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Multi-sided platform development:

Strategies for electric vehicle charging networks

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ABSTRACT OF MASTER'S THESIS

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Multi-sided platform is an attractive business model for organizations that can create value by mediating transactions of two or more sides willing to interact with each other. Electric vehicle (EV) charging networks enable interactions of EV users and charging point owners (CPO), and thus, they can be observed as multi-sided platforms.

This thesis aims at, first, understanding the competitive platform dynamics that characterize EV charging industry, and second, finding suitable multi-sided platform strategies and future development pathways for EV charging networks.

A qualitative interview study was conducted to study the European EV charging market. The empirical data was collected with 17 semi-structured cross-sectional interviews from different stakeholders in the charging industry. Thematic analysis was used to discover patterns in the data and thereafter the results were analyzed in relation to previous body of knowledge on multi-sided platforms and EV charging networks.

The results show that strong but local network effects, low preference for variety and low multihoming costs for EV users characterize the competition of multi-sided EV charging platforms. However, the industry is fragmented to multiple other business models that consist of market roles of electro-mobility service provider (EMSP), charging service operator (CSO) and CPO. Thus, no conclusive results of the competitive environment can be confirmed purely based on platform dynamics. Strategywise, the results suggest designing pricing symmetry and governance of a multi-sided EV charging platform such that growth and quality of the interactions on the platform are supported. Additionally, decision to enable interoperability (roaming) between charging networks is an important strategic choice that depends on the business model, size and strategic ambitions of the network.

For theoretical contributions, the thesis clarifies the distinction between market roles and business models in EV charging and provides a new conceptualization of roaming in EV charging networks. Furthermore, the study extends the research of multi-sided platforms to the context of EV charging networks and provides researchers and managers a snapshot of opportunities and future pathways of a rapidly evolving industry.

Keywords:	electric vehicle, electric vehicle charging, multi-sided platform, network interoperability, platform pricing, platform governance
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Monenpuoleinen alusta on houkutteleva liiketoimintamalli organisaatioille, jotka luovat arvoa toimimalla välittäjänä kahden tai useamman osapuolen vuorovaikutuksessa. Sähköautojen latausverkostot mahdollistavat sähköautoilijoiden ja latauspisteiden omistajien välisen vuorovaikutuksen, joten niitä voidaan tarkastella monenpuoleisina alustoina.

Tämän diplomityön tavoitteena on (1) ymmärtää alustataloudellisia kilpailudynamiikoita, jotka vaikuttavat sähköautojen lataustoimialaan, ja (2) löytää sähköautojen latausverkostoille soveltuvia monenpuoleisen alustan strategioita sekä tulevaisuuden kehityssuuntia.

Työ toteutettiin laadullisena haastattelututkimuksena ja sen tarkoituksena oli tutkia Eurooppalaista sähköautojen latausmarkkinaa. Empiirinen data kerättiin 17 puoliavoimella haastattelulla, jotka tavoittivat poikkileikkaavasti toimialan eri osapuolia. Data analysoitiin temaattisen analyysin menetelmällä, minkä jälkeen sitä verrattiin olemassa olevaan kirjallisuuteen monenpuoleisista alustoista ja sähköautojen latauksesta.

Tulokset osoittavat, että vahvat mutta paikalliset verkostovaikutukset, vähäinen tarve monipuolisille palveluille ja matalat monikotisuuden kustannukset sähköautoilijoille määrittävät monenpuoleisten sähköautojen latausalustojen välistä kilpailua. Toimiala on kuitenkin pirstoutunut moniin muunlaisiin liiketoimintamalleihin, jotka koostuvat latauspalvelutarjoajan, latausoperaattorin ja latauspisteen omistajan markkinaroolien yhdistelmistä. Tästä johtuen pelkkään alustataloudelliseen dynamiikkaan perustuvaa päätelmää alan kilpailutilanteesta ei voida tehdä. Strategioiden osalta työn tulokset suosittavat monenpuoleisen alustan hallinnan ja hinnoittelun symmetrian suunnittelemista niin, että ne tukevat alustalla tapahtuvien vuorovaikutusten laatua ja määrän kasvua. Lisäksi työssä havaitaan, että latausverkostojen välisen yhteentoimivuuden (engl. roaming) avaaminen on tärkeä strateginen päätös, joka riippuu verkoston liiketoimintamallista, koosta ja strategisista tavoitteista.

