suggestion of "pattern matching" by comparing a researcher's own explanations with other interpretations in comparative studies. Therefore, as will be presented in the discussion part, we have matched main findings of this study with previous findings in theoretical and empirical literature; theories of system innovation within the context of sustainability transitions and role of SMEs in regional innovation systems. **For external validity**, as mentioned above in construct validity, it is mostly incapable to generalize main findings from case research to the whole targeted population. Having a restricted scope of this study is due to the non-probability sampling method applied, as well as the unique and distinctive features of its investigated cases. Nevertheless, by studying 9 different cases distributed over 5 classifications, that made it possible for us to compare different cases, thereby opening the door for possible generalization of this study's main findings in upcoming studies. This can be possibly held if findings from this study can be used among findings from other comparable/similar studies to rigorously test for generalizability, which would, in turn, improve construct and external validity of this study's main conclusions.

Lastly, it is worth-mentioning that despite lack of construct, internal and external validity in this study, it holds an acceptable degree of ecological validity, which is highly valued in qualitative research. Bryman and Bell (2015) argued that ecological validity of research holds when a researcher collects data in its "natural occurring situations and environments", and not in pre-designed artificial conditions. Accordingly, this study was keen to study observed social agents (i.e. managerial personnel/entrepreneurs in SMEs), in most of cases, within their natural settings (i.e. working places/environments) and letting them provide their own prospects on the studied topic without any deliberate intervention from us. Therefore, this study is supposedly expected to have a significant positive effect regarding the applicability of its findings on the targeted group (i.e. innovation-driven SMEs residing in western Sweden).

4. Results

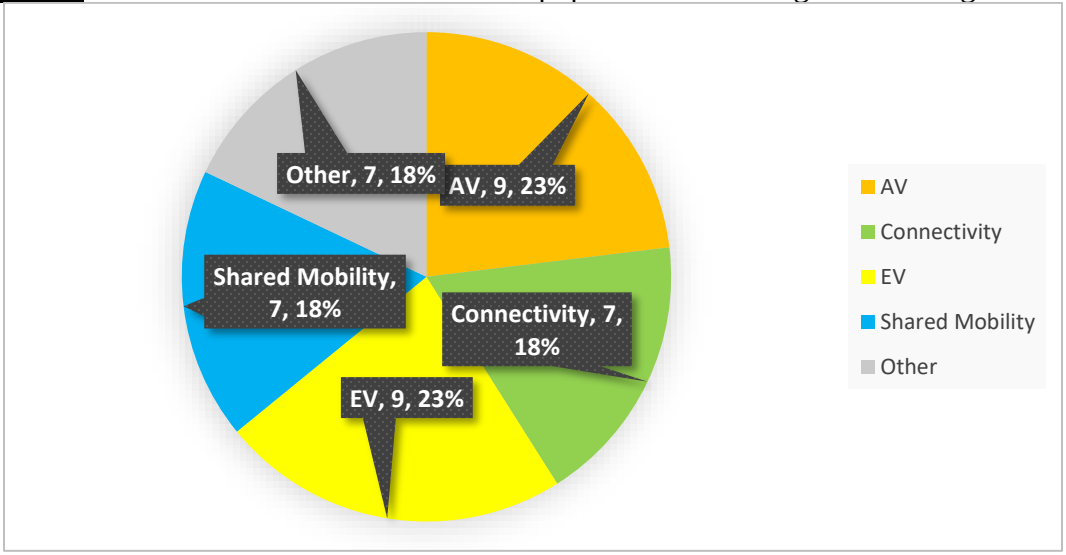
This section is structured and presented based on suggested research design of this study (i.e. comparative case studies), in which we present the main findings directly from obtained primary data (i.e. semi-structured interviews with SMEs) in a comparative design. Indeed, we have compared between investigated cases with respect to the five classifications of technological trends (i.e. AV, connectivity, electrification, shared mobility and other). Moreover, results for selected SMEs sample are presented in line with what we have designed semi-structured interviews; we argue that would provide a better narrative illustration of obtained data. Presentation of main findings of SMEs population and selected sample is also enhanced with main findings of expert interviews, especially the last conducted expert interview for the purpose of data triangulation. Such approach of presenting the main study results has significantly helped us in our analysis, as will be shown in the discussion section later. That is because presented results have provided the solid ground for preliminary concepts/themes that would be further developed and highlighted in the later section, within the process of identifying major themes for SMEs current and perceived roles. Accordingly, we have been using full/direct quotations from interviewees to link with, and further elaborate, main themes presented in results and discussion sections, which would strengthen our argumentation for main findings.

4.1 Results of the final SMEs population

4.1.1 Characteristics of the entire population

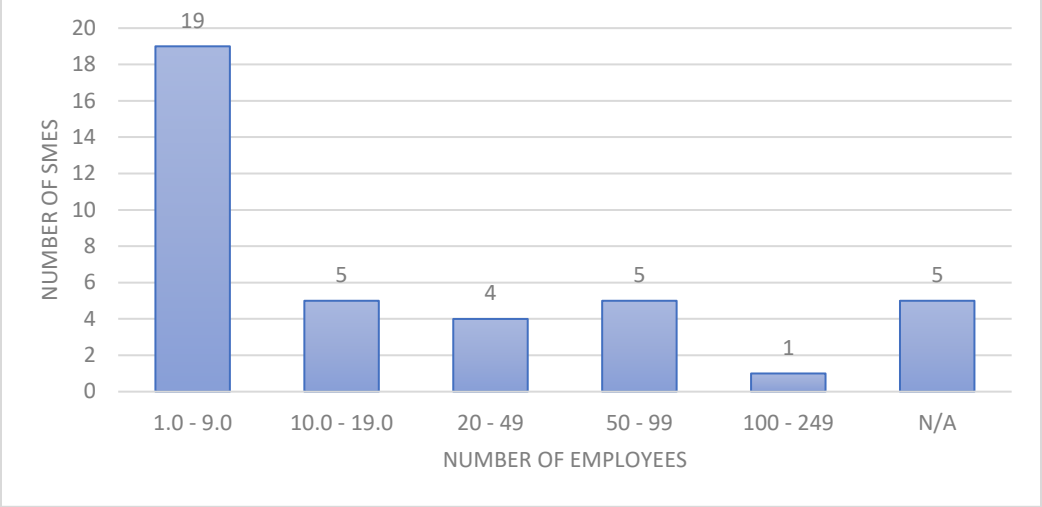
In this section, we further highlighted main characteristics of SMEs final population in order to set its basic features. This is done by visually presenting some basic descriptive statistics, through figures and tables, in relation to the population presented in table no. 3 and figure no. 6 above in methodology section.

Figure 7: Distribution of SMEs in identified population according to technological trends



One interesting finding is the even distribution of SMEs over the five classifications of technological trends. As shown in figure no. 7 above, each technological trend represents nearly 1/5 of the whole identified population, by having either 7 or 9 SMEs each.

Figure 8: Distribution of SMEs in identified population according to number of employees



Despite that fact, SMEs vary greatly according to their size, measured either by number of employess or turnover. Figure no. 8 above illustrates distribution of SMEs according to number employees in which SMEs are presented with respect to EU classification of micro, small and medium-sized enterprises. It is clearly shown from the figure that most enterprises are classified as micro (i.e. having less than 10 employees); 19 micro enterprises represent nearly half of population (49%). Then comes small enterprises from 10 to 49 employess, presented over two categories, with 9 companies (23% of population) in which majority of them have a lower number of employees (i.e. 10 – 19 employees). Laslty, medium-sized enterprises represent the least share of identified population (15%; 6 companies) with just one company having more than 100 employees. Results of this classification suggests an inverse relationship between company size (measured by number of employees) and number of companies in respective category. In other words, the higher the number of employees inside an SMEs, the less number of SMEs in its respective size category. That goes with what have been highlighted by one industry expert, Per Österström. The latter expert mentioned that, within mobility sector, most of employees are working in bigger few companies, while a small portion of employees are working with SMEs, even though SMEs are more in numbers compared to bigger corporations. Lastly, five companies fell short to know their number of employees and include them in analysis.

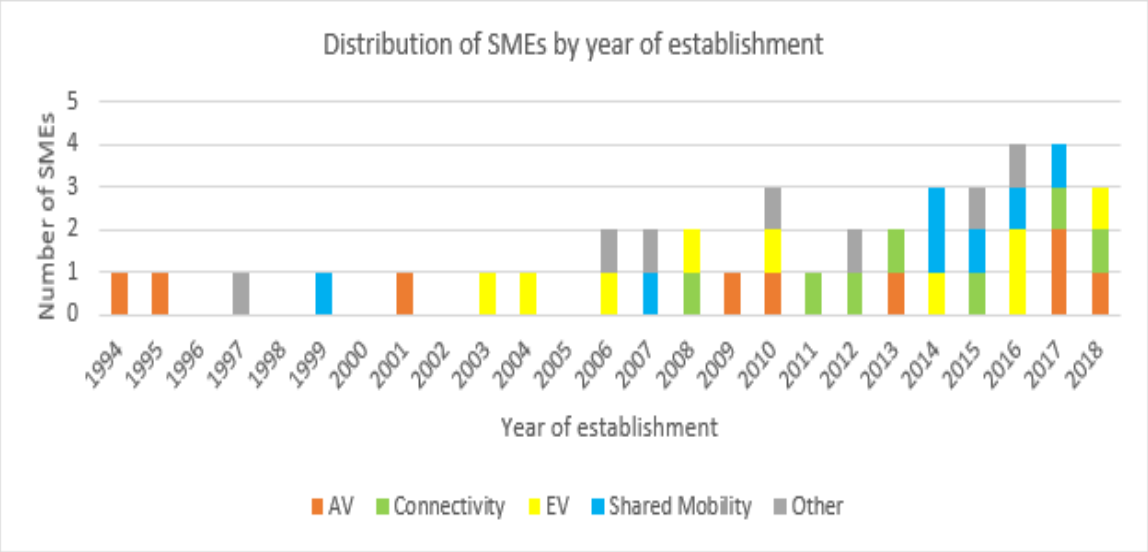
Moreover, table no. 6 represents SMEs distribution according to size, but measured by last available figure of company's turnover, in absolute and relative terms. It can be observed that same trend prevails in comparison with size measured by number of employees, which implies homogeneity of results from different measurement techniques. As presented in table no. 6, majority of enterprises are classified as micro; almost 60% of identified population have less than (or equal to) €2 million as turnover, which goes in line with suggested hypothesis in literature for lack of financial resources as a major obstacle for SMEs. The lowest share goes to small enterprises that have turnover between €2 million and €7 million, with only 2 enterprises. Nevertheless, medium-sized enterprises have a significant share; 26% of whole population (i.e. 10 out of 39 companies) and all of them

exceed €10 million. Lastly, four companies failed to provide information regarding their last turnover figure after searching in all available sources.

Table 6: Distribution of SMEs identified population according to last available figure of turnover

Turnover in (tkr)	Classification by EU definition	Number of SMEs	Percentage from the whole population
0 - 20000	Micro enterprise	23	59.0%
20001 - 50000	Small enterprise	2	5.1%
50001 - 70000	Small enterprise	0	0.0%
70001 - 100000	Medium enterprise	0	0.0%
100001 - 500000	Medium enterprise	10	25.6%
N/A	-	4	10.3%
Total		39	100.0%

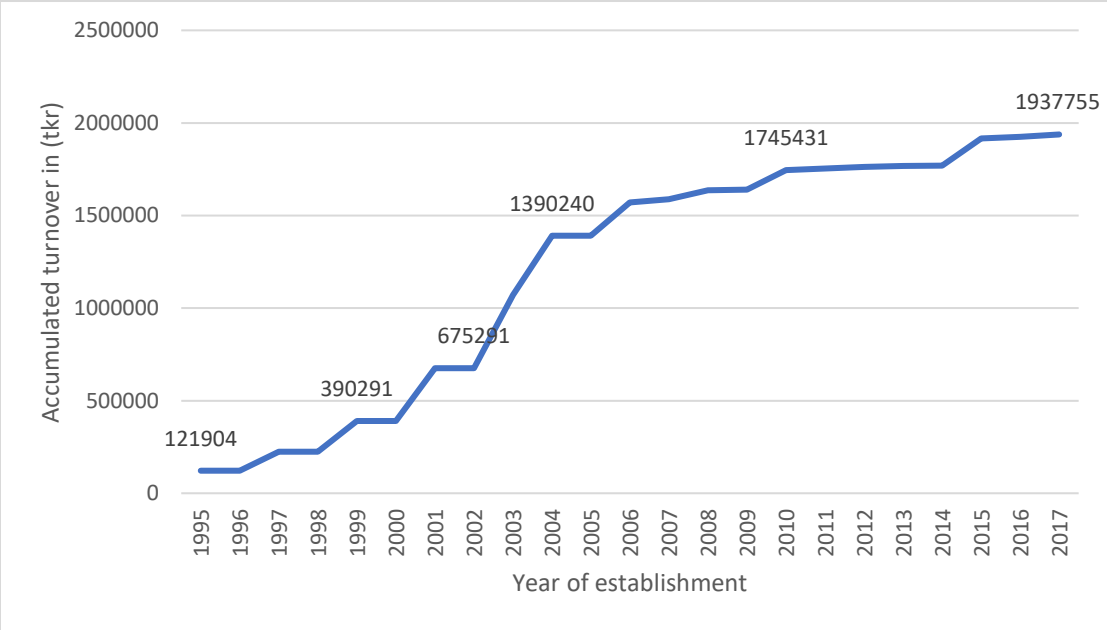
Figure 9: Distribution of SMEs in identified population according to year of establishment and technological trends



On the other side, interesting findings can be highlighted by reviewing SMEs distribution according to year of establishment and detailed by technological trends classification, as presented in figure no. 9 above. At first look, it can be clearly observed that majority of companies were established over the period (2008 – 2018), representing 32 out of 39 of enterprises or 82% of whole population, with more companies established in recent years. While looking at technological trends, it can be noted that enterprises working with autonomous vehicles technologies are well-established in western Sweden mobility system

since 1994. On the contrary, companies developing solutions under connectivity technological trend are more recent into market place with the earliest company established in 2008. It is also worth-noting that enterprises classified under "other" technological trends started to exist into system recently as well since 2006. Although shared mobility began its technological applications since end of 1990s, an increasing trend of established companies in this respective technological classification only started after 2014. In fact, the upward trend of established SMEs in the last few years would suggest an enabling environment within western Sweden mobility system that created favorable conditions for such niche technologies to break through in response to market (i.e. regime) untapped opportunities.

Figure 10: Magnitude of SMEs accumulated turnover in identified population according to an enterprise's year of establishment



In addition, it would be of significant relevance to review magnitude of SMEs accumulated turnover according to their year of establishment, as presented in figure no. 10 above. To remove any potential source of misinformation, it is important to highlight that such magnitude is just for last available figure of turnover for each respective SME in the population. Therefore, by this figure, one can see contribution of each enterprise to the overall turnovers' accumulation in relation to number of years a company is established into market. As observed from the figure, magnitude of accumulated turnover increases dramatically, in absolute and relative terms, for companies that are well-established in marketplace (i.e. old enterprises), with the biggest leaps for enterprises established in 2001, 2003, 2004. However, companies that were established after 2007 do not significantly attribute to the accumulated turnover. In other words, recently established enterprises have deteriorating contributions to this overall magnitude; that does not exceed 8% in relative terms per enterprise in the best cases. Such findings indicate that older enterprises have

higher turnovers compared to newer ones, even though the former are fewer than the latter. In addition, findings from figure no. 10 go in line with, and complete, what have been reached from figures no. 8 and 9 as well as table no. 6 above. For instance, older enterprises (i.e. companies that are established before 2006), have higher turnovers and are in turn fewer in number. While newer ones (i.e. companies that are established after 2006) form the majority of SMEs with diverse technological applications, but they have the lower number of employees and much lower contribution to accumulated turnover, which can clearly reflect their shortage of financial and human resources.

4.1.2 Findings for each technological trend

Autonomous Vehicles (AV): Based on information provided by companies through their online websites, databases as well as accessed clustering reports from BRG, most SMEs under this category are developing IT solutions that enable AV. It has been observed, as shown from table no. 3, that most SMEs in this population have been involved in MobilityXLab. Moreover, companies in this technology classification vary in terms of establishment year and size (as measured by number of employees and turnover). Among the 9 SMEs in this technological trend, 2 companies founded in 1995 and 2001, are located into the upper limit of SMEs; they have a relatively higher number of employees and turnover compared to other enterprises. Lastly, there is one SME that provides a testing arena for autonomous vehicles; AstaZero. From this sub-population, we managed to get two companies for interview; UniqueSec, that develop "advanced signal processing radars" and QamCom which has a bundle of product offerings in autonomous systems and Artificial Intelligence (AI).

Connectivity: Based on information provided by companies through their online websites and other available sources, they are IT-oriented within connectivity, with some elements within AI or Internet of Things (IoT). Indeed, by reviewing business offering, we made sure that their developed technologies/solutions can be classified under the list of connectivity-enabled applications developed by Kavanaugh (2018), as adopted in this study. The sub-population of connectivity, as shown from table no.3, comes from several sources and are not concentrated in a specific reference. Also, they are relatively newly-established; the oldest one was founded in 2008. Most of them are micro enterprises; 6 out of 7 SMEs have less than 10 employees. Two SMEs from this set were interviewed, Criterify, an IoT testing tool, and Viscando, an SME providing a computer vision application for city environments.

Electrification: Based on information provided by companies mainly through their online websites, all companies within electrification have a final customer product, with an electrical propulsion in their core offering. In this sub-population, 9 companies were identified from different sources but mostly from BRG, as shown in table no. 3 above. Like connectivity, SMEs under this classification have a variety of sizes and most of them are relatively new. Amongst the technological trends, this one has the greatest geographical spread and that is observed in 6 out of 8 locations where innovation-driven SMEs within electromobility were identified. Two SMEs from this set were interviewed; Regent

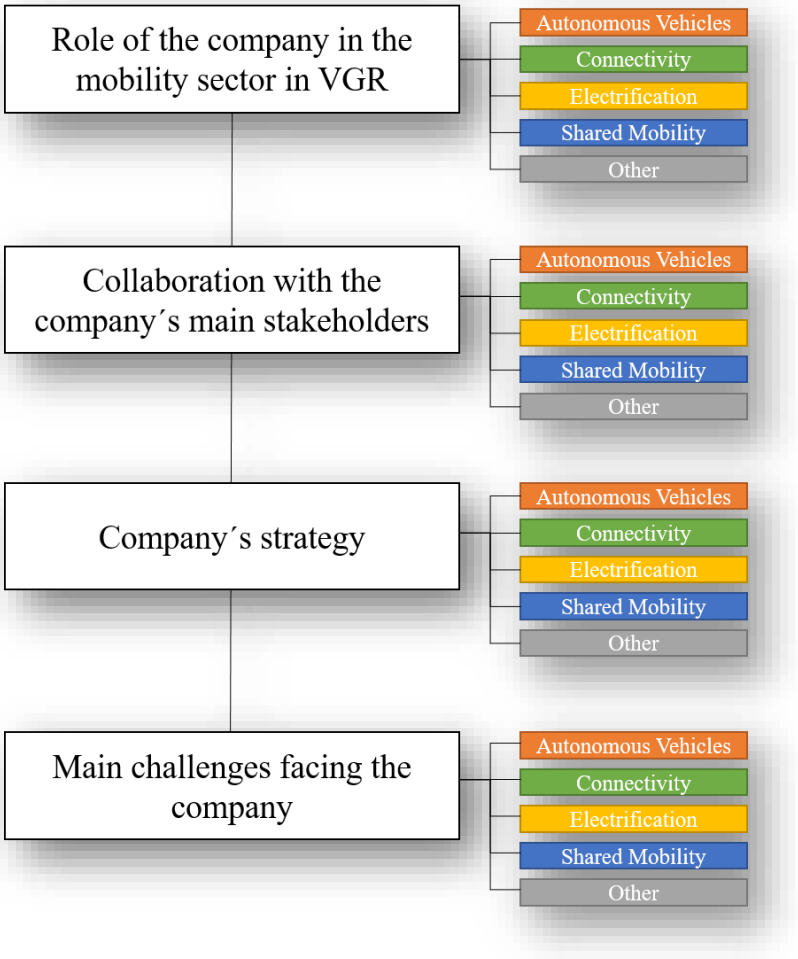
Motorcycles, an enterprise that manufactures electric motorcycles and Orust e-boats, a company that provides integrated solutions for recreational electric-powered boats.

Shared Mobility: After reviewing information provided by companies through their online websites, we found that all of them provide some sort of service-based online platform solutions. Within Västra Götaland County, 7 shared mobility SMEs were identified, and in terms of size, they are all either micro or small according to number of employees. The two oldest were established in 1999 and 2007, while the rest were founded after 2014. Most companies in this sub-population were identified by using alternative sources. It is worth-mentioning that all SMEs under this set are located within Gothenburg city. Two SMEs were chosen for interviews, Company S "a package delivery platform", and UbiGo, an integrated shared mobility/travel platform.

Other: Based on provided information through their websites, SMEs under this set did not match any of the four technological trends identified before; however, they are still considered innovation-driven according to the SMEs set criteria presented in the methodology section. The inclusion of such SMEs in our classification is done according to subjective criteria for innovativeness as inspired by Klewitz and Hansen (2014), for the different types of innovation activities in SMEs. This sub-population set consists of 7 SMEs that were accessed from different sources, and they are distributed over four different locations within Västra Götaland County. Most of them are relatively newly-established, any they are various in size among micro, small and medium as measured by both number of employees and turnover figures. One SME within this set was chosen to be interviewed; Pling Transport, a last-mile delivery company.

4.2 Results of the semi-structured interviews with selected SMEs sample

Figure 11: Structure of presentated results for primary data collection from SMEs and expert interviews



This section is divided into four sub-sections in which main findings for the primary data of semi-structured interviews are presented. That is accompanied with some findings of expert inverviews that enhance argnumentation of such results. Each subsection is orderd by the five classifications of technological trends adopted in this study, as presented in figure no. 11 above. The four subsections align with the structure adopted in SMEs interviews, which is assumed by us as the most approriate approach to enhance narrative flow of results. It is crucial to mention that SMEs codes developed in table no. 4 will be used for their reference in this, and the upcoming, sections. In addition, some preliminary analysis is provided in this section including suggested themes for role played by SMEs, which is further developed in the discussion and conclusion sections.