Tämä työ täydentää aiempia tutkimuksia selkeyttämällä eroa lataustoimialan markkinaroolien ja liiketoimintamallien välillä. Lisäksi työ ehdottaa uutta käsitteellistä määritelmää latausverkostojen yhteentoimivuudelle. Diplomityö laajentaa myös monenpuoleisten alustojen tutkimusta uuteen kontekstiin – sähköautojen latausverkostoihin, ja tarjoaa tutkijoille ja alan yrityksille tuokiokuvan nopeasti kehittyvän toimialan mahdollisuuksista ja tulevaisuudennäkymistä.

Asiasanat: alustan hallinta, alustan hinnoittelu, monenpuoleinen alusta, sähköauto, sähköauton lataus, verkostojen yhteentoimivuus

Kieli: Englanti

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The most difficult part was to get started. I finished my master's thesis quickly once a meaningful topic combining new business development and climate change solutions was found. Surprisingly, I got to continue from where I left a few years ago (Säde, 2015). I want to thank my supervisor professor Timo Seppälä and my advisor Antti Korpelainen, who supported in the thesis process by constantly helping me to crystallize the outcome. Additionally, thanks for all interviewees and colleagues with whom I got to talk and learn more about electric mobility.

My time at Aalto University has passed equally fast. I am grateful to my parents who encouraged me to apply to industrial engineering and management programme – what a community of people have I met during my studies! I have made friends with inspiring people with whom I have shared ups and downs of the study path since the first week. I have learned and grown in the community of Prodeko, and lovely people in Otanko have literally kept my feet off the ground when not studying. Moreover, extending my studies with two exchange semesters in Munich and London has been invaluable. Thank you!

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Helsinki, April 8, 2019

Matilda Säde

Abbreviations

BEV	Battery electric vehicle
CP	Charging point
CPO	Charging point owner
CSO	Charging service operator
EMSP	Electro-mobility service provider
EV	Electric vehicle
EV user	Electric vehicle user
MSP	Multi-sided platform
PHEV	Plug-in hybrid electric vehicle

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Chapter 1

Introduction

An increasing number of industries are organized around technology-based multi-sided platforms. The attractiveness of multi-sided platform business model lies in the unbundling of value and ownership of assets that allows the intermediary platform companies to enable the usage of physical resources more efficiently than it was possible before (Parker et al., 2016). Competitive dynamics in platform economy are characterized by different factors than traditional one-directional pipeline business, and therefore new strategic approaches are required from the companies that wish to capture the positive network effects and become platform leaders.

Electric vehicle charging is a new technology-based multi-sided platform industry that has seen rapid growth recently due to the increasing need for decarbonizing the transportation sector. Globally, transportation accounts for 29 % of total final energy consumption and causes 25 % of the global CO_2 emissions, of which the share of road transportation is 74 % (International Energy Agency, 2018*a*,*c*). Intergovernmental Panel on Climate Change (2018) demands for immediate actions to reduce greenhouse gas emissions in order to keep the global temperature increase under 1.5 °C, and reduce the risks for natural and human systems.

Electrification of transportation and decarbonization of electricity production is an important pathway for achieving emission reduction targets in the transportation sector. For example, in Finland electric passenger cars have the largest and most cost-effective CO_2 emission abatement potential (Granskog et al., 2018, p. 20). Furthermore, electric vehicles (EVs) do not cause direct air polluting emissions, which makes them an attractive choice for congested cities.

Countries, cities and car manufacturers have published roadmaps to increase the share of EVs in traffic rapidly (e.g. Granskog et al., 2018; Lambert, 2018; Luukka, 2018) and new studies indicate that the turn to rapid growth of EVs in the market has started due to EVs getting more cost competitive compared to ICE vehicles (VTT, 2018; Mutanen, 2019).

Together, these signals have attracted several players to develop competing charging networks that are usually managed through digital services. Separated networks that are operated with different business models aim at winning market share. Simultaneously, end users charging their EVs are facing a multitude of isolated and incompatible charging options, of which user experience often lack smoothness, reliability and uniformity.

Prior research on EV charging has focused on EV charging infrastructure's technical side and only few contributions have been made to understand the opportunities that digital charging services offer for business model development. The wide body of knowledge in multi-sided platforms has not been applied to EV charging even though the multi-sided platform business model is a feasible option for charging network companies that mediate interactions between EV users and charging point owners (CPOs).