4.2.1 Role of the company in mobility sector in Västra Götaland County

In this part, we present results of how the SME's interviewee considers the role of his/her SME in western Sweden's mobility system. That is by understanding the journey in which respective SME has come through to realize its radical novelty from idea conceptualization to current status, particularly through detailed explanation about nature of company's business offering as well as milestones that company has passed till it reached its today's position. By this narrative, the interviewee is expected to provide detailed information of how his/her SME managed to scale up its novel technology and establish its niche within current mobility regime/system. As shown in appendix C.2, some follow up/interpreting questions have been used to elaborate on interviewee's narrative such as ways of product experimentation, learning about desirability of business offering from customers, R&D-related activities… etc.

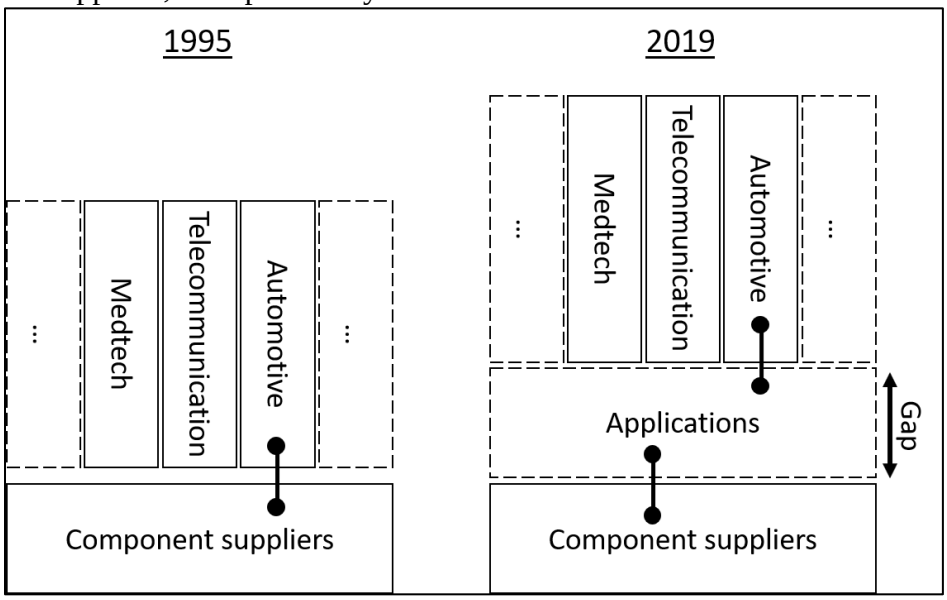
4.2.1.1 Autonomous Vehicles

Despite the significant difference in size between A1 and A2, both are R&D intensive. In addition, both founders have PhD degrees from Chalmers University of Technology, and most employees in both companies are highly educated and technical-oriented. The founder of A1, a relatively young and small company, indicated that this company's technology is applicable in several business areas. The company started developing its applications to provide radar solutions within a wide range of industry applications, due to the highlighted opportunity of small-scale radars, but it switched its resources towards the autonomous vehicles as the later started to become more relevant. That can be summarized by A1 founder in this following quotation: *"we started thinking about a newer application of the smaller scale radars, so as you can see, these radars are .. you can pack it in very small boxes and they are very affordable .. in for example security or survival application. So, then we start thinking if it is possible that we do everything in our lab and so forth, that was the original idea, but we found that actually this is the same problem in automotive industry … We learned that this is the same problem for everybody, and in the automotive industry it is a bigger problem".* A1 founder also explained that his respective company tests desirability of its product by closely experimenting prototypes with customers and having feedback of their demands.

The founder of A2 describes similar patterns; he explained that the automotive industry is only one among several business areas that his company is developing solution for; as it also operates within telecommunication and MedTech. The founder of A2 explained that company's capabilities in terms of providing "single processing components" can be applied in a growing number of industry applications (i.e. verticals), which have increased over last decades including automotive industry. This can be summarized by A2 founder quotation as follows; *"The foundation is single processing, that is our core domain…when we started 20 years ago, it was obvious that the communication system was about to be one of the biggest users of that core domain. Vehicles were to some extent using it but over the years it has been clear that, today, single processing is equal as important as for a*

car…..in our view, the automotive sector is one industry. The usage of these components has a much broader space than only to the automotive.".

Figure 12: Schematic illustration of the increasing gap between the verticals and component suppliers, as explained by A2 founder



In addition, A2 founder mentioned that more applications in many industries are increasing their complexity due to digitalization. Therefore, during the last 20 years, a significant gap has been created and widened; which allowed many new entrants to capture the opportunity by intervening and providing digital solutions in many industry fields. That was confirmed by him, as he mentioned *"the distance between the component suppliers and these verticals increased. So, there is a bordering of the gap in between them…"*. The above illustrative figure no. 12 as developed by A2 founder and adopted by us. The respective figure compares between marketplace in 1995 and 2019 in which digitalization has created a gap and opportunity for new component players/suppliers to step in and develop novel technological applications for many industries.

Founder of A2 explained that his company works within that growing gap, between the component suppliers and the industry fields, as shown in figure no. 12 above. He mentioned that this has benefit his company as well as other new players that stepped in in the last 20 years, especially for developing new solutions in the automotive industry, as *"…and our company have been placed here. Which means that we are in there to make applications. So, we are basically the glue that connects the components with the solutions, and which mean that we work with any vertical…*". To link with verticals, he mentioned that A2 develops partnerships with its customer companies with whom they co-develop solutions in order to reduce risk of failure and to be easily integrated into business models of customer companies. Lastly, both companies expressed that they are R&D intensive, but with different patterns; while A1 is conducting 100% inhouse R&D, A2 co-develop risky projects with its business customers.

4.2.1.2 Connectivity

Both founders of C1 and C2 have a technical-oriented background, the founder of C1 originates from the telecommunication industry. While the founder of C2 worked within an SME that was a subsidiary of SAAB, (a Swedish multinational corporation working in the defense industry). Both founders, together with their respective co-founders, identified market opportunity, based on their technical expertise, before departing from their occupations. C1 found a market opportunity for quality assurance in terms of validating and testing solutions for large operators in telecommunication and transportation industries, by stating: *"We are providing a platform, for quality insurance, especially with products that are communicating, like mobility vehicles…. That is our business solution, that it is cheaper than competitor's solution"*. While C2 co-founder mentioned that they found a business opportunity, after discussions with their old customers, using image processing technology for measuring traffic flow in city environments for which created data/statistics can have many interesting connectivity applications.

Both enterprises exhibit different stages of product development, market establishment and customer acquisition due to the significant difference of company age between both. Indeed, the respondent in C1 commented that his company is still in the early process of establishing relationships with the first customers while C2 has already been established in the market through early adopters. Cofounder of C1 mentioned that in this stage, they depend on doing presentations of their business solution and getting verbal feedback from their customers in big corporations that they used to know from their own business/personal network. While C2 co-founder exhibits a different experience with his enterprise's customers as will presented later in the discussion section.

Moreover, both respondents agree that technology they develop is not disruptive by itself, but it could be disruptive when positioned with the right combination. For instance, the respondent from C1 mentioned; *"No, I wouldn't say that … Take the wheel for example, if you make it run faster, the wheel, in itself, is not what is disruptive but rather what you can do with the faster running wheel that are disruptive."* The other respondent in C2, that has cities administrations/municipalities as its main customers, stated that its offering *"... could be disruptive, but I do not think it will be, because cities are not that fast moving, so we are trying to incrementally push it forward. We try to integrate it with the current system and then add additional functionality."*. The co-founder of C2 further describes how it was hard to get customers when the technology is relatively new, even raising capital was hard, thus, to fund the product development, the employees undertook consultancy missions. Lastly, both SMEs do in-house product development and they have high R&D spending. C1, the younger company, spends around 95% of its resources on R&D while the founder in C2 reported that they spend around 60%.

4.2.1.3 Electrification

The founders of E1 and E2 come from a relatively market-oriented background compared with other companies' founders active in other technical trends. It is interesting that both respondents share a vision for environmental transition that is expected to happen sooner

or later, through which both have identified a business opportunity. For instance, E1 co-founder states *"I went to Beijing two years ago and I noticed that all bikes were electric. And that the government .. they forbid all the petroleum engines. So, it is just a question of when that will happen in Europe as well…"*. While E2 CEO has more detailed vision of sustainable society as new value would be created from collaboration among different stakeholders based on circular business models. In fact, his company is not just focusing on electric boats as its single final product, but to replace existing infrastructure and creating an integrated system of electricity generation and storage. That can be highlighted by his following quotation: *"It is to exchange boats in the harbor that are running on fossil fuel. So, we show up and we show how can we change the market we have today towards sustainable future. Then, it is not only to change the boat but the electric propulsion, how electricity is stored and used at the harbor. So, it is a whole new system… The boat will be incorporated in a green harbor."*. Moreover, the last respondent stressed that innovative business model to capture value from his company product is an essential component of its business offering as; *"Everyone can enjoy this boat, you can rent it, you can invest in it. Maybe you can share it with someone else. You do not need to own it by yourself, so you do not need to pay so much..."*.

To find out about desirability of their companies' solutions, they both use online channels and engage in exhibitions where they could show their prototypes and receive feedback from potential customers. As mentioned by E2 CEO, "*We just use the webpage and today we are also on our way to a boat show in Stockholm; Sweden's first electrical boat show…".* The co-founder of E1 had an exploratory approach early on, to figure out the desirability, before developing the physical prototype, social media was used to reach potential customers. The E1 co-founder explained *"When I started the first prototype, we actually only did a sketching, so we painted a bike and said, 'yeah it looks cool', put it on Instagram to see, 'okay, what is the response on the bike' and it was massive, so we said, 'yeah, maybe we have a case here as well …''*. The last respondent further explained that he later continued testing the product in exhibitions to have a proof of concept, launched online pre-order campaigns and further tested it in real with prospective customers. Both founders of E1 and E2 spend roughly 50% of their resources on R&D. Unlike most enterprises in previous technological trends, the responders stated that they outsource and/or get support from a third party to design and develop parts of the product, from partners and suppliers.

4.2.1.4 Shared Mobility

The respondents of S1 and S2 have a platform-based business model. S1 is a transport management system (TMS) platform of non-time critical shipment for small businesses, by which they can book, ship packages with a competitive pricing. While S2 is a shared mobility solution for households to access different transportation needs and modes through subscription in which car owners is the main target customers. The desirability of both companies' products was discovered in different ways. The respondent of S1 explained that the company was established to meet customers demand of an already existing enterprise, therefore; their demand for a different kind of service made its founder to establish S1. Respondent from S1 also explained that his company managed to scale up

by outbound marketing; reaching our more customers that further spread news about the company through word of mouth. On a later stage, they turned into inbound marketing by raking high on online search engines. S1 respondent further commented; *"From the very beginning we first started with one customer and then we tried new things and we got more customers…. We got a lot of feedback from our customers but of course we cannot satisfy all needs, so we try to solve the most important feedback that is in line with the strategy. We are also looking from where the feedback is coming from, from what kind of customer…"*

On another note, founder of S2 explained that his company conducted a multi-stakeholder pilot project, involving multiple suppliers and customers, to test their concept. Founder of S2 explained the need to conduct this pilot project as; *"We needed to test if for real, you cannot do a market research of something new and ask questions 'how much are you willing to pay for something that you do not understand what it is ….That was the chance when we got to do it in the Gothenburg pilot five years ago and that went over the expectations …"*. The founder of S2 stated that even if the pilot project was a success, it was not feasible to continue with the platform because of the agency responsible for the public transportation services; Västtrafik. The respondent stated that, after the pilot, Västtrafik decided to drop out from the project. This resulted in making the platform very hard to sustain since Västtrafik manages most of the city's public transportation activities. The founder of S2 explained that it was partly the reason why his company has moved to Stockholm to establish the platform there instead. That can be highlighted by S2 founder as follows; *"I can understand that it is a slow process, but it was little bit unfortunately, because if we had gone the right support directly from them during the pilot project then this would have been mature, an existing product in Sweden and we would be ahead of Finland, that started two years after ours…"*.

Both respondents state that their respective companies conduct R&D. Based on what they say, it seems that R&D is not considered as a separate activity apart from company's main operations, but it is core activity of their product development. The respondent from S1, that has an established business, stated *"We don't have an R&D department, but a lot of our activities are related to R&D. But our roles are more connected to R&D. It is more an agile process. It is part of our product development that we do R&D all the time."*. Accordingly, thus suggesting that it is harder to distinguish between R&D activities and operations since all of them are connected to improve or maintain the platform. That is confirmed by S2 founder as he stated, *"But the platform is provided as a service…to our mobility-as-a-service …. we design all of the operations, everything from front to back office is defined by us, and are built in the platform depending on the customer that they have. So, what we are doing in terms of R&D is really on user behavior, business development more than that. We are closer to the business and design of the service and user behavior..."*.

4.2.1.5 Other

By receiving a comprehensive illustration of O1 business offering from its respondent, we were able to decide that value proposition of the company's business model makes it innovation-driven. In fact, being service-oriented is the main competitive advantage to O1, therefore; service innovation can be considered as a significant source of value creation and an essential component of its value proposition. Moreover, its innovative business solution can be considered as radical innovation, despite not classified under the other four disruptive trends. That can be elaborated by O1 respondent's quotation as follows; *"We are providing the service of delivering goods and food, any kind of goods from A to B. But also, distribution; so, we can deliver on point and hand a bigger number of items.....We have one cubic meter of cargo and transporting it in the city landscape without being a hinder for other people, and also being faster than cars. We are not stuck in the traffic congestions. That is quite unique. The combination of being sustainable, and also being able to deliver faster than we would have been if we traveled on the roads"*. In addition, although O1 business offering is not based on a radical digital technology, its respondent has highlighted the sustainability aspect of O1 value proposition in combination with changing a traditional societal view of transporting cargo inside cities. That can be elaborated by the following quotation; *"Our concept that we are only doing bikes, and also that we have an ambition to be sustainable in a social way too …. but I do also believe that we want to challenge the perception of what you can carry with a bike"*.

The respondent in O1 also explained that her respective company was founded after its co-founders have co-founded another company that develops the vehicles/bikes being used by O1. In the beginning, O1 founders aimed to explore the market of last-mile delivery, and they established this enterprise as a platform to test cargo bikes manufactured by the other company. Since starting in late 2012, O1 has taken very slow steps and it has faced many obstacles to scale up, as will be elaborated later. Nevertheless, O1 main activities, as what its respondent indicated, are customer-oriented, and still are exploratory in nature where O1 is experimenting in finding new ways of packaging its offerings. That is done mainly through listening to customers' feedback, as elaborated by respondent in her following quotation; *"Customer asked us if we could do something more for them. They saw us like very flexible and service oriented and nice guys, so they asked us if it was possible to find a good price, we would solve it…. So basically, we learned through communicating with customers…"*. Such experimentation is also done by generating the company's own ideas such as advertising on the company's bikes. Lastly, O1 has low level of R&D, but it indirectly collaborates with the other company (i.e. the bike manufacturer), in terms of providing feedback from experimenting bikes in traffic or when customers have special requirements.

4.2.2 Collaboration with the company's main stakeholders

In this section, enterprise respondents reveal information regarding the nature of collaboration and networking activities that their respective companies are undertaking. That was a logical sequence of data presentation after understanding nature of innovation that respective company is developing (i.e. business offering), how it is developing,

experimenting and testing its current offering, and how it is conducting R&D. Accordingly, this section investigates, as presented in appendix C.2, the main stakeholders for each respective enterprise and what kind of collaboration activities that each company is conducting with its main collaborators. We revealed further information regarding this topic, in light of the various collaboration initiatives and platforms that are taking place in Västra Götaland County and attracting many stakeholders from different backgrounds. For instance, we have been asking for the purpose of entering such collaboration projects/activities/platforms…etc. We also asked some interviewed entrepreneurs about their expectations from such collaborations and if the later met their expectations with respect to their own vision behind, and strategy for, collaboration.

4.2.2.1 Autonomous Vehicles

The founders of A1 and A2 have similar responses, and both are very active in many collaboration activities/initiatives. They both mainly work with their component suppliers for product development. Even if A1 does not have any customers yet, it still collaborates with component suppliers for R&D, while A2 collaborate, as its founder mentions, in both directions (i.e. component suppliers and target customers) in product development projects. A2 founder has also indicated that collaboration with component suppliers is very crucial to his enterprise, and he had two expectations from such collaboration; (1) building mutual trust and understanding and (2) accessing latest knowledge for newest market products. Both SMEs target the automotive industry as among their targeted customers, but it is the only segment targeted by A1 at the moment.

They both collaborate with research institutions and universities, but for different reasons. The respondent from A1 states that a lot of resources devoted to academic research do not solve actual industry problems. Indeed, he mentioned *"the problem is that at the moment in academia, lot of problems, that are made at Chalmers or any other universities, are man-made, they are not real problems … That is the current role of academia. But I believe that academia can contribute in much more in-depth theoretical insight to the industrial and real society problems"*. Thus, reason of collaboration with academia, from A1 founder perspective, is trying to influence its focus more on problems related to what A1 is solving, even though such collaboration is not fruitful yet. The founder of A2, despite partially agreeing with A1 views, has a different goal with the collaboration. His objective is to attract new skilled employees to the company, and to get contact with industry player that can be potential customers.

Both A1 and A2 express struggles working within the automotive industry, as their main client/customer target sector. The respondent from A1 expressed that the big companies are not ready to work with SMEs as the formers already have their established networks of big suppliers, and that is the gap that recently-established technology platforms, such as MobilityXLab, try to bridge. In fact, he mentioned that his company was the first startup to join MobilityXlab since it started and he had concrete expectations while joining in terms of conducting business agreements, proof of concept or product sells. Nevertheless, respondent from A1 states that MobilityXLab has barely any success to achieve this

bridging goal. Lastly, A1 founder also mentioned that he had collaboration activities with many Swedish governmental entities, mainly "Business Sweden" that had significantly helped his enterprise in raising capital and reaching international markets.

4.2.2.2 Connectivity

It is interesting to observe different patterns that both enterprises are adopting regarding collaboration/networking activities. On one hand, the co-founder of C1 explains that his company is still in an early stage where business model started to get defined with the support from Innovatum, therefore; they are still in early stages for recruiting customers by understanding how product can fit their needs. On the other side, the founder of C2 explains that the company has several customers, mainly city councils and municipalities, as well as partners outside Sweden that use and/or sell projects from C2 in new markets within Norway and Switzerland. Compared to C1, C2 is very active in different collaborations; such as with universities, public organizations and in the collaboration arena, MobilityXLab. In fact, C2 cofounder expressed his satisfaction by being in MobilityXLab as it fulfilled his expectations for connecting with big corporations. Nevertheless, C1 co-founder expressed that his respective company is conducting discussions with big corporations and consultancy firms for the purpose of mutual support, business model development and identifying potential projects of product development. Unlike C2, C1 did not agree to collaborate within university projects.

Furthermore, the respondent from C2 reported that the reason for such multiple collaborations is to accelerate product development. That was clear from his comment *"we want to do our product better and more usable, so this is a good way to see future applications'',* when referring to a specific collaboration project between Chalmers and VTI, vägtransportsinsititutiet. In fact, interview with C2 co-founder revealed a close relationship between connectivity and autonomous vehicles technological trends that will be more elaborated in the discussion section later. In addition, C2 is still part of MobilityXLab.

The main collaboration platform that C1 has now is the start-up incubator "Innovatum", and the main collaboration activity within this platform is to receive business skills (i.e. mentoring and support for developing its MVP) and, in a later stage, to scale up. Interestingly, the C1 co-founder explained that collaboration with "Innovatum" was not to access networks with potential customers and/or suppliers as they already had their established network at Lindholmen Science Park. Lastly, both enterprises stated that they received funding from VGR acceleration programs, a step that was essential for product development. In this regard, the founder of C1 claims that funding is becoming more accessible if an SME is already part of an incubation program such as Innovatum. Moreover, C2 co-founder explained that his company inclination for entering international markets is to receive funding from international institutions/projects such as the EU.

4.2.2.3 Electrification

It is observed that collaboration patterns are quite different between the two respondents' enterprises. On one hand, the co-founder of E1 indicated low level of collaboration with

public stakeholders such as Almi, VGR or Vinnova; he argued that it is a very time-consuming process and not viable financially to apply for public funding. The respondent also mentioned that E1 does not have any collaboration activities with research centers, incubations programs, universities or technology platform as he "does not know how to approach them"; however, this can potentially change in the near future after having stable operations and revenue sources. He also indicated that E1 is a subsidiary of two other companies that provide substantial resources basically for R&D expenditures. In addition, E1 is outsourcing the production of some bikes' parts from international suppliers. Therefore, in general, the main collaboration activities are with suppliers, for the purpose of product development, and customers.

On the other hand, the respondent from E2 states that his company has strong collaboration with many research institutes, as he has a strong vision of the desired outcomes from such collaborations. One of the purposes for these collaborations is to develop a sustainable business model for circular economy in which electric boats are core element, as E2 CEO mentions; *"Orust e-boats is part of a collaboration to work with circular revenues, we are going out into nature without killing nature..."*. Indeed, E2 respondent explained that one collaborative research project includes other big corporations, besides research institutes, to develop such circular business model. E2 is also among the incubated startups within Innovatum Science Park incubator program. E2 CEO provided positive thoughts regarding such collaboration as he stated, *"Today it works as a partner where you can discuss what is working and how to achieve the goals, what strategy and tactics, and how to make it to work".*

4.2.2.4 Shared Mobility

Both respondents of S1 and S2 have expressed that they have an extended network with suppliers and customers. S1 has a limited range of collaborations; most of its focus is with suppliers. Respondent from S1 has indicated that his respective company is looking forward to integrating in a partnership with bigger suppliers to exchange customers and identify business opportunities together. However, the respondent from S1 also stated that his company does not have any current plans for collaborating with any other external stakeholder such as innovation arenas or networking platforms. In fact, S1 does not visualize any value from collaboration platforms that are taking place in the region, as well as collaboration opportunities with universities or research institutions.

For S2, as its founder mentioned, monopoly operators of public transportation, in addition to city councils/municipalities, are "key stakeholders". Indeed, these two stakeholders are crucial for shared mobility platforms to be able to operate. While S2 also focuses on collaboration platforms such as Lindholmen Science Park and Almi. In that regard, the former respondent showed a strong vision towards such collaborations as he believes that a collaborative initiative can succeed when contacting the right and "bold" persons inside organizations that dare to do a change. Moreover, such collaborative projects have research outcomes that serve as concrete scientific evidence for realized behavioral change of prospective customers, which is expected to change attitude of public authorities inside

such collaboration initiatives towards more co-operation with startups and SMEs. On the other side, S2 founder expresses his concerns of being part of such collaboration platforms. S2 founder has mentioned; *"If you are looking in those kinds of projects, if you are a small company, it is of course important with financing. But it can also be dangerous because there are a lot of companies that get stuck in running projects based on public money and they never really take off…".*

Both companies have approached public institutions for the sake of acquiring funding and/or gaining help to enter international markets. The respondent from S1 reported that his company, after its launching, was part of a short internationalization acceleration program conducted by "Business Sweden". Both enterprises got significant seed funding from Almi; respondent from S1 stated that was part of a pitching contest that his company won. S2 founder also highlighted that applying for such funding provides some sort of accreditation or credential for being able to collaborate with big public transport operators such as "Västtrafik" or city municipalities. That goes in line with what has been raised before by C1 cofounder regarding the correlation between being part of collaborative platforms and having easier access of public funding/support.

4.2.2.5 Other

The respondent of O1 stated that her respective company main collaboration partners are suppliers as well as customers that have different needs. Some of O1 customers are big corporations and public entities. The respondent also highlighted that O1 is open to participate into collaborative research projects; however, nothing concrete has been implemented yet. The company is also active to participate into other networking events and platforms as it is involved into "godsnätverket" that is facilitated by municipality. Despite O1 is not officially collaborating with university or research institutions, its respondent mentioned that the company can easily reach out appropriate contacts and ask for advice (i.e. it has an informal contact with relevant stakeholders). In summary, although the O1 is not actually engaged into collaborative projects, it is open to participate into multi-stakeholder networking initiatives and has informal contact with different entities in the region.

Lastly, the following table no. 7 summarizes the main collaboration patterns between interviewed SMEs and their respective external stakeholders. It is important to mention that all enterprises collaborate with customers and suppliers by default; therefore, they are not included in the table. Based on identified patterns from the above analysis, we have classified collaborations into five main forms, and they are presented from the most to the least repeated. The most repeated pattern is R&D collaboration with suppliers in which the respective enterprise is co-developing its final product with its supplier partners, either between the two sides only or in the form of a collaborative multi-stakeholder project, and that can be observed in enterprises within the four disruptive technological trends. It is also observed that majority of SMEs (i.e. 6 out of 9) have collaborated with public organizations such as VGR, Vinnova, Business Sweden for the sake of acquiring funding or having professional support to access national/international markets. Five enterprises are heavily

engaged into technology platforms/networks mainly, MobilityXLab, Lindholmen Science Park, and Almi. In addition, four SMEs stated that they are part of research projects with universities and research institutions such as Chalmers University of Technology and RISE. Two enterprises are still part of incubation programs in Innovatum Science Park, (while some other companies are either former participants in other incubation programs or working closely with them such as A1 and C2). Apart from that, we observed that 3 enterprises showed either low interest into collaboration with external stakeholders or no actual involvement with real collaboration activities.

Table 7: Summery of main collaboration partners with interviewed SMEs

Collaboration	SMEs
R&D collaboration with suppliers	**A1, A2, C1, C2, E1, E2, S2**
Public organizations	**A1, C1, C2, E2, S1, S2**
Technology Platforms/networks	**A1, A2, C2, E2, S2**
Universities and research institutions	**A1, A2, C2, E2**
Start-up Incubators	**C1, E2**
Low Collaborations	**E1, S1, O1**

4.2.3 Company´s strategy

In this section, the company's scaling up strategy will be presented, in order to understand what path a respective SME has adopted to scale up its radical novelty. That is either through a traditional growth strategy, or other potential mechanisms for increasing rate of technology application. In addition, that section is a natural sequence of interviewee's narrative after investigating collaboration patterns with the SME's main stakeholders. In that regard, we have been asking, as presented in appendix C.2, for the company forthcoming goals (i.e. within the next three years), as a general inquiry of strategy. Nevertheless, we have added a follow up question in which we further elaborated, and paraphrased, the main question by specifically asking the approach of top management team regarding the implementation of such strategy, in terms of expected actions, decisions, investments, new projects, collaborations …etc. In order to have an overarching view of company strategy, during some interviews, we asked about the company's vision. In fact, we have asked this question to some interviewed entrepreneurs that have a strong vision of where/how their respective enterprises will be positioned in the future within its ecosystem.

4.2.3.1 Autonomous Vehicles

The companies A1 and A2 are in different strategy stages. The respondent of A1 indicated that his company main strategy focus is continuing with product development that incorporate service-based innovation; as both software and hardware development would take place. That is better elaborated by A1 CEO and founder as follows; *"…because since*

this technology is a very high-end technology … It is a lot of consultancy, and a lot of services upgrade to this product shall made continuously so we have our software and hardware development for the next three years at least or maybe for five years that we need to continue development as well…". While A1 secondary goal is finding new markets, which would take more time in the future, as mentioned by its founder; *"… And expanding to the new markets is also in our horizon but it is not yet materialized. Because it is a little bit to go, and this technology is a little bit futuristic technology. And it needs a few years still to be realized in the market…"*. In fact, A1 respondent explained that his company has given up in finding customers in Sweden and it is now reaching out customers internationally in other countries mainly in East Asia such as Japan and South Korea. Interestingly, A1 founder considers that his respective company is working in a niche market; however, he has a vision that A1 can penetrate the mainstream market of radar applications within mobility system in the future.

A2 CEO and founder described his company's strategy based on three challenges identified by the top management team to solve in the near future; *"Shaping our offering in the market, finding the people and finding an organizational structure that support this"*. To elaborate, the former respondent explained that his company's main objective now is to increase his company competency by innovating its business model for packaging such competencies; hence, introducing a new revenue structure. That was argued by A2 founder by his rejection of current business model in marketplace through which customers price an hour of consultancy work with a fixed value. Respondent of A2 explained this by mentioning *"The strategy is to move, I mean the main challenge we have, in the environment we are in, is that people typically want to buy your competence by the hour… which means, the better we become, the worse that model is. Therefore, we need to package our knowledge in other deliverables. The strategy is to move slightly upwards in this…"*. Furthermore, A2 respondent explained that his company investing much resources in redesigning the organizational structure to make it more efficient. Lastly, the former respondent mentioned that his respective company is expanding in new geographical locations in order to overcome one of main challenges it faces; finding the right competences to join the team.

4.2.3.2 Connectivity

The two companies are in different stages of their strategy, while the respondent in C1 indicates that the company is still developing Minimum Viable Product (MVP), the founder of C2 reported that his company is in a scaling up phase by growing in the market of traffic signaling in parallel with product development. Although C1 is in its early stages of product development, its co-founder stresses on the agile approach that the company adopts "when it comes to development". Such agile approach is dependent on customer feedback for product development in combination with a quick scale up fueled by more funding on a later stage, as explained by C1 respondent; *"But at the moment, we are doing MVP, marketing and if we can get a collaboration soon. Then the idea is to scale quite fast through investors or other options..."*. A1 respondent also mentioned that entering new market segments is not among his company's strategy. The last respondent has also

expressed a strong vision for his company that includes an estimated share in market for testing tools.

On the other side, it has been a combination of timing and formation of the strategy that switched C2 focus to scale up. C2 founder explained that by mentioning; *"It is a slow-moving market, but we start to see now that things are happening. Cities want to have the censors out the ground and are looking more into imaging pictures. They are looking more towards the future now. But in the end, it is a strategy decision from our side… ...you can argue that we should have started a bit earlier. It is dangerous to wait too long. So, it is a combination of timing and the formation of the strategy."*. In other words, C2 founder stressed that although it is slow moving-market for traffic controlling, things start to happen, so it would be dangerous to wait too long before taking the decision to scale up. In that regard, internationalization is part of scaling up strategy for C2 in which its co-founder is trying to find new partners to access new markets inside the EU. Lastly, although C2 product has applications in more than one market segment, C2 founder excluded the option to enter such new segments while discussing about strategy. For instance, C2 founder explained why his company has deliberately stayed out of the video surveillance market. The given reason was because of its complicated technical requirements and high risk related to defects in its product's systems.

4.2.3.3 Electrification

Both E1 and E2 founders have provided a vision for their respective companies, albeit different from each other. While the founder of E1 mentioned a vision of being one of the main electric motorcycle manufacturers that are safe and affordable in Sweden with a pre-determined share in the European market. The vision of the founder in E2 is more holistic and sustainability-oriented; by combining environment and economic dimensions of sustainability in such vision. In fact, E2 founder mentioned that his company's vision is to enable society to live in harmony with nature; by having environment friendly e-boats, a supporting infrastructure and legal regulations that would enable replacement of those running on fossil fuel. That can be better elaborated by E2 statement; *"We want to be involved in developing the entire electricity network… we want to see a change in the regulatory framework, which is why we cooperate with the organizations…"*. Despite the different visions, both enterprises are having similar strategies to achieve such visions, more product development and scaling up in the same market segment by attracting more customers.

Until recently, the strategy of E1 has been to get pre-orders of its product, not just in Sweden but from other overseas/international markets. According to its founder, this would serve two purposes. First, confirming the existence of a market, and secondly, attracting new investors to secure necessary funding for manufacturing the vehicles (i.e. for scaling up by traditional growth). That can be elaborated by E1 co-founder as follows; *"We just try to build the bikes. And sell them one-by-one, right now …. but we need to look down more investors in the company to actually do a proper strategy and execute the plan. So right now, it is just selling bikes as fast as possible. And then get investors…"*. Another

important element of E1 strategy is to build an in-house technical platform for developing the motorcycles' system, which can be sold later to other manufacturers. Interestingly, E1 co-founder has mentioned that he approached Vinnova for one of its innovation projects for sustainable vehicles, but he has not got a grant yet. The strategy for E2 is similar; it is to gain customers and rise capital. Compared with E1, E2 is in an earlier phase of a similar strategy.

4.2.3.4 Shared Mobility

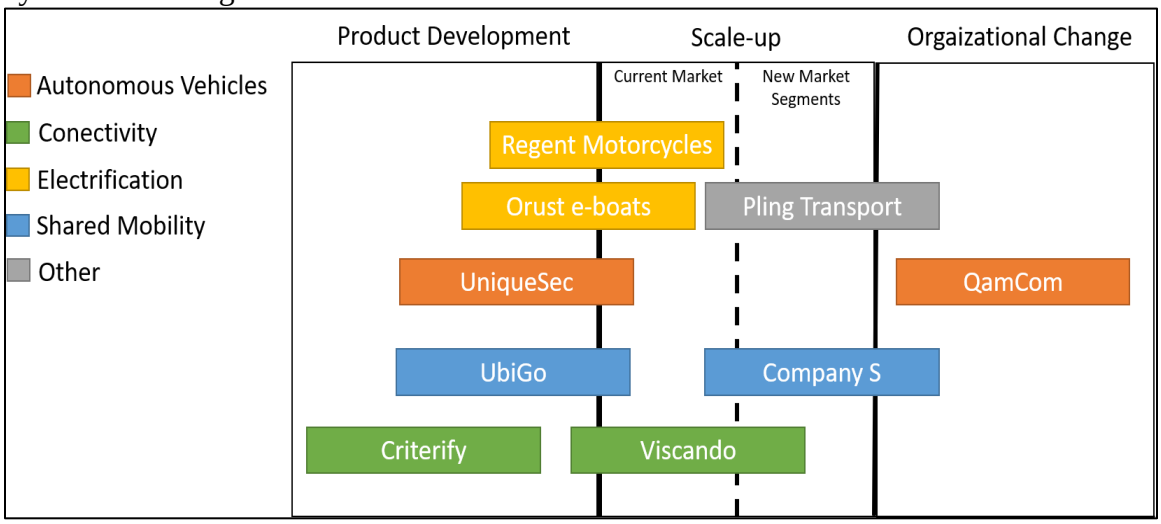
Both companies are very similar in the regard to their strategies. Both respondents expressed multiple goals that they want to work on simultaneously; scaling up and continuing their product development. However, the approach for scaling up is different. S2 founder and CEO expressed a strong vision for his company to succeed by first establishing a strong network of local partners that are essential to operate and share knowledge, contacts ...etc. Such network is also essential for product development before being able to scale up and attract new customers. Moreover, the respondent from S2 explained a type of franchising concept for different markets to enter, as well as hiring new members to the management team as S1 approach to execute its strategy.

While S1 is quite in an advanced stage to scale up as it aims to attract new customers outside Sweden to its existing platform, for this it needs to adapt the platform to the new market. The former respondent also mentioned that such scale up would be funded by venture capital investors and such investment would be directed to upgrade the capabilities of its development team, due to the nature of S1 service-based business offering. It is interesting to mention that S1 team sees the increasing digitalization trend could be a significant factor to improve and extend their product offering further in the future. That was mentioned by S1 respondent *"We are looking at a lot of trends. When trucks are self-driving and digitalized, we are going to adapt to those trends. We want to be in the front of building the very best for our niched segment, a TMS-system for the smaller shippers…"*.

4.2.3.5 Other

The respondent from O1 described a sustainability-oriented vision for her respective company; reducing CO_2 emission by replacing combustion transportation delivery vehicles with its last-mile service. To do this, O1 has developed a well-defined strategy plan, as highlighted by its respondent. Such strategy focuses on scaling up by expansion into existing and new cities, in which branding is a key element, as stated by the following; *"In Gothenburg, we will be stronger stakeholder, having a stronger brand and being more well-known. And people will choose us because they know what we are standing for more clearly…"*. The O1 respondent also states that focusing on an engaged team is a very important factor to achieve the enterprise strategy. Lastly, the respondent indicates that her company tries to create new sources of income through new offerings, which can be considered as another form of product development.

Figure 13: An illustrative figure of the three main strategy options for interviewed SMEs by their technological classifications



Lastly, we were able to summarize the main strategy options for the interviewed enterprises, as shown in figure no. 13 above. In general, there are three strategy options, product development, scaling up by traditional growth, and organizational change. Moreover, we were able to separate between two different scaling up strategies, as either in the same market application (even though in a new geographical location) or entering a new market segment(s) by having different market application(s) of the developed technology. It is crucial to note that we were also able to sort strategy options in relation to different types of innovation activities by SMEs (i.e. product, process or organizational innovation) as suggested by Klewitz and Hansen (2014). As shown from figure no. 13, product development comes in the early stages of SMEs as the latter must validate product with target customers, and that is more linked to product innovation. Then, as an enterprise scales up, mainly by traditional growth, either in the same market segment or other new markets, more process innovation is needed. That was confirmed by C2 cofounder as he mentioned that his company is in the beginning of entering a new market segment; *"Right now, I believe we spend much more on the product, but as we scale-up we will need more process development as well…"*. Such finding was confirmed from S1 respondent as well. The last stage is when the SME is mature enough as it would consider organizational restructuring to increase efficiency and introduce other potential sources of value creation such as new revenue sources. In this case, organizational innovation would take place, and A2 is considered a perfect example of the former strategy option. Lastly, it is shown from figure no. 13 that most SMEs are in the scale up stage. Some other SMEs are combining different types of innovation strategies as they come across different strategic options, mainly between product and process innovation.

4.2.4 Main challenges facing the company

In this last section, we are presenting the main challenges that each interviewee has highlighted for his/her respective company. In order to keep the narrative flow of interview, we have linked the last section with this section by asking for the key bottlenecks that

hinder interviewee's company from achieving its strategy, as presented in appendix C.2. Furthermore, customized follow up questions have been asked to each interviewee to provide more explanation/details for the nature of challenges brought up be him/her. To end this section, an interviewee was asked if s/he thinks that regional public authorities, represented in VGR administration, would be a significant stakeholder for the enterprise to help it overcome/solve such bottlenecks. The latter question was a direct inquiry by us to understand how respective enterprise considers the role of VGR in supporting the process of accelerating/scaling up its technological novelty.

4.2.4.1 Autonomous Vehicles

The main challenge for A1 is raising capital for R&D expenditures; that is what hinders it from employing more developers to speed up product development. Although A2 founder shares the same concern for recruiting employees, the reason for this challenge is different from that of A1. According to A2 founder, the market demand of his company's offerings is not the challenge, but rather in order to meet that demand, A2 needs to find new skilled people. The respondent explains that skilled people are available out there, but they are usually reluctant to move.

Furthermore, A1 founder considers collaboration with big corporations in the automotive industry a major bottleneck that his company faces, despite the fact of being engaged with technology platforms; *"Big enterprises are waiting for mature, big, famous brands which is totally against the concept of SME. So, an SME is a company which is not by definition mature … even they have concrete need, they do not know how to collaborate with a money wise..."*. A2 CEO shares the same challenge; despite reasoning it differently than A1 founder; *"And that is a big challenge within the big organizations, finding stable models of contributing value…"*.

Regarding role of VGR, A1 founder mentioned that VGR can have a significant role to overcome funding shortage, especially for R&D expenditures, by changing/simplifying terms and conditions for SMEs to acquire such funds. It can be elaborated by the following statement of A1 founder; *"So VGR can help us with supporting with R&D money … because they are saying you need to bring the same amount of money as capital for yourself. So, this is against of the concept of R&D…"*. According to A1 respondent, many innovation funds by other public authorities are channeled either to established corporations that already have enough funds for R&D, or to university research that does not have concrete results in terms of number of new patents released. On the other side, A2 founder expressed his doubts if regional authorities can influence current system bottlenecks using traditional methods. However, the respondent proposes a pivotal role to be played by VGR in which the latter can organize collaboration activities using other methods, such as crowdsourcing platforms, based on real well-defined needs and problems from different parts of the region. He further explained that SMEs would actively engage in such platforms among other stakeholders and thrive for finding innovative solutions to the regions persistent problems; *"One way it could do, is to find interesting problems that are relevant to the region. I mean in the region you have a lot of different actives going on.*

They could list them up and the challenges they see and invite people and companies to try to solve that…. they should put the bar really high because in those, in the solutions to those problems, you might have global challenges. And if you address them locally, and with the companies that are in the region, everyone knows that they are going to work on real problems…".

4.2.4.2 Connectivity

The main challenge both responders in C1 and C2 expressed is funding, it is the main hinder C1 faces to roll out its product. C2 co-founder expresses such challenge from a business model perspective; as it is not sustainable for C2 to generate a stable flow of income, since it is selling units based on few projects. However, C1 and C2 contradict regarding their need to recruit skilled employees. Despite that C2 co-founder raised the issue of finding the right skills to recruit within the company as a challenge, C1 is not in a phase where they can or need to recruit more people. The C1 respondent also highlighted the challenge of collaboration between SMEs and large corporations, that current technology platforms fail to solve, by the following statement; *"When it comes to larger companies …. we need to have other ways to be compliance to their business…. But because we are talking to enterprises, it requires deeper knowledge. And we think that Innovatum is lacking that kind of knowledge…".*

For VGR role, C1 co-founder has stressed on the significance of short-term funding gained from VGR, in the early phase of product development, based on a recommendation from Innovatum Science Park. Interestingly, the respondent indicated that his company accessed VGR money on relatively easy terms as S1 did not have concrete partnerships yet, that would have work as an informal guarantee to such money. However, the C1 respondent does not know what other kind of services that VGR provides. C2 cofounder shares the same view regarding the significance of VGR funding and mentoring programs in the early phase of its product development. Moreover, the latter respondent suggests that VGR can also help SMEs in networking with the right connections inside their target organizations such as municipalities; C2 main customers, as well as with universities to increase their visibility.

4.2.4.3 Electrification

Respondents in both companies stressed on their priority to reach their markets. The founder of E1 mentioned that liquidity is the main issue, his company would like to employ more people, but it does not have enough capital. In addition, respondent of E1 has expressed "delivery on time" as one of critical bottlenecks that his company has; as it can take more time to co-develop the product with suppliers Thich would create a major disadvantage to E1 product; as elaborated in following quotation *"It would have been great if we had our own workshop as well, but it is a matter of price, we cannot afford it right now, so deliverability is a bottleneck right now…".* Furthermore, E1 founder mentioned that it takes more effort to apply for public funding than to gaining the same amount of money though conducting part-time consultancy tasks. Indeed, E1 founder was clear about the time-consuming process he had gone through to apply for funding through VGR and

Almi by mentioning *"The problem is that when you go to VGR or Vinnova or Almi, you get this sheet with questions they want you to fill in. And we fill in the form and send it in, and then they are like 'hey you need to redo it' they do not give proper feedback. They do not say, change this or add that. They are like 'do it again'. And we do it again and sending it in and then we get the same response and we have to do it again. This goes on five times."* The founder of E2 also express his flexibility for accepting external funding into his company as he is "open for funding opportunities".

On another note, E2 founder argued that current regulatory framework is hindering the diffusion of his company's product and its supporting infrastructure by mentioning that; *"These solutions are surprisingly prohibited by law. Easier and better combustion was forbidden. This made fuel consumption better…"*, despite that was not highlighted, by E1 respondent, as a chronic problem in the meanwhile. In fact, the latter respondent has indicated that his company's product is designed to avoid any infrastructure unsuitability for charging the electric motorcycles. None of the responders expressed any major challenges with finding the right skills on the job market and/or recruiting the right skills to their companies.

Regarding role of VGR, E1 founder mentioned that public authorities can simplify procedures to apply and acquire their funds, by having a kind of guidance for SMEs, to save time and effort while applying to such funding. In addition, the last respondent agreed with C2 co-founder that regional authorities can play the role of networking by linking his company with available collaboration arenas in the region. Lastly, E2 CEO did not provide any thoughts regarding specific role to be played by regional authorities.

4.2.4.4 Shared Mobility

In the interviews, it was revealed that platform owners are very dependent on the suppliers, so failed collaboration with current and/or new suppliers constitutes a major challenge for both enterprises. The respondent in S1 says *"Our suppliers are very important. But if one carrier does not want to work with us that is fine because we are not that dependent on a few…".* On another note, S2 founder revealed that he has been struggling in establishing his platform as it was extremely difficult to collaborate with stakeholders in Gothenburg mobility ecosystem, mainly with the public transport monopoly company, Västtrafik. The S2 founder explained; *"Because it is a problem when you want to develop new things and you are depending on public monopoly and they really do not want to participate, being slow or hindering and so on…"*. Indeed, S2 founder is skeptical if collaborative projects can properly work and have real results under the current regulations that make such goal impossible.

Furthermore, the challenge after that is to have a sustainable business model, the founders of S2 summarized it like *"there are only four kinds of challenges running a service like we are doing; finding customers, finding suppliers, making money and get funding".* The respondent in S1 stated that it is hard to recruit the right skills in Gothenburg, and the main bottleneck for expansion is funding. According to both respondents, to accelerate the scale up process, his company needs more funding.

Regarding role of VGR, respondent from S1 stated that his respective company did not approach regional authorities before, but it can do so in the next phase of internationalization to acquire more funding for expansion. In fact, the respondent had a perception that VGR's available funding is just granted to high-tech SMEs. On the other side, S2 founder held regional authorities accountable to ensure that collaborative projects, in which other public companies participate and have monopoly power, are open for real change, in order to make them attractive for SMEs to participate, test and develop. That can be summarized by S2 founder statement; *"If you are not open for real collaboration or operational collaboration as a public sector as VGR and Västtrafik, then you can run as many innovation projects as you want, but nothing will fly here because nothing can do it for real…"*.

4.2.4.5 Other

The respondent in O1 expressed a need to optimize the company's own capabilities through increasing productivity and being more efficient. That is the ultimate way to be more profitable. According to O1 respondent, until now, finding new employees has not been a problem. The main challenge is the short-term scalability, since the company's capacity is limited to the number of available vehicles and personnel. Therefore, it would be a challenge to undertake a major project for a customer if requested. Interestingly, O1 does not see any challenges from the existing city infrastructure/regulations that could potentially hinders the company's operations; as its respondent mentioned; *"I believe it is not likely that rules or regulation that will prohibit the transportation of goods on the bicycle lanes. I rather believe the opposite that the restriction will be higher on the streets. Thus, making the roads more accessible and the infrastructure will become better…"*.

Regarding role of VGR, O1 respondent was sure that regional authorities are promoting sustainable transportation including biking; however, her enterprise is not active for any collaboration with VGR in the meanwhile. In fact, the latter respondent has suggested a pivotal role of VGR to devote/facilitate creating collaboration spaces for its, as well as other last mile delivery companies', operations alongside big corporations and municipalities in the region.

Lastly, we were able to summarize the main challenges that interviewees have highlighted for their respective enterprises in the following table no. 8. It is worth-mentioning that most of the discussed issues in this section are considered as challenging aspects of business model innovation. In other words, SMEs are facing critical bottlenecks with business models they operate on while they scale up their technology applications. As shown from the table below, most companies (i.e. 7 out of 9) have highlighted "capital" issues as the most persistent and relevant for their product development and growth, which goes in line with what Tödtling and Kaufmann (2001) argued regarding lack of financial resources available for SMEs. Nevertheless, findings revealed a debate among interviewed SMEs for the availability of human resources as a major bottleneck to operate or grow. As shown in table no. 8, recruiting competent skills was a critical issue for three enterprises (i.e. A2, C2 and S1), while C1, E1, E2 and O1 did not agree on such views; as their respondents

expressed available access to required skills. Another important challenging aspect of business model innovation is supplying to bigger customers in automotive industry and public authorities, where enterprises in AV and electrification technological trends find it challenging. On the other side, the two enterprises in shared mobility trend are finding it quite challenging to establish stable relationships with their supplier collaborators, due to the nature of their platform-based solutions. At the end, two companies have shown the urgent need to optimize their operations, as a major challenge, for the sake of increasing profitability by finding new revenue sources; A2 and O1.

Table 8: Challenging aspects of business model innovation for interviewed SMEs

Challenge	SMEs
Funding	A1, C1, C2, E1, E2, S1, S2
Recruiting required skills	A2, C2 S1
Supplying to big customers	A1, A2, C1, C2
Collaboration with suppliers	S1, S2
Profitability	A2, O1

5. Discussion

In this section, we approach a comprehensive answer of this study's research question(s) by presenting the main themes that would describe the *current* and *perceived* roles of SMEs located in Västra Götaland County, under the realm of latter's mobility system. That is based on main findings presented in the last section and in a direct link to investigated theoretical and empirical literature as well as interviewees perspectives. In fact, thematic presentation of current SMEs role is mainly describing what they are doing in the meanwhile under the current system's preoccupations (i.e. rules, structure, stakeholders, networks ..etc.) within the process of scaling up their niche innovations. However, suggested themes of perceived SMEs role would explain expected role to be more adopted by such niche players based on their potential. SMEs' perceived role has been assumed based on the broader impact that they would create, if they embrace a sustainability-oriented vision of innovation. *Therefore, it is important to mention that perceived SMEs role is not demonstrated as a replacement of their current role, but rather an addition to it; a role that is unleashed when SMEs bottlenecks are solved.* That would lead, at the end, to acceleration of process of "scaling up niche innovations" by further developing SMEs novel technologies, and introducing their innovative business solutions towards a sustainable transformation of western Sweden mobility system.

5.1 Current role of innovation-driven SMEs

5.1.1 The creation and maintenance of specialized niches

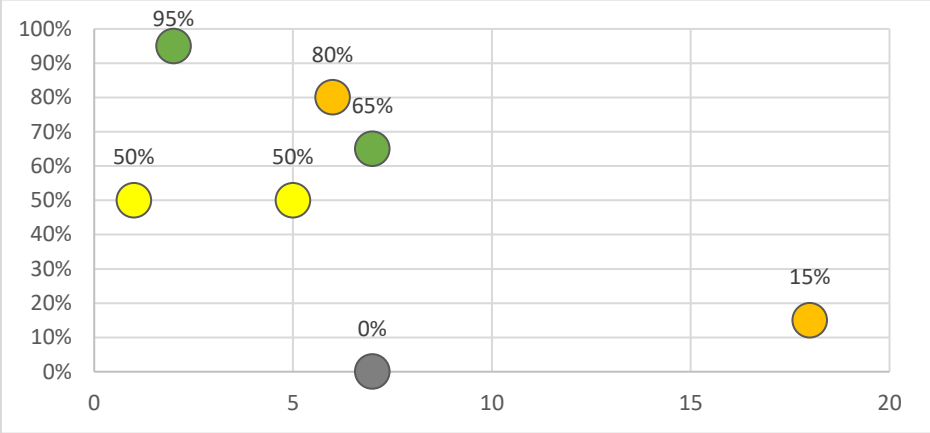
This role aligns with what Smallbone, North et al. (2003) assumes for technology-driven SMEs that are working on the frontier of latest technologies. Nevertheless, all interviewed SMEs are mainly developing new business offerings that do not only have a high-tech component in its core (i.e. for the first 4 technological trends) but also a service-based innovation (i.e. the fifth technology classification). In other words, the fifth classification of technological trends exhibits a new type of niches that can be created and maintained by providing a sustainable solution for a societal persistent need/problem as the core of SME's value proposition. Such a new value proposition does not only consider economic aspect but also environmental and societal aspects that can be delivered on a service-based offering/packaging. All interviewed SMEs expressed process of development by continuously **experimenting and testing** their offerings in a close contact/engagement with their respective customers. Moreover, such role goes in accordance with the creation and development phases of SNM, and it fulfills the first aim of niches proposed by the respective theory (i.e. learning about desirability of the new technology). It was also revealed, from findings, that SMEs, as a pivotal actor in the niche level of system innovation, are strongly linked to the first two steps of SNM and formation; the choice of technology and selection of an experiment, by creating the appropriate settings for developing and testing the new technology. Within these two steps more distinctive features of SMEs are observed as follows;

An engine for job creation inside the region with a shift towards service-based value creation: Primary data findings for the whole SMEs population have confirmed secondary data that we have accessed from VGR action plan regarding current role of SMEs as a

major source of equalizer for the intra-sectors transformation by shifting a significant portion of private sector employment from manufacturing industry to service sectors. That has been confirmed by the industry expert Per Österström while he explained the population set that BRG experts have created for companies working within western Sweden's mobility sector, as he further explained; *"When we looked into how value has changed over time in this sample … you can see that added value has increased and number of employees has increased, number of working places has increased over time. …. we can see that number of employees has decreased in bigger companies …. The growth has happened in the companies that have been created after 2008. So, the smaller companies that come into the picture, they are the job creators, you can see that also on the added value, major parts of the added value, actually 40% of the presorted value comes into new companies that were created after 2008. So, it is important to put focus on the new companies; if they are developed well, they are the ones that create the new jobs and adding value in the region…"*. In fact, we have seen that most SMEs in this study population have been established since 2008, which represent 82% of whole population, with more companies established in recent years. That finding aligns also with what Smallbone, North et al. (2003) mentioned regarding the increasing importance of SMEs role inside EU regional innovation system, specifically as major source of job creation because of the structural shift between manufacturing and service sectors. In that regard, it is important to highlight that the service component of SME's value creation is not exclusive to specific technological trends over others; it is a common feature among most technological trends. For instance, A2 founder explained that development of his enterprise's high-tech technology is not only product oriented, as consultancy service is an essential component of A2 offering; *"It is not only product, because since this technology is a very high-end technology. It is not just selling a mouse and then they can manage it by themselves. It is a lot of consultancy, and a lot of services upgrade to this product shall be made continuously"*.

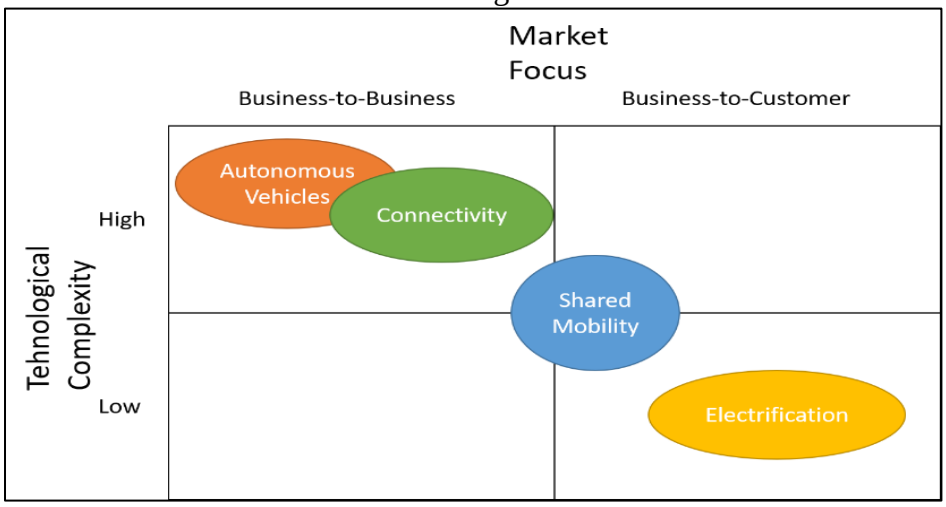
Inhouse R&D is a core, albeit not the only, element of SMEs product development: Most enterprises expressed that they are heavily conducting R&D to develop their novel technologies. That trend was particularly observed for enterprises in the first two technological trends (i.e. AV and connectivity). The two enterprises under electrification classification exhibit lower percentage of R&D expenditures (i.e. 50% each) despite both are newly established. Nevertheless, companies within shared mobility could not decide on a separate figure for their R&D expenditures as they consider such development cost integral to their operational costs for "platform infrastructure maintenance". Therefore, it can be argued that inhouse R&D is not the only form of product development for two reasons. First, some enterprises mentioned that product development is conducted in the form of collaborative development projects either with suppliers, customers or other stakeholders with mutual interest, which would transfer a significant part of such process to collaborators. Second, for some other enterprises, product development is expressed as part of maintenance cost to enhance platform infrastructure and its developers' competences (for enterprises in shared mobility) or as development of new service-based packaging of company's offering (for the enterprise in the "other" technological trend).

Figure 14: Depiction of an enterprise R&D spending as a share of its total spending in relation to its respective age



Moreover, such finding is further enhanced by observing correlation between an enterprise age and its respective R&D spending as a share of total spending. The above figure no. 14 depicts the relationship between R&D spending and company age using color codes for each technological classification (except for shared mobility). Indeed, figure no. 14 suggests an inverse correlation between the two measured variables, which can suggest a pattern for R&D spending overtime for the investigated SMEs. In that regard, it is important to highlight that this pattern only represents the SMEs sample with no conclusion/generalization to be made for the whole population, as previously mentioned in the methodology section. Otherwise, further research has to be implemented to support such argumentation on a wider scale. On another note, it is worth mentioning that A2 has a higher R&D spending (in absolute monetary terms) but its founder only accounts it roughly 15% of total R&D spending, 18 years after A2 was founded. This pattern indicates that while SMEs, that develop intensive digital/IT technologies, have an R&D spending that accounts for the majority of total spending early in their lifecycle, such pattern tends to diminish as these enterprises grow. Accordingly, product development takes other forms than its classical inhouse R&D form.

Figure 15: Relationship between level of technological complexity and market focus for SMEs niche solutions within the four technological trends



Different technological trends have different niche market focus; That can be reasoned by variations between technological trends with respect to complexity of developed niche solutions. In fact, level of technological complexity is partially measured by level of R&D that SMEs undertake in each respective technological trend. Findings show a correlation between the level of technological complexity and the range of possible solutions that respective SMEs can provide; hence, the needs that such solutions can fulfill to different market segments. The above figure no. 15 depicts the four technological trends in relation to level of their technological complexity (either high or low) and market focus (i.e. business-to-business "B2B" or business-to-consumer "B2C"). Again, it is crucial to highlight that figure no. 15 only reflects the investigated SMEs sample that in turn suggests the positioning of each technological trend in the respective figure. Interestingly, both enterprises under electrification trend, that have relatively lower levels of R&D expenditures in comparison to AV and connectivity trends, focus mainly on mass end-users' market. Indeed, founder of E1 stated that *"anyone can build an electric bike"*, which emphasizes low R&D barrier to enter such market. While AV and connectivity, that have relatively higher R&D expenditures compared to other technological trends, are providing their solutions as B2B mainly to incumbent regime players, as will be elaborated later. SMEs within shared mobility are somewhere in between the last three trends. That can be partially explained by their business model that tend to be platform-based. Because of the nature of such business model, it would allow for a dual market focus; one as B2B and another as B2C. Moreover, difficulty to estimate R&D spending for shared mobility SMEs, since it is integrated into the overall maintenance costs of platform as incremental improvement are added over time, suggests a lower level of technological complexity for SMEs in such trend than what their counterparts in AV and connectivity have.

Furthermore, market focus of respective SMEs has a direct influence on their product development in terms of evaluating desirability of developed solution with target customers. For instance, SMEs that are more into B2B have reported significant difficulties

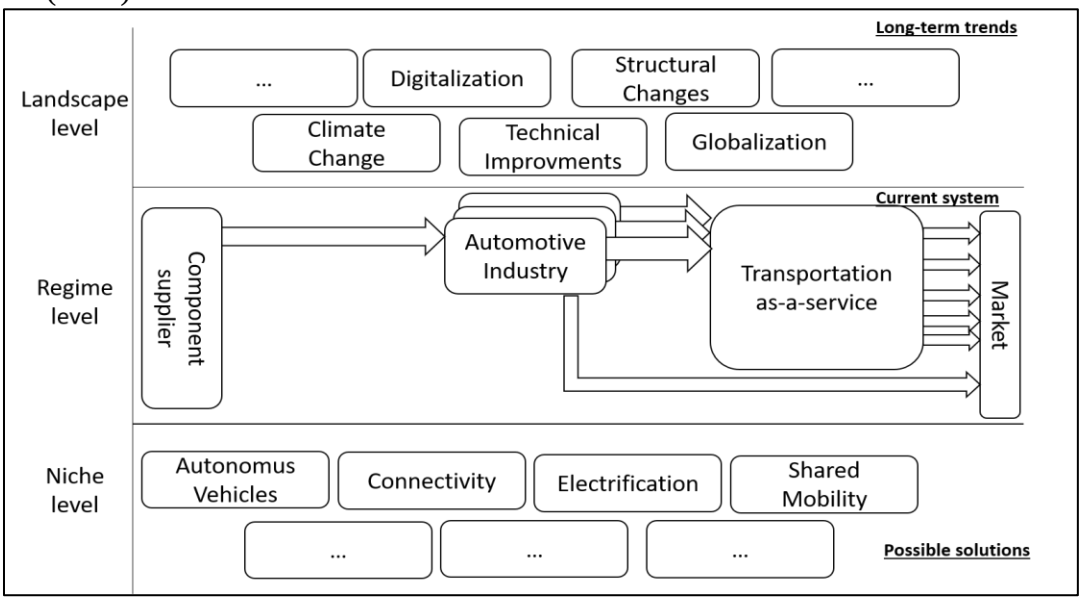
for testing their developed technologies with respective customers. In fact, they expressed no clear channel while testing prototypes with target customers and many SMEs expressed hard times they spent with client representatives to explain the product's benefits/advantages, and if they manage to do so, they risk of talking to the wrong contact that does not have the authority inside client organization to collaborate with respective SME. Moreover, some interviewed entrepreneurs expressed that they need to balance between what they want to, and can, disclose about developed technology in order to limit risk of imitation. On the other side, SMEs with B2C business models demonstrated more success when it comes to investigating desirability of developed solutions with end-users/consumers. Indeed, they use more established channels to reach their target groups such as exhibitions, social media and online advertising.

More reliance on product innovation than other forms of innovation practices: That pattern is revealed in three interview sections that capture interviewees' perspective regarding SMEs role, collaborations, strategy. In fact, high relevance of product innovation warrants the high R&D expenditure (as a share of total expenditures) within most of studied SMEs, particularly for newly established ones. On another side, other types of innovation are expressed as among strategy for most SMEs in upcoming phase, or as a current practice, for few SMEs, that needs to be further enhanced. Such finding validates this study's assumption, as presented in appendix C.1, regarding product innovation as a core focus of interviewed SMEs. Interestingly, other forms of innovation are expressed as crucial for scaling up, and they are presented in a direct link to the SMEs set of challenges.

Growth is the main strategy for most SMEs in scaling up their niche innovations: An interesting finding for most SMEs is their aim for traditional business growth (i.e. having a positive rate of change in annual SME turnover, a higher market share or more capital investment) in order to accelerate rate of application/penetration of their novel solutions, as shown in figure no. 13 for SMEs strategy options. Moreover, such scale-up strategy of growth has been expressed either by expanding in the same market segment or by entering a new market application of niche technology. Such findings consent with argumentation of Hockerts and Wüstenhagen (2010) that growth is the most favorable option for SMEs (i.e. emerging Davids) to penetrate mass markets. Indeed, findings show that investigated SMEs are following a more offensive strategy in terms of their tendency to enter and compete in mass markets. Therefore, a disruptive effect is expected from such niche technologies when they enter regime level; hence, realization of regime transformation. However, such disruptive effect of niche technologies does not aim for replacing existing regime incumbents as will be further elaborated in the next section.

5.1.2 Forming symbiotic relationship with current regime actors/stakeholders

Figure 16: Mobility system of Västra Götaland County using system levels of Geels and Schot (2007)



Secondly, a crucial current role played by innovation-driven SMEs is establishing complementary/symbiotic relationship with regime actors/stakeholders under the current structure of mobility system within Västra Götaland County. The latter is presented above in figure no. 16 by borrowing "system innovation" depiction of Geels and Schot (2007) and by inserting different elements we have identified in each system level. As presented in figure no. 16, on the niche level, we have incorporated the four technological trends in addition to other possible innovative solutions that we classified in methodology section as "other". Moreover, five landscape global trends, in which four were suggested by VGR, are assumed to affect development path of regime and niche levels. In that regard, it is important to mention that global/landscape trends are many and they are re-enforcing and affecting each other. Therefore, including all of them is nearly impossible without doing a comprehensive study with a flawless methodology just for identifying and arguing where to draw the line of what a global trend is. Interestingly, we were able to identify four essential pillars of current mobility regime within western Sweden; component suppliers, automotive industry, Transportation-as-a-Service (TaaS) and end market users. Interestingly, we have observed directional pattern among these four pillars and that is highlighted by arrows. In fact, some of these arrows represent a supply chain between regime actors.

Accordingly, we have developed a detailed analysis to better illustrate formation of such symbiotic relationship, based on findings and within the context of system innovation suggested by Geels and Schot (2007). That can be presented as follows;

Digitalization, as a global/landscape trend, creates windows of opportunity for many radical niche innovations to penetrate current regimes: This global trend outstands

other macro trends as a major disrupter for many STS. That finding was confirmed by some interviewed entrepreneurs as well as one industry expert. For instance, A2 founder argued that digitalization has created a significant gap between traditional component suppliers and many industry applications, as shown in figure no. 12, which attracted new small players to step in and fill such gap by forming new relationships and developing new solutions with big incumbents in many industries. In addition, Per Österström from BRG highlighted that digitalization, together with globalization and urbanization megatrends, have provided ample opportunities to smaller businesses and local suppliers to create new value within the global supply chain. He further explained; *"... globalization has created a demand for the suppliers to be more local ... And that will push for totally new value chains and business relationships. At the same time, we have technological breakthroughs ...In this set up, there is new suppliers, new competences required, and you have a total re-organization the company. Different chains around different values... And of course, there is here an opportunity for start-ups and SMEs to take this journey"*. The latter expert also argued that digitalization has enabled the opportunity of finding new patterns and utilizing new technological breakthroughs to introduce innovative solutions to other megatrends that put pressure on unsustainable regimes; *"You have to look into the patterns. Similar when it comes into electrification you have to look into patterns of how to put the charging infrastructure, find out business models. It is not just going to happen if you are looking at it physically. You have to look at it digitalized...."*.

Findings show that all interviewed SMEs have capitalized digitalization to identify and verify a market as a first step and then to develop a business model to fit the current mobility system as a later step. Therefore, based on field observation, it can be determined that connectivity, AV and shared mobility technological trends are strongly influenced by digitalization, while electrification has a close connection to it. In that regard, it is reasonable to consider digitalization as one of the main contributors to the level of complexity in the respective technological trends since digitalization allows exponential possibilities of integration to already existing technologies within the realm of Information technology (IT). For instance, two of investigated technological trends (i.e. AV and connectivity) are strongly linked to IT in terms of expertise and business offering. This can further explain why IT-oriented SMEs (i.e. those that have digital solution in their core offerings) share many similarities such as business-to-business approach, project-based business model, as will be elaborated later, as well as high R&D spending as explained above. Overall, digitalization was found to be one of the most important landscape trends that unlocked many opportunities where startups and SMEs can play a key role. According to interview findings, that is the domain where most identified SMEs in the population have been found, especially for AV, connectivity and shared mobility. Out of 39 SMEs, at least 23 can be considered as strongly linked to digitalization, while the rest are still affected by digitalization in a major way. In addition, by wider spread of digitalization in many industry applications in the near future, new gaps will emerge as incumbents would find it relatively risky and costly to develop new solutions by their own.

On another note, that finding validates theoretical assumption put by Berkhout, Smith et al. (2004) regarding the top-down direction of initiating system innovation and regime transition. Indeed, such landscape factors/trends were successfully linked to niches by stimulating innovations on the latter, then innovative technologies would scale-up and link to opened-up regime on a later stage. This summarizes our observed mechanism of creating "windows of opportunity" as initiated by landscape developments/trends. Moreover, these findings also go in line with the last reference argumentation for the role that IT would play to cause "emergent transformation" in different technological regimes; as small businesses from outside industries can step in and develop unconventional solutions.

SMEs developed technologies are mostly add-on competence-enhancing: Such trend has been observed from most interview findings in which respective SMEs are conducting product development together with their partner suppliers/customers, or within project-based collaborations. A common stakeholder in all previously-mentioned forms of product development are big incumbents that are keen to establish strong relationships with their component suppliers in their value chain. The industry expert, Per Österström, explains that despite the fact that huge innovation is happening at big incumbents, they also tend to open up and collaborate with other small enterprises in times of transition, especially when there is a persistent pressure for more sustainability-oriented solutions. That is better explained in his following three quotations;

"We have the big companies, they are some type of engine in our system. They are creating a lot of opportunities for the smaller companies..."

"...let's make more environmentally friendly solutions, lets push the demands for the power suppliers to be more green, this is exactly what the vehicle industry is doing …"

"So in transition times, some companies says 'we will not be able to solve this ourselves, let's see who can collaborate with us'..."

Moreover, we argue that development of competence-enhancing technologies is a direct consequence of filling-in-gap role, played by SMEs, between component suppliers and various industry applications, as shown in figure no. 12 above. As new players are establishing new forms of partnerships with big incumbents in such industries and are becoming the latter's new "component suppliers". Therefore, new technological co-developed applications can be easily integrated into the incumbent's business models. Accordingly, one suggested way to describe regime level, based on such findings and as presented in figure no.16, is that increasing space between incumbents and component suppliers is the major breeding ground for the new niches when they are introduced into regime level. In this process, startups and SMEs act more as satellites around regime incumbents, navigating through industry, trying to understand the structure and finding unmatched need in the system that they can capitalize on. On the other side, incumbents' main activities are static and predictable, even though they have R&D divisions that conduct a lot of exploratory activities. In fact, variation between SMEs and incumbents in terms of their organizational characteristics make them fit into different exploratory

purposes. While incumbents can sense new market needs of already established customers, SMEs try to discover untapped market opportunities that cannot be captured by regime incumbents.

On another note, such competence-enhancing technologies are applicable in more than one industry application, which constitutes a major benefit for SMEs by opening the door for a broad spectrum of application to their technological innovations. As a result, interviewed SMEs are considered as truly agile companies that can explore a wide range of markets, especially enterprises that develop IT/digital solutions in the two technological trends of AV and connectivity. Such finding has been confirmed by A1, A2, C1 and C2 respondents when they described industry applications for their developed technologies. For instance, A1 founder explained his enterprise solution by the following statement; *"So UniqueSec started to develop industrial radars for different applications like level measurement, speed measurement, distance measurement and so forth. But specifically, for mobility sector what we do is developing automotive radar test system…"*. In addition, C2 co-founder reported that the whole idea, around autonomous vehicles, is very interesting and mentioned two examples of how his respective company could be part of that ecosystem. The former respondent further elaborated; *"We think that the whole connecting vehicle is quite interesting, there is a lot of vehicles that will be talking with each other, and then you will have a lot of things that will not be talking with the cars. For example, pedestrians or bicycles, so we are seeing ourselves as an infrastructure device that can communicate 'here is a pedestrian or a bike'; so that is one collaboration point. Another is to use our device to record how the traffic is moving in a certain scenario, and this can later be used to help an autonomous vehicle to redirect itself during changes."*. More evidence has been provided by the industry expert, Per Österström, while explaining current digital transformation of many industries; *"That is what is happening right now, and you can see it in the transition where different industry segments are meeting each other. It happens now, not everyone have figured out how they can make use of it…"*.

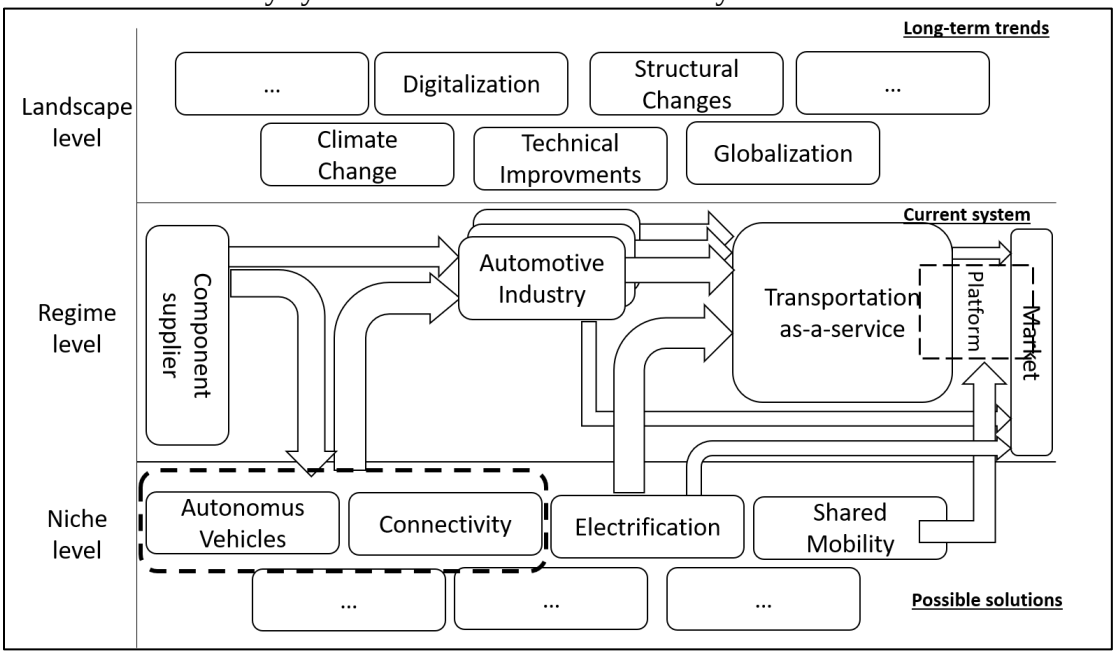
Accordingly, it can be concluded that such findings confirm the co-evolutionary pattern for the process of creating and accumulating technological niches as suggested by Geels (2004). In fact, niche solutions introduced by investigated SMEs are linking to each other and to other regime technologies, by following a "co-development" pattern. In that regard, it is important to asset on the major role that some industry incumbents play as essential niche stakeholders for developing innovative technologies. Moreover, we argue that such niche solutions are complementary to existing incumbents' technologies that face many constraints in their functionality, on one side. They are also forming a kind of symbiosis link to existing technologies that are mainly developed by incumbents, on another side.

Mobility system of Västra Götaland County follows a reconfiguration pathway, suggested by Geels and Schot (2007), in its transition towards sustainability: we have reached this finding based on the above analysis, and by revising the two factors that decide which pathway a STS is adopting in its transition (i.e. timing and nature of multi-level interactions). Regarding timing, we have found that landscape pressures on regime level,

due to digitalization and other macro trends, are taking place when technological niches are in an early process of formation and accumulation; as many of niche stabilization factors suggested by the last reference are not realized yet. In fact, the intensive product development phase, that most SMEs are going through, suggest an early phase within the establishment of a dominant design and creating a significant market share of such niche technologies. For nature of interaction, as mentioned above, we found that most developed niche technologies can be considered as "add-on competence enhancing" that are co-developed, in many cases, in collaboration with suppliers/customers of the current regime. Even though many interviewed entrepreneurs expressed the disruptive nature of their developed technologies by either competing with some prevailing regime technologies or by having positive expectations of transforming current mobility system on the long-term.

That's why we assume that current mobility system of Västra Götaland County is an early phase of a reconfiguration pathway in which niche innovations are forming symbiotic relationships with current regime actors, especially incumbent firms in automotive industry. As the latter aims to solve current persistent problems caused by landscape pressures. As more developments take place on the landscape level and new gaps are created on the regime level, new windows of opportunity are expected to attract more SMEs to fill such gap. Hence, this would stimulate more development of technological niches that would have better resources to stabilize and scale up to regime level. In addition, findings show that current regime actors are actively engaged in the process of learning more about niche technologies as they are "exploring new combinations" by co-developing such technologies with niche players (i.e. SMEs). In that regard, collaboration activities and platforms are essential factor in this reconfiguration process as they have resulted into new types of relationship between many regime and emerging niche actors. Lastly, other findings confirm this particular transition pathway because current system is featured by interaction of more than one technological configuration that have many industry applications, as mentioned before. Another reason is the pivotal role that regime incumbents and big corporations continue to play within transformation of current system, as asserted by most interviewed SMEs entrepreneurs and industry experts.

Figure 17: A dynamic illustration of "reconfiguration pathway" that represents transition for the current mobility system of Västra Götaland County



The above figure no. 17 depicts a dynamic presentation of reconfiguration pathway in which we provide a detailed illustration of how SMEs niche innovations would scale up and link up to created regime gaps/windows of opportunity. Interestingly, we have observed different scaling-up paths for each of the four technological trends. In that regard, we have implicitly assumed that findings for SMEs in each technological trend would suggest a scaling-up path for the respective niche within the current system. As shown from figure no. 17, SMEs within AV and connectivity niches aim to establish themselves in the supply chain of big incumbents in automotive/transportation industry as well as other industries either within or outside mobility system. For instance, some SMEs technological applications in connectivity niche are provided to transportation infrastructure which is mainly under the public sector domain. SMEs under electrification niche aim to supply their own mobility solutions directly to market customers (i.e. mass-market end-users). Nevertheless, we have also observed an interest from TaaS providers to invest into electrified fleet. Accordingly, some SMEs in electrification niche are expected to link with TaaS providers as a crucial step to transform transportation infrastructure towards more electrification. A prominent example is E2, as revealed by its vision to be an essential player in developing electricity transportation network to replace other forms of combustion engines. SMEs within share mobility niche aim to position themselves as intermediary service-based platform(s) between TaaS and automotive industry on one end, and market end-users on the other end. Lastly, the only "other" technological niche identified in this study is following a similar scaling up pattern of SMEs in shared mobility niche.

5.1.3 Undertaking active collaboration with other regime and niche players

A pivotal role that SMEs are currently playing is being an active stakeholder in many collaborations that take place in Västra Götaland County. Such active SMEs engagements are with other players on regime as well as niche levels of mobility system, and they are taking various forms and mechanisms, as demonstrated in the results section of company's collaborations with main stakeholders. These findings consent Tödtling and Kaufmann (2001) argumentation regarding SMEs innovation processes that are characterized by engagement with external stakeholders and exchange of knowledge "within inter-organizational and intra-organizational" interactions. Indeed, as the latter reference expected, most SMEs are heavily engaged with their products' co-developers mainly customers and/or suppliers. Interestingly, findings of SMEs collaborations show that they are actively engaged with knowledge providers such as university and research centers, more than expected by Tödtling and Kaufmann (2001). Nevertheless, that finding confirms one of this study's assumptions regarding SMEs tendency to collaborate with science and technology centers (i.e. knowledge providers) due to their high-tech/IT focus. Another crucial finding that SMEs are undertaking new forms of collaboration activities with non-research institutions, mainly with suppliers, that aim to create and transfer scientific knowledge. Such collaboration activities are mainly R&D co-development projects that have either mutual or multi-stakeholder form, specifically for the first four investigated technological trends.

Moreover, collaboration activities are not undertaken for the lone sake of linking up SMEs with bigger niche and regime stakeholders. In fact, findings show that active collaborations are also taking place between small niche players and each other. For instance, A2 founder illustrates that his enterprise is co-developing projects with some small companies that can be located into other industries/sectors for which applied technologies (i.e. autonomous systems) have potential disruptive effect in such industries. The latter founder further explained; *"In some cases, there are niche markets, they might be much smaller than you see there, there could be niches in the telecommunication industry for example. And in those cases, I would say that we are disruptive. …. if we look in another direction, there might be disruptive market direction, using only known technology but applied in a different direction…"*. On another note, we have observed a different pattern of collaboration for the "other" investigated technological trend. Indeed, findings show a "tacit knowledge transfer" for such type of technological trends that are highly dependent on "service-based" low-tech innovations, through informal contact with relevant stakeholders. Other major distinctive features of SMEs collaboration activities are highlighted in the following;

Technology arenas/centers/platforms, newly established in Västra Götaland County, are locus for many collaboration activities taking place in the region; That includes MobilityXLab and CampX inside Lindholmen Science Park and Volvo group respectively. These platforms aim for a new mechanism of linking startups and SMEs with big incumbents in automotive/transportation industry. Significance of such platforms has been highlighted by some interviewed industry experts and SMEs. For instance, the industry

expert "Per Österström" has further explained how such platforms are utilized by both types of enterprises in the following quotation; *"CampX is such an interesting initiative where you can have internal innovation happening together with others outside the normal system….. But I think that the internal system of the big companies they are not adapted to the need of the start-ups and at the same time the start-ups have not always thought through the product or service but to how to scale that on a global market, and maybe maintain that. And that is where MobilityXLab is a good example where you can develop our idea during several months and find a viable solution for a global market…"*. Furthermore, it was revealed that many SMEs are utilizing such collaboration platforms and networks to integrate within the current mobility regime, either to find new customers/suppliers with whom they co-develop their own product offerings, or to form new partnerships with bigger and more influential regime players to identify new business opportunities together (i.e. co-innovate business models) by sharing creation and capture of new value (i.e. E2 is a prominent example). Such findings agree with argumentation of Hockerts and Wüstenhagen (2010) for the interplay between small enterprises "emerging Davids" and old incumbents "greening Goliaths" within different stages of sustainable market transformation. That is because both sides utilize such collaboration platforms to capitalize on each other's strengths by following partnering/complementary strategies while developing and introducing niche innovations into market.

Accordingly, we argue that such collaboration platforms enabled SMEs to undertake a crucial process of SNM suggested by Kemp, Schot et al. (1998); *coupling of expectation* for niche technologies. Indeed, the latter reference argued that niche players are engaged into collaboration activities to substantiate expectations and promises of new technologies with other stakeholders that have different values, beliefs and interests of such niches. Moreover, other few SMEs are actively engaged into another SNM process; *articulation of barriers* to regime transitions, and possibilities to solve them. For instance, a crucial reason for E2 to engage into collaborative projects, as its CEO argues, is to achieve a "wider infrastructural change" that can incorporate E2's product, as well as to "influence current regulations" towards a favorable legal framework of its sustainable solution. That can be better elaborated by the following quotation of E2 CEO; *"Today they do not know if they can trust it, if it works, where to load and where to get the energy and so on. So, we want to show them how to solve those problems…."*.

System bottlenecks presented into incumbents' inertia, hinder collaboration from achieving its potential; One of the major challenges, that investigated SMEs have argued, is major difficulties when it comes to collaborating with system incumbents. The latter includes big corporations in automotive industry, public sector monopoly companies and public regional and local authorities, either as suppliers or customers. Such bottleneck constitutes a major challenge for enterprises within AV, connectivity and shared mobility niches that can seriously affect development and scaling up processes of their niche technologies. Even though previously-mentioned collaboration arenas were established in the first place to overcome challenges that different stakeholders always complain about, these platforms/arenas are still in an early phase of figuring out mechanism/processes of

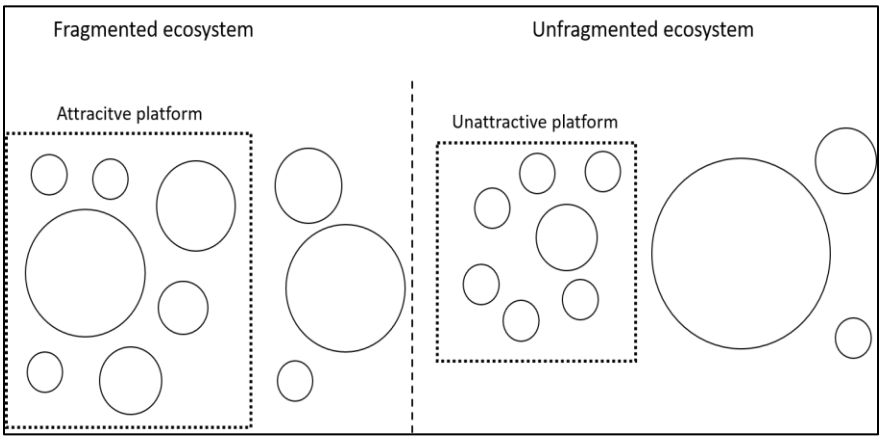
linking different stakeholders together into successful collaborative projects/programs. In other words, MobilityXLab and other similar platforms are still in the process of discovering and developing tools/procedures to make such collaborations come up concrete results. That finding has been confirmed by A1 CEO as he mentioned; *"We and many other companies that have been in MobilityXlab that came out without any concrete result from it. But we are still trying to get through these contacts some deals with the Swedish partners. It is not the MobilityXLab problem, it is the industry problem."*.

In fact, some interviewed entrepreneurs as well as industry experts have thoroughly explained their own views why influential stakeholders in the current mobility regime are not fully agile/open for collaboration with new small niche players. For instance, A2 founder argued that such collaboration platforms are not formulated to have well-defined goals, and big regime stakeholders have their own agendas that can influence the direction of such collaborations. The latter respondent further explained; *"But you also see in the formulation in those that how hard it is to be concrete. It is really hard to be concrete around what it is really benefaction. In those arenas, most companies of relevance are already in there. That does not make it any easier. Because they all have their own agendas. They want to formulate, they want to win as much as possible, and they shape it in a direction that suits them, which is not strange or any problem really. I think eventually something good will come out from those collaborations. You do not really know exactly how and what…"*. The BRG expert, Per Österström shares quite similar views as A2 founder, as he argued that big incumbent face challenging time during transition phases to open up and let other players such as small enterprises develop and supply what big companies cannot do themselves. In such case, it is hard to collaborate with other stakeholders, even though when big incumbents take the decision to do so. That is because they would have a full control of their own destiny; therefore, it would be hard for them to clearly formulate what requirements they need from market, under the binding constraint of cost uncertainties.

Interestingly, both C2 and S2 share the same views regarding collaboration challenges with public stakeholders, as the former has city municipalities as its main customer segment while the later had Västtrafik as the main stakeholder supplier/collaborator on its shared mobility platform. Both have highlighted that public authorities are very slow regarding opening-up for their technological solutions and a lot of time is invested before such stakeholders change attitude towards their engagement with SMEs. For instance, C2 cofounder explained that despite C2 has its established customer network of cities administrations, it has been a long process that C2 founders have come through to explain their technology to perspective customers; *" what we presented to the cities was something quite new; they were not really used to this kind technology and/or all the kind of data you could get from the system, so we had a quiet time to just explain what you can get out from the system and how it works, and the administrations are not that fast either …."*. Nevertheless, both entrepreneurs expressed that pivotal factor of success in such collaborations is to connect with the right personals in public organizations, specifically those personnel that have both the power and attitude to open up, as C2 co-founder

mentioned; *"It is good to get the right connection with the right people, it is like I said before, if you do not talk to the right people, nothing would happen…"*.

Figure 18: Ecosystem structure for SMEs operating within shared mobility technological niche



On another note, we have found that ecosystem structure has a significant impact on an SME's ability to engage into collaborative projects/activities, specifically within shared mobility technological niche. Because of the platform-based business models for SMEs under this respective niche, the size and number of stakeholders inside ecosystem would significantly decide either it is an attractive platform for respective SME to engage into or not. As shown in figure no. 18 above, it can be clearly highlighted the contrasting experiences of two SMEs developing platform-based shared mobility solutions. While S1 was founded in 2017, it is now expanding its services to new markets, while S2, founded in 2014, is still struggling to establish itself into the system. Having a closer look at both ecosystems, S1 system is relatively fragmented with many actors that have different sizes, as illustrated in the left-side of figure no. 18. On the other side of same figure, S2 system is dominated by one big actor that control the major share of public transportation; hence, making it challenging for small enterprises to establish themselves into market. S2 CEO and co-founder further explained that collaboration with Västtrafik, the biggest public transportation monopoly in Västra Götaland County, is a big challenge for any business opportunity or innovation collaboration to succeed. That can be elaborated by S2 founder in following quotation; *"When public companies do a lot of things that they should let to the market instead…that is a hinder not only in the mobility sector, but for innovation itself. Because people do not really, can, or dare to do things because they know that the city might, or the region might, do something similar and then you will lose the money. It is a good thing to support with funding and setting up projects, but you really need to show that you are open to do real collaboration with the commercial sector and help funding the SMEs..."*. Accordingly, we suggest that establishing a platform-based business model in an unfragmented system is more challenging than in a fragmented ecosystem. That would explain why S1 is in an advanced phase of scaling-up its business operations than S2 that is in a very early phase of the same strategy, as shown in figure no. 13 above.

5.2 Perceived role of innovation-driven SMEs

In this section, we further explain what perceived role expected to be played by SMEs, as pivotal niche players, in the process of scaling up niche innovations toward the sustainable transformation of mobility system of Västra Götaland County. We discuss such perceived role within the context of its preoccupations from two perspectives; a broader system transition perspective as well as a more specific niche actor-based perspective.

5.2.1 A system transition (i.e. regime/niche interactions) perspective

Based on findings of previous section, current role, despite being crucial for creating a sustainable transformation, lacks many aspects and suffers from major bottlenecks that hinder the realization of desirable transformation path of the whole regional mobility system. Most importantly, SMEs current role demonstrates limitation of technological niche due to their fragmentation; they do not have enough momentum in terms of networks, investment/needed capital and public support, as expected by Geels (2012). Therefore, there is quite probability that they may fail to scale up and create a salient disruptive effect on current regime structure. In that regard, the current technological developments at niche level are matching what Wells and Nieuwenhuis (2012) argues as "system disintegration around technology fragmentation". That would have a negative consequence in terms of creating different and semi-competing pathways that are driven by different/competing interests of niche and regime players/stakeholders, which would eventually lead to transition failure.

SMEs/Incumbents interactions: Interestingly, Geels (2012) argued that current automobility systems are very stable and persistent to sustainable transitions, as powerful regime players/groups are strong advocates of the prevailing status-quo. Furthermore, Wells and Nieuwenhuis (2012) explained, in their analysis to understand transition failure in automotive industry, that dominant regime players (i.e. incumbent automotive manufacturers) are a major source of regime stability/inertia, which can partially explain incumbents' rigidity to open up and collaborate with small niche players (i.e. SMEs and startups). Nevertheless, the last reference argues that regime incumbents have the potential to create needed momentum to initiate transformation, as many of small niche players are "firmly imprisoned in their niches" and they are strongly tied to actions of their regime incumbents. That's why activities of small niche players in terms of experimentation and testing of radical novelties are necessary, but insufficient, condition for creating a fundamental change in current regime structures. Besides, in order to create a more profound transformation towards sustainable mobility, it is crucial to create new "organizational structures, economic relationships and social or cultural attitudes". That warrants major changes of dominant business models of old automotive incumbent and their small component suppliers at the core of this process. Berggren, Magnusson et al. (2015) agree with such view and further argue that incumbent firms, working as multi-level actors, have a significant role to drive more niche development and accelerate/expand application of niche technologies into mass markets, by adoption of integrating innovation strategies with their small niche counterparts. That is because the latter players are still bounded by many knowledge limitations that hinder them from satisfying mass market

requirements. In fact, the last reference goes in consent with this study finding in terms of the reconfiguration transition pathway of heavy vehicle industry while analyzing innovation strategies of different regime and niche players.

Transition Pathway: on another note, we assume that reconfiguration pathway would continue to prevail in the near future to lead sustainability transition of the region's mobility system. Indeed, it is the most appropriate pathway that would maintain the co-evolutionary pattern of transition between both regime incumbents and emerging small niche players, in which both players would complement each other actions, strategies and roles. However, it is critical to make sure that symbiotic relationship between SMEs and regime incumbents would NOT eventually lead to incremental innovation; hence, keeping "dynamic stability" and "path-dependency" of current regime settings. That motivated the perceived role that regime incumbents have to adopt as we explained in the last paragraph, and expected role that SMEs would play, as detailed in the next section. Lastly, we expect that AV, connectivity and shared mobility niches would continue to utilize the same windows of opportunities as presented in figure no. 17 above, as they would follow the same expected trajectory for breakthrough and scaling up to regime level. Nevertheless, we expect that electrification niche can adopt a different transition pathway than what is suggested for the other technological niches. This can be further explained as follows;

A different transition pathway for electrification niche: In that regard, we expect that electrification niche can follow a more disruptive transition pathway in the near future; "de-alignment and re-alignment" suggested by Geels and Schot (2007). That is mainly because current regime incumbents are gradually de-aligning investments in ICE technologies by increasing their relative share of R&D investments into more radical technologies of electric propulsions, which created more windows of opportunities for electrification niche to penetrate regimes. Most importantly, many niche players, including SMEs and incumbents, are gaining a significant momentum towards creating dominant designs of new green/electric propulsions that can re-align current mobility systems into a new structure that would transform not only final product but also supporting infrastructure. This trend was supported by BRG industry expert "Per Österström" as he explained that Sweden is picking up quickly towards global developments in electrifying different modes of transportation, he also explained how big incumbents are developing electric drivelines that can work as flat platforms for various new mobility solutions. The latter expert further explained; *"But what it is really ending up is new mobility solution because it is a very flat system, you can build whatever you want on top of it. And it is a moving battery. You can use it as an effect balancer for the power grid. So, it is not just ending up as a supply to the vehicles but also as a supply for a piece of the future power grid system…"*. Besides, such pathway goes in line with what we have accessed through secondary data sources (i.e. consultancy firms reports) for the recent advancements in vehicles electrification, represented in different versions of electric propulsions, as many manufacturers are marketing their progress towards achieving the goal of zero-carbon emission vehicles. Another reason that support our argument is interview findings with entrepreneurs in this respective trend; both have clear sustainability-rooted vision for their

respective enterprises. In fact, such vision was a major driver for E2 founder to design E2's business model on a circular economy concept and actively collaborate with different stakeholders for the goal of solving binding system bottlenecks of regulations and infrastructure.

Alternatively, despite many supporting argumentations, this study does not aim to confirm what pathway electrification niche would adopt to transform mobility system, due to many theoretical and empirical findings. In fact, Dijk, Wells et al. (2016) concluded that current momentum of electrification disruptive niche is not sufficient to replace the tradition ICE stable regime. The latter reference argued that despite the increasing application rate of electrification technologies; such technologies are not sufficient to create a dramatic breakthrough for FEVs. It is important to highlight that main difference between both technology options (i.e. ICE and FEV) is the source of energy they use, and the relative scarcity cost of each energy source. If enough electricity supply would be secured to the extent that it would reduce its scarcity cost relative to cost of ICE energy sources, then the prospects of electric engines would be better. Moreover, that would support transformation towards electric propulsion without compromising the electricity demand of other societal functions; hence disrupting ICE. Accordingly, it is more reasonable to think that main obstacle to wider electricity transformation is the system bottleneck of electricity production capacity. Another barrier of electrification niche is current regulatory framework that favor the continuation of ICE established technologies, as highlighted by E2 CEO and Dijk, Wells et al. (2016). In that regard, Wells and Nieuwenhuis (2012) explained that existing automotive incumbents are pressuring for a privileged status, by delaying or banning regulatory change. That is done externally through political lobbying in times of harsh transitions and internally by avoiding costlier and riskier innovation options. Dijk, Wells et al. (2016) also explained that EU policy makers have been targeting sustaining innovation policies for reducing CO_2 emission that could be met by current regime of ICE. Moreover, in today's system, a significant portion of government's public finance is dependent on tax revenues from gasoline and diesel. That creates a conflict-of-interests problem to national governments, as transferring the nation's ICE-based fleet to an electrified one would result into a chronic/unsustainable fiscal deficit. That is combined with the costly subsidy support programs that many governments undertake to encourage diffusion of environment friendly FEVs. In this case, one suggested solution would be the gradual shift of tax system on transportation by simultaneously considering other new revenue sources created by emerging technologies in both mobility and energy systems.

5.2.2 A niche actor-based perspective

It is important to highlight that this study assumes innovation-driven SMEs can significantly contribute into sustainable system transformation by development of SOIs mainly through adoption of innovation based and/or sustainability rooted strategies. Nevertheless, a critical finding, based on SMEs current role, is the absence of sustainability rooted vision as well as strategies, for most investigated enterprises, in their identification of windows of opportunities to link up with created gaps on the regime level. That finding raises many questions/doubts regarding the disruptive nature and/or radical effect of

developed technological niches on current regime settings. Moreover, findings of this study confirm one of the interviewed expert views regarding biasness of many SMEs and incumbent firms towards economic aspect of sustainability. Many SME entrepreneurs and top personal of incumbent firms neither perceive nor fairly value other aspects of sustainability (i.e. ecological and social) which push towards unsustainable business models, collaborations and/or scaling up strategies. This would eventually lead to slowing down or failure of transforming current unsustainable systems. Therefore, we argue that most challenges that interviewed SMEs reported are directly associated with absence of a comprehensive sustainability-based strategy, supposedly as a driver for business model innovation, scaling up and/or collaboration with other niche and regime players. On another note, empirical findings of current SMEs role don't provide enough evidence; hence refute, the claim of system innovation theories that niches are "locus of radical innovation" within the regional context of this study. The reconfiguration pathway of current mobility system and symbiotic relationship that technological niches are forming with regime stakeholders are the main supporters of such argumentation. That is besides the fact of long-term span that a desirable transformation would require, in which niche innovations have to come through binding rules that form the current regime's institutional arrangements.

Accordingly, all the above-mentioned reasoning suggests a perceived role of innovation-driven SMEs that can be explained as; ***the introduction of more SOIs by combining the three aspects of sustainability (economy, society, and environment) in their core value creation and proposition; hence, realization of radical/disruptive effect of niche technologies***. This perceived role would be undertaken by incorporating three interconnected sub-roles, in relation to business model innovation, scaling up strategy and collaboration activities respectively as follows;

5.2.2.1 "A business model co-innovation" role

Co-developing business models with regime incumbents as a core activity of SMEs business model innovation: That role requires SMEs entrepreneurs to have a holistic approach while identifying market needs (i.e. regime's windows of opportunities) by incorporating social and environmental bottlenecks that current regimes are suffering from, hence creating more sustainable vision of their technology solutions. It is important to highlight that co-development of business model would allow the three types of innovation activities (i.e. product, process and organizational) to be executed simultaneously and interchangeably. That is expected to happen through tacit knowledge transfer between regime incumbents and SMEs, that master different innovation activities, within such process. On another note, co-development of business models is an essential requirement of restructuring current transportation regimes by reorganizing business relationships/practices (Wells and Nieuwenhuis 2012), hence a wider change would be expected in other regime arrangements/dimensions such as regulations and social values.

5.2.2.2 "A new scaling-up" role

Combining other forms of scaling up, besides growth, at the core of SMEs strategy towards more diffusion of niche innovation: That role is strongly linked to business model innovation regarding co-creating new forms of value between SMEs and other niche and regime players. Accordingly, we suggest that SMEs need to combine at least two of the four pathways to diffuse sustainable business models and realizing mass market transformation, as suggested by Schaltegger, Hansen et al. (2016). Interestingly, it has been found that share mobility niche can be a pioneer into introducing new forms of technologies' diffusion, other than traditional growth. For instance, S2 founder mentioned that his enterprise is currently introducing a new business model based on a "franchising" concept, while expanding into international markets. In addition, the latter reference mentioned a successful example of a German startup developing a car-sharing platform; it was able to scale up its solution, not only by growth, but also through replication and mimicry of its business model.

5.2.2.3 "An initiator of collaboration activities" role

More engagement into articulation of system/regime shortcomings: We have found that most SMEs are active into a crucial process of SNM; "coupling of expectations" regarding their developed technologies through active collaboration with relevant and influential regime stakeholders. Nevertheless, such SMEs have to embrace a broader vision of collaboration that is not just limited/narrowed to introducing their novel solutions into markets but also to thoroughly include existing as well as potential system barriers that can impede innovations from creating a disruptive wider effect into their ecosystem. Therefore, innovation-driven SMEs have to be more actively involved with other regime and niche stakeholders into well-articulating (i.e. clearly and continuously stating) regime bottlenecks that hinder scaling up innovations aiming to solve current system challenges. Moreover, a crucial part of articulation processes of regime barriers is co-finding and co-developing solutions to such bottlenecks as a main outcome/target of the region's collaboration activities/projects/initiatives.

More engagement into network formation and direction of collaboration platforms' goals: Despite the demonstrated active engagement of SMEs into various collaboration initiatives/platforms in Västra Götaland County, ineffectiveness of such collaborations, as highlighted by many interviewed entrepreneurs, reveals SMEs tendency as more re-active than proactive towards such multi-stakeholder activities. Indeed, none of the interviewed SMEs, except E2, exhibit a proactive approach in influencing current collaboration activities towards their goals. Moreover, none of them have initiated the creation of a network or a collaborative project that has clear goals in relation to their developed solutions, visions or strategies. As network formation is a critical process of SNM; SMEs as a pillar player of system niches have to be more actively engaged in this fundamental process. Moreover, a proactive SMEs role in formation and direction of collaboration activities goals has to be towards achieving the first two above-mentioned roles. That is expected to have a positive impact on niche stabilization and establishment of dominant design of many radical niche technologies through continuous and more cumulative learning/experimenting processes of such technologies.

6. Conclusion

Mobility system of Västra Götaland County is witnessing major transformations in which innovation-driven SMEs are playing a crucial role to direct it towards a more sustainable path. Transformations are driven by many developments that take place on landscape as well as niche levels. At one side, digitalization, combined with other disruptive global trends, are causing many persistent pressures, not exclusively on automotive/transportation incumbents, but also on other stakeholders that have a direct/significant influence on the region's mobility system. On the other side, SMEs, with their agile structure and explorative nature, are creating and maintaining niches of technological solutions. Such innovative niches are not exclusive to high-tech IT solutions, as assumed earlier in this study, but they extend to include new forms of service-based, environmentally- and socially-oriented, solutions. Moreover, SMEs are untapping new market opportunities by utilizing gaps/windows of opportunity within current regime. Scaling up niche innovations to link with regime major stakeholders is a pivotal role that such SMEs are currently, and expected to continue, playing within the process of initiating and accelerating regime transformation toward sustainability. This study found that current role played by such SMEs is in an early phase of creating desired disruptive and transformative impact. Despite the highly disruptive potential of SMEs niche technologies, they are forming symbiotic bonds with regime actors and causing a transition pathway that is characterized by exploring new combinations through interactions among multiple technological configurations. Nevertheless, fundamental changes in the regime structure, as a result of this reconfiguration pathway, suggest new forms of relationship to be created between regime stakeholders and emerging niche players, which SMEs are currently utilizing through active collaboration and further acceleration of their technological applications. Current system bottlenecks, as well as SMEs shortcoming regarding absence of sustainability-rooted business models, have raised major questions in terms of realization of a desired sustainability transformation. That motivated this study's perceived role to be played by SMEs in the upcoming phase of system transition. Most importantly, incorporating environmental and social aspects, along with economic aspect, of value creation is the major driver for the disruptive effect of SMEs niche innovations. That would enhance SMEs capabilities for more adoption and combination of different innovation forms. Moreover, other diffusion mechanisms of niche technologies would stimulate co-development of innovative business models between SMEs and other niche and regime players. Lastly, SMEs are expected to have more decisive role in creation of networks that aim to overcome current regime bottlenecks. That would lead to a better articulation of niche technologies in line with the agreed-upon vision of sustainable mobility system; hence accelerating their rate of application/diffusion.

- **Policy recommendation and suggestions for further research**

Undoubtedly, VGR has a decisive role to play regarding the path that current mobility system in Västra Götaland County can adopt in the near future. That role has to be enhanced by common vision(s), consented by all stakeholders, of which pathway has to be followed to achieve the desired sustainability transition. Moreover, such pathway has to be directly

linked to the region's circumstances; its unique set of problems and opportunities (Wells and Nieuwenhuis 2012). Therefore, we are providing some policy insights for what VGR can exert more effort on the upcoming phase to further enhance SMEs upscaling their niche innovations, and help them overcome challenges they face to undertake their expected/perceived role as suggested in this study. **First,** VGR is expected to continue providing its financial support and training/mentoring/capacity building programs to SMEs as such role has proved to be significantly beneficial to many investigated SMEs to overcome financial and human resources constraints, especially in the early phase of product development. Nevertheless, this support has to be easier to access by SMEs and more directed into funding their risky R&D expenditures. In other words, VGR has to simplify application processes, terms and conditions to its funds, as well as to provide guidance to such funds in order to correct any wrong perception that SMEs would have. **Second,** VGR has to play a pivotal role into influencing collaboration activities between SMEs and their stakeholders. One suggested role, as highlighted by A2 founder, is organizing/supervising a collaboration activity that resembles crowdsourcing platforms in which the regions' well-defined problems and needs are put on table for all relevant stakeholders to sit together and co-develop solutions to such challenges. Another suggestion is to facilitate testing arenas for SMEs that need such spaces to collaborate with big incumbents in certain transportation businesses. This study supports the last two suggestions as they go in line with SMEs perceived role of initiating collaboration activities, particularly in terms of articulation of region's bottlenecks and more influencing goals of collaboration platforms. **Third,** VGR has to utilize current collaboration platforms to market its support programs as well as other available opportunities to SMEs, and to play a network coordinator for attracting and linking SMEs with their stakeholders. In that regard, VGR has to exert more pressure on influential regime incumbents, especially public transportation monopolies, to open up and change their attitude towards more collaboration with SMEs, in order to make such collaborations attractive for the latter to participate and co-develop technological solutions. **Lastly,** VGR has a pivotal role to enable legitimization of radical innovation, which constitutes one of the biggest barriers of regime transformation. In that regard, we assume that such role would be realized when concrete results are obtained from collaboration activities, which would create a persistent need for regulation change. In this process, we assume the inevitability of bridging policies, undertaken by regional and national governments, that aim for broadening as well as deepening niche technologies in their linkage with mass markets, as suggested by Berggren, Magnusson et al. (2015). The latter reference highlighted the importance of such policies into the success of integrative innovation strategies of regime incumbents, which can in turn, help solving collaboration challenges between incumbent firms and emerging niche players.

At the end, this study opens the door for a variety of research directions that fall under the realm of sustainability transformation of Västra Götaland County mobility system. However, we suggest a more delicate investigation of regime/niche interaction, specifically between SMEs and their main regime stakeholders to identify root causes of collaboration bottlenecks that both sides face. Another suggested topic is the understanding different types of SOIs that SMEs go through/adopt during phases of scaling up niche innovations to mobility regimes.

Appendix A: Phase I in the C-Lab

A.1 Background

- **The Challenge Lab**

Challenge Lab is a neutral space at Chalmers University of Technology in Gothenburg. It is intended for master students, with a wide range of different backgrounds, both disciplinary and cultural, to write their master theses by identifying and answering questions that would help into reaching a sustainable future. It is worth mentioning that spatial/geographical focus is on west Sweden. The structure followed in the lab is unique, as it allows students to be in a close collaboration with relevant stakeholders from a wide variety of background; industry, academia, public sector, and civil society.

Figure A. 1: Manifestation of the challenge lab in the context of triple helix innovation system by Holmberg (2015)

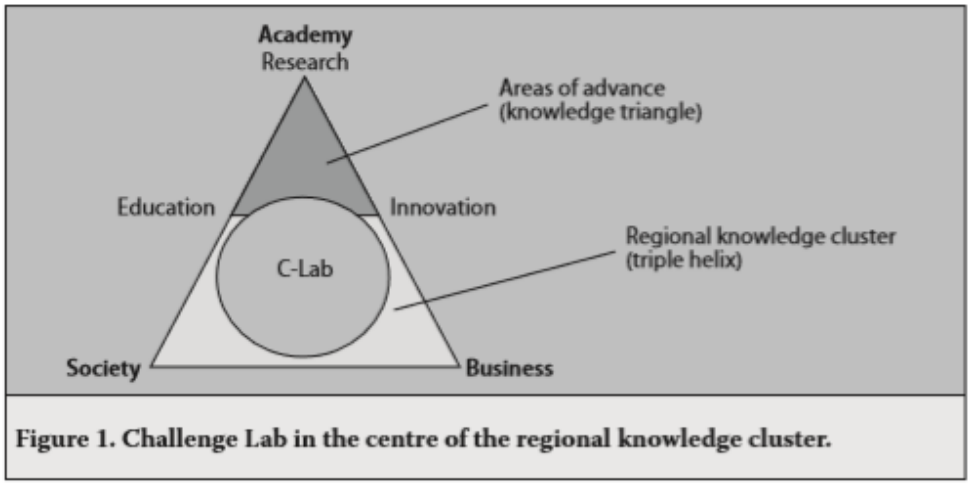
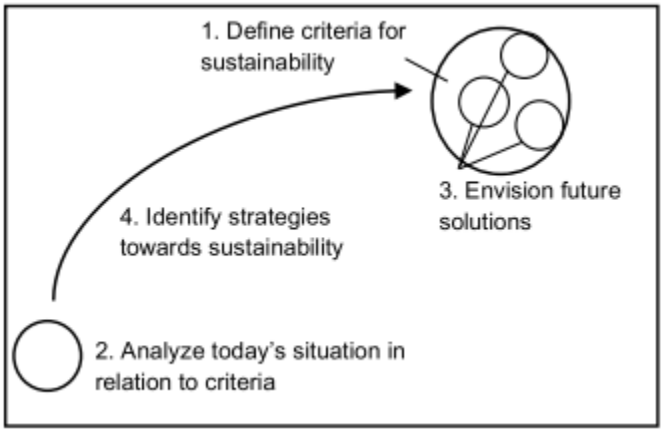


Figure 1. Challenge Lab in the centre of the regional knowledge cluster.

The lab can be interpreted as twofold ideas, where they reinforce and support each other. The first idea is to work as a platform where stakeholders from west Sweden can meet, set together and discuss big issues about sustainability for the region. The second is to provide a learning space in which the students can work on their master thesis, taking upon them the big sustainable challenges in the system and aiding the transformation through an experimented and iterative process, utilizing the back-casting process, explained further later. Together, they can be summarized as the triple helix by Holmberg (2015), presented in figure A.1 above. The distinctive feature of C-Lab is that students can create a collaborative environment where this group of heterogenous stakeholders feel safer and be willing to share information that can enable sustainable transformation. The whole process is guided and facilitated by the C-Lab team.

- **Theory: Back-casting**

Figure A. 2: Steps of back-casting methodology for sustainability transitions by Larsson and Holmberg (2018)



The origins of back-casting approach can be traced back to spring 1974 when the American scientist, Amory B. Lovins, used a new predictive technique to analyze the future for the energy system in Japan, 1974, and later also in Canada, 1976 (Robinson 1982). During the same period, Steen et. al. used similar techniques, again in a similar context as Amory B. Lovins (Dreborg 1996). There were lack of research and understanding on this new method, as most of strategic management and sustainable development research have been adopting "forecasting" as a mainstream methodological approach, for scenario planning and analysis. However, Robinson (1988) called in his paper for unlearning the old beliefs of forecasting as predictable, since they are only based on the past and can only tell what is likely to happen. In the last reference, Robinson has emphasized that humans' previous decisions should not dictate our vision of the future's state; the future is still untold, and people have the power to change the course of it. In 1990, Robinson laid out the foundation of the back-casting approach (Robinson 1990, Dreborg 1996). Since then, back-casting has gained an increasing academic recognition within different disciplines, especially within sustainable development and sustainability transition literature. The foundation for back-casting together with the four non-overlapping principles for sustainability inspired a new version for such method (Holmberg 1998). It has evolved into four steps and was used mainly to conduct strategic planning for sustainability in business corporations. Figure A.2 above shows the four consecutive steps of back-casting methodology, and they can be further elaborated as follows;

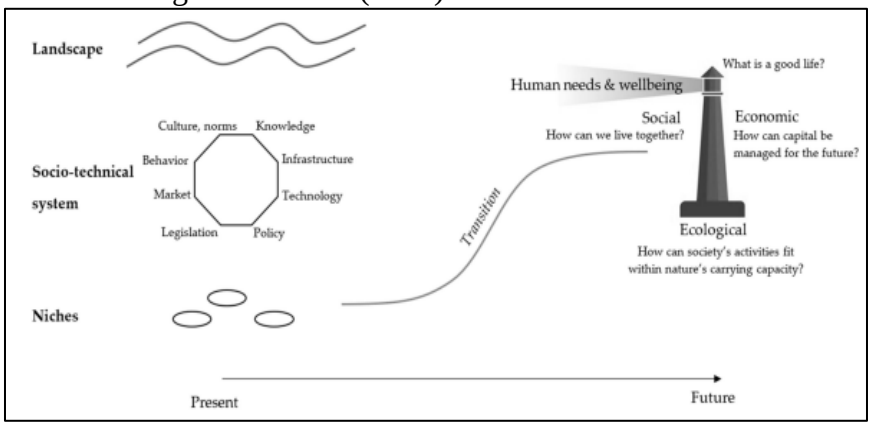
Step 1 – Frame conditions for a sustainable future on a level of principles:

Figure A. 3: Sustainability lighthouse illustrating the four dimensions of sustainability as presented in Holmberg and Larsson (2018)

To support transitional leadership with sustainable directions, a new framework of sustainability lighthouse was presented to help guide transitions as presented in Holmberg and Larsson (2018). It is based on four dimensions; ecological, economic, social and human needs & and wellbeing. This was illustrated as a lighthouse for pedagogical reasons as shown in figure A.3 above. During the first week of the C-Lab, students have identified the basic principles in each of the three dimensions of environment, society and economy based on their own values and views of desirable future (as will be discussed in detail below in the method section). It was implicitly assumed that realization of such principles in the respective three dimensions would lead to the fulfillment of human needs and achievement of human well-being as the ultimate end of such framework. It is worth mentioning that Holmberg (1998) has suggested four non-overlapping socio-ecological sustainability principles that can be used as guiding principles to develop a sustainability lighthouse under various contexts.

Step 2 – Analyzing gaps between the present situation and the sustainable future:

Figure A. 4: How sustainability lighthouse can guide transitions in socio-technical systems as presented in Holmberg and Larsson (2018)



In this step, the current unsustainable activities including bottlenecks and persistent sustainability problems are highlighted and discussed. Moreover, sustainability lighthouse and the guiding sustainability principles developed in step 1 are used to guide the discussions about the current socio-technical systems. In other words, discussions about the current system's gaps and challenges have to be in relation to the desirable future outlined in step 1. Therefore, a sustainability lighthouse has an essential role of guiding current discussions about sustainable future as shown in figure A.4 above (Holmberg and Larsson 2018). In the first phase of the C-Lab, such discussions were designed and implemented using the framework of socio-technical systems of pre-identified sustainability themes: (1) mobility, (2) food, (3) energy, materials and resources.

Geels (2005) has introduced socio-technical systems within the context of system innovations (i.e. when there is a transition from one socio-technical system to another). Socio-technical systems consist of many elements such as infrastructure, technology, policy, legislations …. etc., as shown in figure A.4. The latter reference has analysand socio-technical systems on a multi-level perspective, as they are divided into three levels. In the lower level, there exists technological niches, in which radical innovations are developed. Niches are considered incubation rooms that protect and accelerate such radical innovations and as a learning space. On the upper level, the landscape is positioned, and it comprises factors from external environment that would affect socio-technical developments. Therefore, landscape is not under the direct control of actors/stakeholders in the regime level, which is located between landscape and niche. On the contrary, macro developments in the landscape can affect regimes and assist to initiate larger system innovation if some preconditions are met. In the regime, different groups and actors are interacting and coordinating their activities. It is worth mentioning that regime level has a significant account for the dynamic stability of socio-technical systems, as incremental innovations are continuously evolving. System innovation is comprehensively reviewed in the literature section of this study as the main theoretical approach for answering research question.

Step 3 - Envisaging a future situation/identifying leverage points interventions for bridging the gaps: During this step, future possibilities (i.e. leverage points) are set based on the sustainability principles and the current unsustainable situation identified in previous steps (Holmberg 1998). Leverage points are formed based on areas of opportunity that can be small interventions inside the gaps discussed in step 2. In that regard, Meadows (1999) has introduced a general definition of "leverage points", suggested 12 points to intervene in a system, and arranged them from last to first based on their effectiveness (from the least effective to the most effective). Indeed, such small interventions will work as bridges between gaps and bottlenecks (in steps 2) and the desirable future (in step 1). Holmberg (1998) has recommended that, during this step, engaged actors should think in a broader way, in order to open their minds to new solutions, opportunities and options that have

never been thought about before. Accordingly, students at the C-Lab have identified leverage points on a later stage after conducting dialogues with relevant stakeholders in the above-mentioned sustainability themes.

Step 4 – finding strategies for sustainability: In such a step, strategies are developed, based on and to work with, leverage points reached in the last step. Moreover, stakeholders are engaged into a series of experimentation processes that comprise a lot of iterations. However, students in the C-Lab did not get into this stage as they were engaged into further development of the identified leverage points in the last step for the sake of thesis pair formation later on.

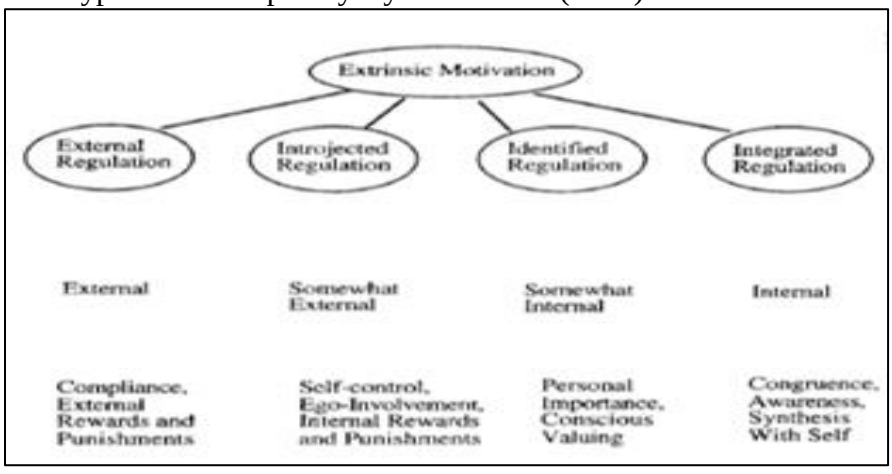
A.2 Methodology

As mentioned above, back-casing is the main methodological approach followed during phase I that lasted for four weeks. Moreover, two perspectives are combined with the back-casting method; the "outside-in" and the "inside-out" perspectives. The former includes tools, methods and theories of sustainability, managing transition and system thinking, while the later consists of tools and methods used to understand and align students' visions, values, believes and motivations. Both perspectives are aiming to build leadership capabilities for creating a change towards a desirable future in mind. Accordingly, students would be able to come up with preliminary research questions at the end of this phase.

- Values clarification

Motivation for conducting the master's thesis is something that C-Lab has recognized as an important factor for a successful thesis. Even though the C-Lab values are clear, it is also crucial to recognize the students'/participants' personal values. Members are more engaged when their own personal values are clear, demonstrated and reflected into the working environment, rather than understanding and/or pursuing the organizational values (Posner and Schmidt 1993). On another note, personal values are crucial when it comes to personal motivations.

Figure A. 5: Extrinsic motivation as a major source of human motivation and its four different forms/types as developed by Ryan and Deci (2000)



Indeed, there are different sources for motivation (Ryan and Deci 2000, Pink 2009). One of them presented by Ryan and Deci (2000) is extrinsic motivation which refers to *"the performance of an activity in order to attain some separable outcomes"*, as distinguished from intrinsic motivation. There are four types of extrinsic motivation, as shown in figure A.5. Among them exists 'identified regulation' which refers to identifying the value of the ultimate personal goals. Assigning valuation, or more precisely, conscious valuing, would provide meaning for personal actions taken to reach goals. Conscious valuing of what is important for each member (i.e. inside a certain organization) will increase their awareness of their personal values, what they find important, and what they are doing at such organization. This will hopefully assist them into aligning values with results to create a sense of inner purpose. A sense of inner purpose is important by itself, but it is also said that it can stimulate motivation (Pink 2009).

Accordingly, during the first phase of the C-Lab, to identify the personal values, each member has chosen five to ten core values from a list of values. Thereafter, a personal development exercise was conducted, in which a facilitator from the C-Lab divided students in groups of three, and in turns, they changed their roles every 15 minutes. There were three roles; focus person, listener and observer. The focus person chooses a value and shares a specific experience connected to it, towards the listener. The listener listens without commenting or asking questions. Lastly, the observer should listen and observe what is happening between the focus person and the listener, also without interrupting the focus person.

Directly after the session, in the same groups, a short reflection for 3 minutes is given to each student/participant through answering the following four questions:

- How was it to talk without interruption?
- How was it to listen?
- How was it to observe?
- What happened between you?

To make this session more effective, it was important that participants feel safe to share their experiences. Therefore, all participants applied a rule that is: "whatever is said in the group is kept as confidential". Last activity was to write down the core values in small notes so that they would be available to students anytime.

- Mission Statement

Based on the values from the previous session, all members/students were asked to formulate key sentence(s) that reflects one's core values. That became later as one's mission statement. It is important to mention that having a clear mission statement and values have supported the work later on, while defining the sustainable principles. Instead

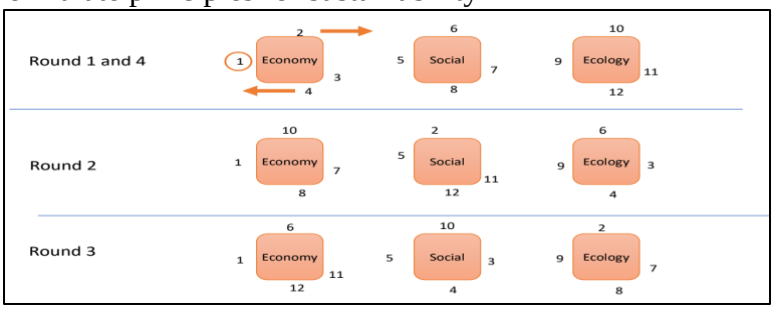
from starting with pre-identified values, the sustainable principles can be filled with more purpose if defined by the group based on their own personal values.

- Sustainable principles

The process of reaching a sustainable future starts with identifying the principles that are agreeable among a group of people within a certain organization, a community, a society …etc. To imagine the future state, as done in the back-casting process, one first needs to identify what is a desirable future (Robinson 1982, Robinson 1988, Robinson 1990, Dreborg 1996, Holmberg 1998). This is completed though formulating sustainability principles for a desirable life in which human well-being is achieved, and inspired by Holmberg and Larsson (2018) lighthouse.

Within the C-Lab, formulating sustainability principles was done through sequential steps, during the first week of phase I. It is important to mention that this process followed a structure of three phases. The first phase followed divergent pattern in which all possibilities are opened, then the second phase is emergence, where participants go back and forth between suggested and generated principles. The last phase is convergence where all group members agree on certain principles that would present a desirable future and exclude other unrelated or non-representing values. On the first step, a brainstorm session was conducted for 15 minutes where keywords on post-its were put on the wall in two groups. A crucial condition for generating principles was that well-being should be universal, and that it should be held for all people in all different stages of life. The next step, which lasted for 25 minutes, was to cluster and add post-its in the same two groups in silence. Thereafter, for 25 minutes, the whole group co-joined higher level key words, each group presents its high-level words, as the goal was to reach between three and seven top-level words. There was a comparison with the principles' guidelines for additional changes before the next step.

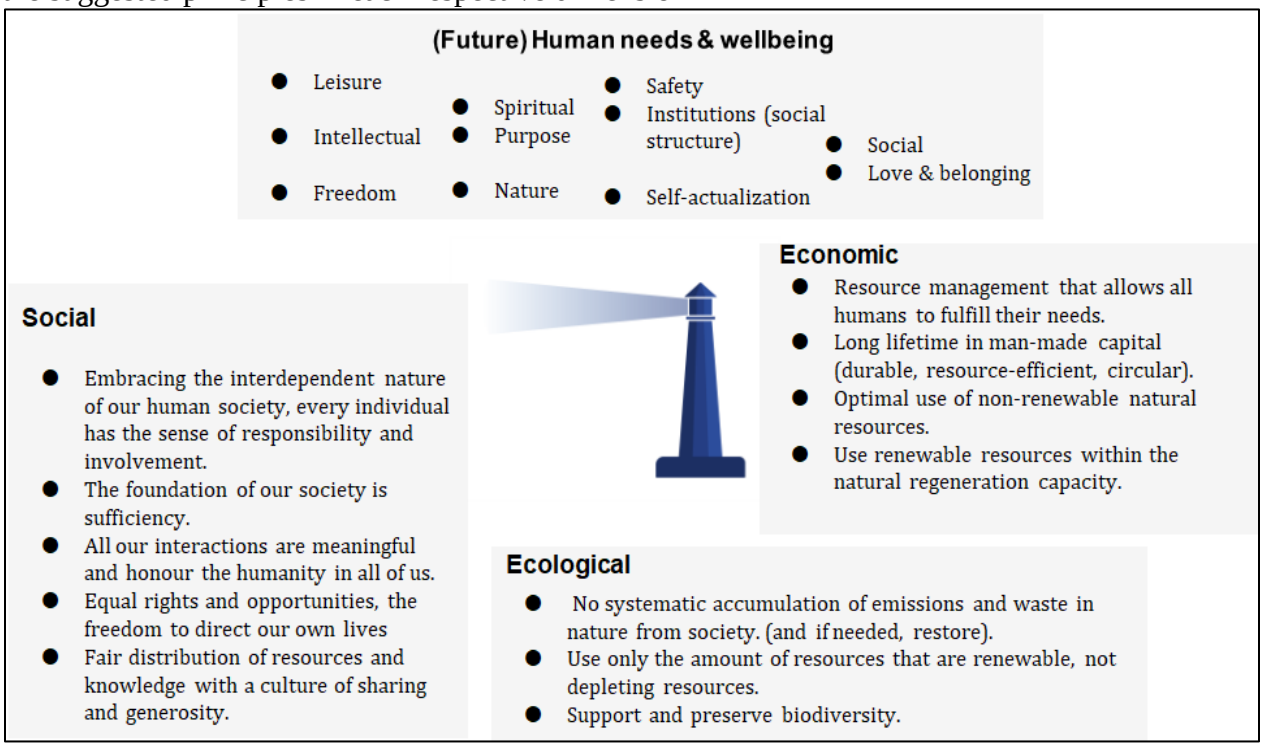
Figure A. 6: Structure and rotation mechanism for world cafes to form sustainability principles as developed by the C-Lab 2019, presentation on step 1 of back-casting methodology: formulate principles for sustainability



Next step was to divide the group in three. This step was called world café and is designed to rotate parts of the group into opposite directions every 15 minutes, one to right and two to left, so that three out of four get the chance to participate in every group. Figure A.6 above shows the structure and rotation mechanism for world cafes. Each group focuses on

one of the three dimensions: ecology, economy and social. The one person staying with the same dimension during the whole session works as a facilitator in each group round and is called "table host". The table hosts' role is to give a short introduction in maximum 5 minutes about work done in the last round and then continue the discussion. At the fourth round, all participants return to the original table to finalize the work. The whole session ends with a presentation, in which each group presents the principles that have been identified in their dimension. After that, there is an opportunity to add missing aspects and/or handling overlaps in the principles.

Figure A. 7: Sustainability lighthouse created by the C-Lab student patch in 2019, with the suggested principles in each respective dimension

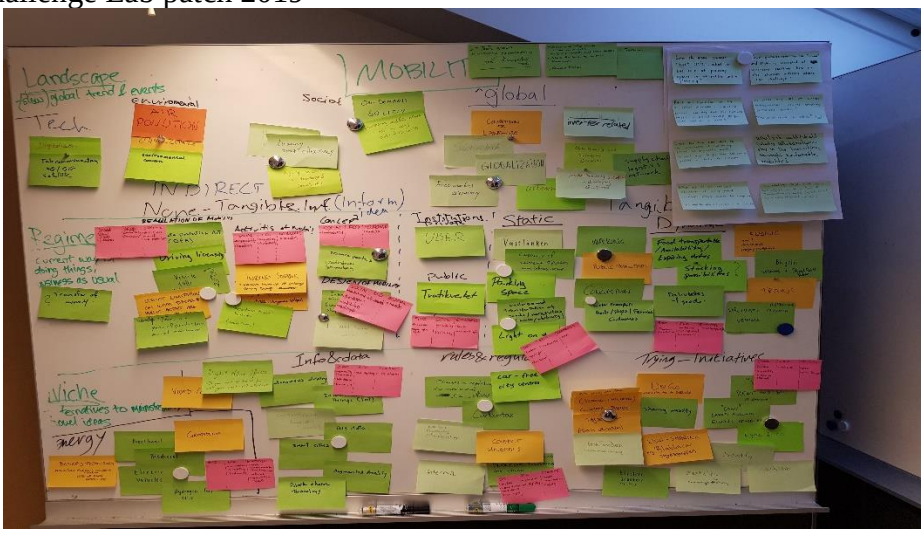


Lastly, the resulted principles from phase I in the C-Lab 2019 can be seen in the above figure A.7.

- Systems mapping and information gathering

First, it is important to mention that the purpose of doing such maps was to get an overview insight of the whole systems to detect gaps, and hence solve the right problems later. In addition, having the right identification of problems would significantly help students to decide on the most appropriate leverage points to work within the next stage. Therefore, students were asked to develop such elements in each map based on the current situation (i.e. challenges, points of energy/potential, ongoing processes on the ground). Moreover, analysis of systems has been taken from a multiple level perspective, as many elements were included such as technologies, infrastructure, markets …etc., as suggested by Geels (2005).

Figure A. 8: A preliminary system map of mobility thematic area, as prepared by students of the Challenge Lab patch 2019



Accordingly, students have started step 2 of back-casting methodology by first developing system maps of each of pre-identified thematic areas; "mobility", "food", and "energy, materials and resources". These maps were structured by following Geels (2005) concept of socio-technical systems that has been discussed above. Therefore, each map comprises three levels of analysis: a landscape, a regime and a niche. Students were divided into three groups to work on developing elements of each map. In addition, students were moving iteratively between the three thematic areas to maximize their participation in developing elements in each theme. The above figure A.8 represents the system map of mobility theme that has been prepared by students at the end of phase I first week.

Afterwards, students were asked to prepare questions that would address identified gaps in the system maps and based on the developed sustainability lighthouse in figure A.7. These questions will be directed to stakeholders that would be invited to a series of dialogues hosted by the C-Lab.

- Stakeholder dialogues

In the second week of phase I, step 2 of back-casting continued as students have arranged, hosted and actively engaged into live dialogues with stakeholders. The later stakeholders were invited to seven rounds of dialogues directly related to the pre-defined thematic areas. The titles of seven dialogues, that would implicitly indicate their content, were: "mobility of people", "food", "energy", "circularity/circular flows", "equality/accessibility and participation", "climate 2030 agenda", "mobility of goods". Invited stakeholders were selected based in their relevance and experience in the dialogues' suggested content.

C-Lab students have participated in the dialogues by performing different roles, such as being active dialoguers, active listeners, facilitators, note takers …etc. It is crucial to mention that dialogues were aiming to reveal practical information from the invited

stakeholders about the gaps and bottlenecks that current societal systems face, as well as their views of a desirable future based on the students' developed principles in the first step of phase I. In the end of second week, students were asked to update the system maps of the three thematic areas, as well as to present them by addressing the following points:

- The most relevant gaps inside each map.
- What should be done to move forward from today's system into a sustainable future.
- The main roadblocks/bottlenecks towards achieving this shift.
- Topics of promise, energy from stakeholders' dialogues.
- Current projects taking place inside Sweden that can be connected to themes.
- Areas of potential involvement/participation of stakeholders.

- Leverage point identification

This third step of back-casting method started at the beginning of phase I third week. The definition of leverage point is borrowed from Meadows (1999), as *"Places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything"* page no.1. Students were divided into four thematic areas; the three pre-defined areas plus a forth new one named "innovation and strategy", based on their own interests. Each student was asked to come up with at least two leverage points inside his/her thematic area. In addition, each leverage point should include a topic focus, a related sustainability challenge/gap, a local problem as presented in a particular context, key stakeholder(s) and ongoing process(es) connected to such leverage point. It is crucial to mention that leverage points have to be formulated based on the student's personal motivation (i.e. his/her academic and personal interests). During this step, the two researchers worked collaboratively in the innovation and strategy theme to come up with common leverage points, and that was before thesis pair formation. At the end of this step, each student had to present his/her own suggested leverage points in front of the C-Lab team and rest of colleagues, and amend them based on received feedback.

Accordingly, in the first step, the two researchers had to identify the research topic and purpose. This has been started with reviewing the dialogues conducted during the second week in phase I with relevant stakeholders. The researchers have got an inspiration from the dialogues of mobility of people and mobility of goods, as a number of challenges were touched upon. Such challenges were identified based on some comments and opinions raised by the stakeholders who participated in the dialogues. Some of these quotations can be presented as follows:

- "It is hard to test new technologies in public places and get feedback."
- "Technologies are available but there is lack of adoption and commercialization of these technologies."

- "we have to dare to try and dare to fail. (we should have the attitude of being allowed to try and fail)."
- "Think big, start small and act now."
- "Share and learn how to do it."

Moreover, in another dialogue (mobility of goods), two stakeholders have discussed problems and hinders of collaborating between big companies and small ones for transportation solutions inside Gothenburg city. One stakeholder was representing a big transport manufacturing company and the other one was representing a startup developing a water transport solution. Both have expressed the issue of collaboration as complex and it includes many aspects that need to be addressed. Accordingly, the researchers have worked together to propose the leverage point as follows;

Overarching sustainability challenge/gap:

- Knowledge gap between stakeholders
- Slow rate of sustainability transformation and adoption of new innovations.
- Not enough collaboration for sustainability.

Local problem as manifested in a particular context:

- Consensus among stakeholders that mobility sector is based on collaboration and not competition.
- However, innovation costs more than what it brings as benefit.
- No proper identification of opportunities because of not enough collaboration (low levels of shared learning and co-development).
- A lot of new cooperation initiatives exist, but there is lack of collaboration among different platforms for testing and co-development of new technologies.

Hence, the two researchers have decided on a leverage point based on their own research interests and academic background as well as what have been manifested during dialogues as major sustainability challenges in the mobility sector inside western Sweden. The leverage point is: *the opportunity to increase collaboration between different stakeholders working in the mobility sector*. Specifically, by focusing on a part of the developed system map for mobility theme during phase I of the C-Lab, and based on the two researchers' interest, focus would be *on niche innovations brought by SMEs*. It is assumed by researchers that innovation driven SMEs are a major source of niche and disruptive innovations, and to have a significant impact in the mobility system and its path towards sustainability transformation. However, there is no available map of innovation driven SMEs and startups that are developing new solutions inside the mobility sector in Västra Götaland County. This leverage point was identified under both themes of "innovation and strategy", and "mobility". Moreover, researchers have relied on the following sustainability principles from step I in backcasting:

- Economic: Long lifetime in man-made capital (durable, resource-efficient, circular).

- Social: Embracing the interdependent nature of our human society, every individual has the sense of responsibility and involvement.

A.3 Results and Research Question

- Process of arriving at a research question: how did it go?

At the beginning of phase I forth week, and after identifying the leverage point and going through the thesis pairs formation, the researchers have come up with a preliminary research question and title for the thesis. The suggested thesis title, that has been based on the identified leverage point, was *"Developing a system map of innovation driven SMEs with new mobility solutions in Västra Götaland County"*. The suggested research question was: *What are the patterns of involvement of innovation-driven SMEs developing mobility solutions in the mobility sector inside Västra Götaland County?* The research question was a general one and it has included two sub points to elaborate on it. First, collaboration with other stakeholders in mobility sector within the region: What are the current collaboration initiatives that are taking place inside Gothenburg and that involve startups and SMEs working on mobility solutions? Second, what/where are the bottlenecks that face SMEs working on mobility solutions inside Västra Götaland County?

- Research Question

However, based on time and resource limitation, the researchers have received a feedback and suggestion from the C-Lab academic team to focus more on beneficiaries of such map (i.e. who are the stakeholders addressed in such a map and for whom thesis recommendations and results are targeting?). Accordingly, more limitation to the research topic is implemented. In line with this, the regional development strategy of VGR is under development right now. More focus would be on the role that regional authorities can play in solving such bottlenecks facing SMEs in the region. Moreover, the identification of bottlenecks that face SMEs in accelerating/scaling up their innovations is based on investigating the gap between the current role that such entities are playing and the perceived role they are expected to play based on their potential. Hence, a more directed approach, when decided on methodology and design of interview questions, can be implemented. Accordingly, the modified thesis research question is:

What is the role of innovation driven SMEs in upscaling/accelerating niche innovation within a regional context?

Under this question, there can be a list of sub, more specific questions;
- What is the current role played by innovation-driven SMEs in the mobility system within Västra Götaland County?

- What is the perceived role to be played by innovation-driven SMEs in the mobility system within Västra Götaland County?

- What are the bottlenecks facing innovation-driven SMEs hindering them to fully achieve their perceived role?

Appendix B: Unstructured interviews with industry experts in western Sweden

As highlighted in methodology section, we have conducted most of expert meetings in the early phase of deciding on methodological choices and during data collection process. In this appendix, we provide a detailed presentation of main outcome for each individual expert meeting/interview. Table B.1 below shows the name, organizational affiliation as well as main interview outcomes of each respective expert.

Table B. 1: Main outcomes of experts' unstructured interviews

EXPERT NAME & ORGANIZATIONAL AFFILIATION	MAIN OUTCOMES FROM MEETING
PER GYLLENSPETZ - CURVE NAVIGATOR, CONCEPT DESIGN AND TRANSPORTATION STRATEGIES	• He provided his views of mobility system from the perspective of collaboration challenges between different stakeholders. • More specifically, he discussed the challenges faced by incumbent firms in transportation industry and why they are reluctant to collaborate with SMEs. • He indicated that that big corporations are pressured to optimize their manufacturing processes which in turn requires significant investments. Incumbents are aware of inevitability of change toward sustainability but at the same time they face enormous risks to undertake required processes to pursue such change. • Furthermore, he stated that the main bottleneck for collaboration between incumbents and smaller entities is "the current culture". He mentioned that employees at incumbents struggle to keep the balance between being professional and asking hard questions. • He also stated that most startups are dependent on public funding from actors as Vinnova that are hard to access. • Lastly, he underlined that at the bottom line, it is the incumbents that can lead the real change towards sustainability.
BO NORRMAN - INNOVATION OFFICE, CHALMERS UNIVERSITY OF TECHNOLOGY	• He is the contact person for VGR, as he is recently assigned to work with VGR regional development strategy till 2030. Therefore, meeting with him focused on VGR role in supporting a sustainable transition of mobility system. • He gave his insights of the regional context of mobility system in western Sweden and the specific goals that Västra Götalandsregionen has for a sustainable transportation system till the year 2030. • He also offered access to some transportation industry reports by leading consultancy firms of technological trends that could be disrupting mobility regimes worldwide. • He recommended some experts to contact, and Business Region Gothenburg as a good source to start identifying the population.
ERIK-WILHELM GRAEF BEHM & LARS BERN - BUSINESS REGION GOTHENBURG	• They provided a broader picture of mobility sector from a system level and industry clustering perspective. • They hinted the challenges that this study can potentially have in terms of identifying the SMEs population.

	• Behm mentioned that there are already fewer start-ups to be included, within the mobility sector than what has been thought while preparing cluster analysis reports for transportation sector in western Sweden. • Both Behm and Bern provided valuable advice regarding how to collect data about SMEs. For instance, they did not recommend using industry codes while searching for SMEs on online databases. They explained why the industry codes are not the right approach, which was quite reasonable, and that manually picking the population would be a preferable approach to do that. • In addition, Behm indicated that it is important to be clear about the suggested title of "SMEs working with mobility solutions". In other words, do we mean companies that are only in transportation industry or those that develop IT solutions with direct applications in mobility sector? • Lastly, Bern mentioned that a 100% picture of population is barely not possible because of constant changes in the region.
MAGNUS KARLSTRÖM - SWEDISH ELECTROMOBILITY CENTER, CHALMERS UNIVERSITY OF TECHNOLOGY	• He devoted more focus on academic approach, expected role of VGR, and related organizations and events to access more data. • He also gave insights of the challenges that SMEs face due to their limited amount of resources. • He also indicated that it is hard for SMEs to participate in collaboration platforms. • He provided some recommendations of best SMEs to contact and gave us some contact information inside these companies. He also suggested some online resources and real events to attend in order to access other potential companies that would be interesting to include in the population. • On the other side, he gave his advice on academic approach of the study. For instance, based on his academic and professional experience, he claimed that companies working with mobility solutions, under some disruptive technological trends, do not need protective spaces such as incubator and acceleration programs, to operate and grow, as theory of strategic niches management would suggest. That, in turn, inspired us to investigate if empirical data would support theoretical literature while answering the research question. • In addition, he briefly mentioned the expected role to be played by VGR, taking into consideration that some challenges require decisions to be made at city or national level. • Lastly, he indicated that the nature of current disruptive trends in mobility require substantial software skills which many SMEs are lacking. Indeed, he pointed out that this big lack of software developers is not only in Sweden but also globally. Therefore, VGR can step in and solve such bottleneck by providing skills development programs to SMEs.

PER ÖSTERSTRÖM - BUSINESS REGION GOTHENBURG	• Österström works under the cluster of strategic collaborations between different stakeholders, inside BRG. He provided us with very thoughtful insights about mobility transformation, based on his extensive work with the transportation sector and conducted numerus reports about automotive industry and surrounding ecosystem in the region. • He mentioned that new companies are continuously coming up and added to the mobility sector inside western Sweden, and many of them are not classified under automotive industry as they come from other industry classifications. Therefore, his views contradict with Behm's with respect to the number of SMEs to be included under mobility sector in western Sweden. However, his approach, as well as Behm tips, have been utilized to identify the population of innovation-driven SEMs in this study's methodological approach. • He also shed light on global trends and provided insights of what is happening in other parts of the world. • He is not convinced that the small entities (i.e. SMEs) have the capacity to drive the transformation, but it is rather other global incumbents from other industries that drive the mobility transformation. In fact, Amazon and Alibaba were mentioned as the drivers that will push the mobility transformation. • Furthermore, he stated that start-ups and SMEs are dependent on the local automotive industry's survival because it enables new business opportunities. A disruption to the industry would affect the whole supply chain. The electrification disruptive trend was brought up by him as an example *"And then when you do that you will affect the value chains, there are new supplies for this system than to the old system. There are new global centers in the world that are good at electrification that will be shining starts in the future."*. • He suggests that, in order to get the most out of this disruption, incumbents and start-ups need to collaborate. The incumbents need to lower the level of control and invite others to come up with solutions for their challenges. An effective collaboration needs to have clear requirements. For the incumbents, it has been hard to formulate requirements for collaborations because they do not know exactly where they are moving towards.

Appendix C: Semi-structured interview guide for participant SMEs

C.1 Development steps for SMEs semi-structured interview guide

Developing a guide for SMEs semi-structured interviews was a crucial step in order to decide on the list of topics/issues to be covered. Therefore, it would function as a memory guide to us as suggested by Bryman and Bell (2015). Identifying areas of discussion as well as list of questions in each respective area is necessary for having a minimum level of comparability, as argued in the methodology section, to align with the comparative design of this respective study. However, such list of questions should not be too specific (i.e. having too many pre-occupations such as a questionnaire) in order to allow for other options of inquiry for interviewees, to provide their world/holistic views regarding investigated topics. Moreover, while we were preparing the guide, it was important to provide a logical order of discussed topics, as well as questions in each respective topic, for having an intuitive flow of interview, along with retaining the option to alter the order of topics/questions if necessary. During this process, we had to make a delicate balance between having a comprehensive approach while setting interview questions to reach deep answers for the studied phenomenon on one side and avoiding complicated/unfamiliar technical and scientific terminologies that respective interviewees are not aware of. Accordingly, we have considered our interviewees professional background while formulating questions in order to make the later relevant to the interviewee's context. The guide was under revision many times even after starting SMEs interviews, and was amended based on feedback from early interviews. That was either through reordering questions (putting the most important ones in the beginning) or suggesting new ones based on interesting topics highlighted by interviewees.

The interview guide was designed, as presented in C.2, in six sections; two sections for introduction and ending as well as four sections for the main interview's body. The length of interview was allowed to be 45 – 60 minutes approximately, which goes in line with what Gillham (2008) states as necessary for gathering high quality data (i.e. if the interview lasts for more than 60 minutes, quality of obtained data would decrease). Therefore, each section would be expected to last for 10 – 15 minutes, with 10 minutes for introduction and ending (5 minutes each). The structure of interview guide's main body is based on investigating what has been found in literature; mainly through addressed theoretical explanation of system innovation in the context of sustainability transition, and role of innovation-driven SMEs in regional innovation systems. Therefore, the four sections in the main body are directed to gain a better understanding of the dynamic role that SMEs are playing in technological niches, by making a clear link between the study's research question(s) and obtained data from answering questions in respective sections. For that reason, we have first developed some basic assumptions about interviewed SMEs based on literature, that were used as guidance for designing questions in the four main interview sections. Indeed, we assumed that SMEs are:

- Developing high tech solutions
- Adopting product innovation relatively more than any other types of innovation

- Working in market or technological niches
- Undertaking R&D activities as part of their product innovation
- Having innovation-based and/or sustainability-rooted strategies
- Having a higher tendency, and are more open, to collaborate with science and technology entities
- Suffering from lack of financial and human resources

It is important to mention that these developed assumptions are mainly for guidance to design interview questions, and they will not be presented to SMEs. In addition, they are not binding in the sense that we do not want to prove them. Indeed, because of qualitative nature of this study, we would be very open and flexible to discover the characteristics, and develop a deeper understanding of, each studied case if such assumptions are proved to be inappropriate. Therefore, a more comprehensive analysis can be completed based on obtained data, which would result in more robust conclusions.

The introduction section: It has two goals; first, it serves as a kind of ice breaker between us and interviewee, as will be shown later in interview settings sub-section. Second, it was a background check; as we quickly verified the SME's business offering/developed solution, year of establishment, size in terms of number of employees, and (if possible) last year's turnover or turnover trend over the last few years (depending on years of operation). Checking for such kind of information was done to make sure that respective SME falls within pre-determined EU definition, as adopted in this study.

The following sections comprise, as shown later in appendix C.2, a set of overarching/introductory questions (usually the first question in each section) that cover main points to be addressed in this respective section. These kinds of questions are open-ended and broad in nature. Nevertheless, a set of follow up/interpreting questions are prepared after each major question to help interviewee elaborate and highlight different perspectives of the discussed topic.

Section one, role of the company in the mobility sector of western Sweden: It is mainly concerned with investigating nature of radical innovation that respective SME is developing. We assumed that would be revealed by having a narrative for the steps/phases (i.e. milestones) that company has come through since idea realization till current status. That would also reveal how the company managed to scale up its innovative technology. In that regard, we assumed that having CEO, founder or co-founder as the prospect interviewee would enable us to get the best possible insight of the scaling up path of company's innovation.

As niches are protected spaces for development and experimentation of promising technologies, it was crucial to ask about how the respective SME is conducting experimentation and learning about desirability of new technologies basically from customers. As Tödtling and Kaufmann (2001) has assumed that customers are SMEs main innovation partners, and are essential to guide the latter's innovation activities.

As it was also revealed from literature that R&D expenditures are a major component of SMEs innovation towards sustainable transition. Therefore, we are also keen to ask about how much an SME would spend on R&D in absolute and relative terms (if possible), and how the company would conduct product development if it is not dependent on in-house R&D.

Section two, collaboration activities/patterns with the company main stakeholders: We base this section mainly on the assumption set by Tödtling and Kaufmann (2001) that SMEs innovation process is characterized by their involvement with other external actors in interactive learning networks. This study also assumes that upscaling niche innovation is a co-evolutionary process in which SMEs interact with other stakeholders within innovation system either on niche or regime level. In addition, it was assumed by Smallbone, North et al. (2003) that availability of strong R&D institutions, venture capital firms, spin-off companies and technology networks would make SMEs strong candidates to drive radical innovation. That is because collaboration platforms can provide windows of opportunities to niche SMEs developers to break through into regime levels. Lastly, Tödtling and Kaufmann (2001) argued that main problem SMEs face in terms of resources limitation can be solved through integration with regional innovation systems.

In that regard, we have been investigating the SME's main stakeholders, collaboration platforms that it is engaged into (if any), and what kind of collaboration activities the company is conducting.

Section three, the company's strategy: As strategy (i.e. SME long-term plan) is a cornerstone for which path an SME would take for scaling up its niche innovation (i.e. increasing the rate of application/penetration of new technology), this section is mainly concerned with the SME's scaling up strategy. By identifying scaling up niche innovation as the diffusion of such innovation not just by business growth, but it also includes other mechanisms, according to the co-evolutionary process of transforming mass markets by sustainable niche innovations (Hockerts and Wüstenhagen 2010). Nevertheless, the last reference suggested also that growth is the first option for SMEs to scale up their radical novelties, as new emerging Davids must aim for mass market penetration rather than staying on niches, otherwise their innovation would not be considered disruptive. Asking for strategy was also warranted as it was not clear from literature what kind of innovation strategy an SME would adopt; either defensive or offensive strategy (i.e. either aim to just develop on a niche market or to compete in a mainstream market). On another note, we have been reliant on Klewitz and Hansen (2014) argumentation that innovation-based and sustainability-rooted strategies of SMEs would result into radical innovation, which in turn would affect sustainability transitions on higher system levels.

In this regard, we asked within this section either the company is going to scale up by having a traditional growth strategy, such as entering new market segments, or following other options such as collaborating with more/new stakeholders, doing more product development …etc. We added a follow up question, as an elaboration to the main question

in this section, in order to get a better insight of what kind of actions taken by management team to achieve the company's strategy.

Section four, main challenges facing the company: In this section, we aimed to highlight how interviewed entrepreneurs perceive challenges that their SMEs face. As revealed from literature, SMEs are challenged regarding lack of internal and external financial resources as well as compatible human resources, which would affect its ability to innovate. In fact, resource scarcity would affect an SME ability to "scan, identify and respond to opportunities and threats" (Tödtling and Kaufmann 2001). The last reference also argued that many technology-driven SMEs are suffering from challenges, other than lack of financial and human resources, that are rarely recognized and addressed by them. Hence, we assume that such challenges would affect ability of SME's new configurations/innovations to take advantage of windows of opportunities and break through to regime level. Moreover, it is important to mention that we take challenges from abroad perspective; not only those related to scaling up/growing radical novelties but also those related to other aspects of experimenting/developing new technologies. Accordingly, we have been asking about the main challenges that interviewed entrepreneur perceives to hinder his/her company achieve its strategy.

On another note, we have assumed that regional authorities in Västra Götaland County are interested into supporting SMEs overcome obstacles and help them grow and accelerate their sustainable innovations towards the region's sustainable development. In such context, it was crucial for us to ask for the interviewee's point of view regarding the role that VGR can play to reduce/solve challenges his/her company faces.

Last section, ending: This part is set to finalize the interview and let interviewee add/elaborate on other points not touched upon during the interview and that s/he thinks important to the raised/discussed issues. Therefore, this section functions as "catching perspectives" that previous sections failed to capture (Bryman and Bell 2015).

C.2 The final SMEs interview guide

Thank you for your interest to have this interview with us, we really appreciate it. The interview is planned to be divided into four parts, each would last for approximately 10-15 minutes.

Background check (5 minutes) – verifying basic information about the company available through its website and allabolag.se.

For example: what is the developed product/service? Year of establishment, number of employees ..etc.

First section: Role of the company in mobility sector in Västra Götaland County

Basically, tell us more details about the product you provide in the market (deeper understanding of the solution). What is the story of the company from the idea till the

current status? Briefly tell us what processes/steps the company went through from the idea phase till today if possible?

Some suggestions:

- How did you manage to scale up the business?
- Did you do experimentation of the product? How do you learn about its desirability by your customers?
- Do you do any Research & Development?

Second section: Collaboration with the company's main stakeholders

Can you share with us with whom your company collaborates?

If any, what kind of platforms the company is involved in currently?

Suggested stakeholders that the company can collaborate with include: customers, suppliers, other businesses in your sector, science parks, consultancy firms, universities, other technology or research centers, governmental organizations …etc. And if they reside inside or outside the region?

And what collaboration activities that the company is generally engaged into with its stakeholders?

Third section: The company's strategy

Could you tell us about the company strategy for the next 3 years? (i.e. scaling up business, entering new market segments, more development of product …etc.)

What is your approach (as a management team) to achieve the company's strategy, and reach its goals?

Fourth section: Main challenges facing the company

Can you highlight the main challenges/bottlenecks that could hinder your company to achieve its strategy?

Do you think that VGR administration can help the company reduce/solve such challenges? If yes, in what way, do you think VGR can intervene and help in this regard?

Ending: Other points that you would like to add, and think are interesting and relevant to the raised topics.

Appendix D: List of terminologies

Almi: It is a Swedish public investment company. It provides two services; capital investments/loans to startups/SMEs as well as established enterprises that have high growth potential, and business development consultancy services to assist entrepreneurs who lack managerial and market skills. It provides its services all over Sweden and has 16 regional subsidiaries.

Business Sweden: It is a public organization owned by the Swedish government and representatives from different Swedish industries. It aims for increasing exposure of Swedish businesses, especially SMEs, to global markets, through its extended international network. It also aims to help international investors to enter and invest inside Sweden.

Business Region Gothenburg (BRG): It is a public entity, located in Gothenburg city, that aims of creating attractive business environment for trade and industry within the region. It focuses on sustainable business development and growth in 13 municipalities within Västra Götaland County, and it develops many industry mapping and clustering reports.

CampX: It is an innovation arena, recently established by Volvo group in May 2019, in which the latter's partners are invited from different fields (i.e. startups, suppliers, academia, research centers, public authorities ..etc.) to co-develop transportation solutions. These collaborations aim to utilize latest digital technological trends that expect to disrupt automotive industry.

Innovatum Science Park: It is a science center, located in Trollhättan. It administers many technology projects and has its own incubator program for startups with around 30 enterprises in its portfolio.

Lindholmen Science Park (LSP): It is a collaboration arena, located in Gothenburg city, where actors from business, academia and public sector can work together on large-scale research and developing projects, with the vision of strengthening Sweden's competitiveness, mainly within future mobility applications.

MobilityXLab: It is a collaboration platform between startups/SMEs and six big corporations in the automotive and telecommunication industries. The six big corporations are Volvo Group, Volvo cars, Ericsson, CEVT, Veoneer and Zenuity. It is located in Lindholmen Science Park, and it states its aim of co-developing and accelerating new mobility solutions together between both entities.

Västra Götaland County / Västra Götalands län: It is the second biggest region in Sweden, and it is subdivided into 49 municipalities. It has a population of 1.6 million. The region is a major hub for automotive industry in the whole Scandinavian countries.

Västra Götalandsregionen (VGR): It is the County Council of Västra Götaland. The council has an extended reach of responsibilities stretching from the region's health care to public transportation system. VGR owns many public entities directly or indirectly

within the region. Västra Götalands Regional Council is elected through the regional elections.

Västtrafik: It is the public transport monopoly company of Västra Götaland County, and it administers many modes of transportation (i.e. buses, ferries, trams and trains). It is fully own by Västra Götalandsregionen (VGR).

Vinnova: It is Sweden's innovation agency, with an aim of strengthening the nation's innovation capacity through directly funding innovation and research projects with startups/SMEs and bigger enterprises. The agency provides 28 financing offers, through which innovation projects are funded all over Sweden.

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