Moreover, a multitude of future business opportunities besides charging have been identified in the industry that is still in its infancy. For example, batteries of electric vehicles can become virtual power reserves that can be used to balance the variable production of electricity in the grid. These kinds of developments open opportunities for multi-sided platform owners, as ownership of electricity and its value creation can be de-linked and mediated between platform participants.

The purpose of this thesis is to, first, describe EV charging networks as multi-sided platforms and understand the competitive dynamics that affect public charging market formation. Secondly, the thesis aims at understanding which strategic instruments EV charging network companies can use to strengthen their position in the market given the competitive environment and its trends. Thirdly, the thesis aims at shedding light on the future opportunities that exist in the industry beside charging.

The findings should make important contributions to the field of EV charging business models by bridging the gap between EV charging network literature and multi-sided platform theories. Furthermore, the insights aim at providing tools for EV charging companies, first, to recognize their business model and position in the ecosystem, and second, enable making of smart, long-term strategic decisions that take into account the specific characteristics of rapidly evolving platform-based industry.

1.1 Research objective and questions

The research objective is to describe the attributes shaping the competitive environment of EV charging networks by applying the theory of multi-sided platforms. In the context of competitive multi-sided platform dynamics, the second objective is to find out what strategic instruments are desirable for long-term development of EV charging networks considering the future directions in the industry.

Hence, the following research questions are set:

- *Which factors characterize the competitive platform dynamics in EV charging industry?*
- *In the context of platform industry dynamics, what kind of multi-sided platform strategies should an EV charging network company devise?*
- *What future development opportunities exist for EV charging companies?*

1.2 Scope

This thesis focuses on studying the research questions in the context of public electric vehicle charging networks. Private and semi-public chargers are excluded as they are not available for everyone and different business models concern them. However, the existence of private and semi-public charging is acknowledged, and they are considered substitutes and complements for public charging.

Geographically the focus of this thesis is in Europe meaning that the data is collected from EV charging industry participants from five European countries main focus being in Finland where the thesis was written.

1.3 Structure

This thesis is organized as follows. First, a literature review (Chapter 2) is conducted in two streams: EV charging networks and multi-sided platforms. Subsequently, the theories are brought together to a synthesis that acts as the hypothesis for the empirical part of the thesis.

Chapter 3 Methodology introduces the empirical part of the research and describes the research process and thematic analysis method.

Next, chapter 4 Findings describes the first-order themes that emerge from the empirical data. Subsequently, the findings and prior literature are brought together in chapter 5 Analysis to answer the research questions.

Finally, the thesis concludes with chapter 6 Discussion and conclusions that summarizes the contributions of the thesis and indicates topics for further research.

Chapter 2

Literature review

In this section, an in-depth synthesis of the relevant body of literature on EV charging and multi-sided platforms is generated to frame the research problem conceptually.

First, I introduce the technological concepts and market roles in EV charging and review and scope them for the purposes of the multi-sided platform economy analysis. Second, I continue by describing two streams of multi-sided platform research, and subsequently, I discuss the key concepts, such as network effects and platform participants, to create grounds for understanding the antecedents that lead to either a monopoly platform or multiple competing platforms. Next, strategies to cope with different market structures are discussed.

The chapter concludes with a synthesizing framework of EV charging as a multi-sided platform that acts as the frame for the empirical part of the research project.

2.1 Electric vehicle charging

Academic research on EV charging as business has mainly emerged from the technical perspective of available charging solutions and its focus has been on guessing what kind of operators will appear, and on what conditions will public and/or fast charging be profitable (Schroeder and Traber, 2012; Motoaki and Shirk, 2017; Neaimeh et al., 2017).

Business models have been analyzed with cost-based approach and as comparison to internal combustion engine (ICE) vehicles (Schroeder and Traber, 2012; Madina et al., 2016). As the industry is in its infancy, there has been a lot of uncertainty related to standards, market roles and business models that will emerge. Many authors consider charging business as part of electro-mobility that comprises of EV business models, mobility services and charging (Kley et al., 2011; Bohnsack et al., 2014). Conceptualizations of the roles in the ecosystem have also been proposed (e.g. Gomez et al., 2011; Madina et al., 2016), and those are in the focus of the thesis as they relate closely to the platform economy thinking.

However, I will start by explaining the key terminology and technological standards in the industry. Then I follow with discussion on the market model and how charging ecosystem participants interact with each other.

2.1.1 Design of EV charging infrastructure

The interest of this thesis is in plug-in electric vehicles that includes both battery electric vehicles (BEV) and plug-in hybrid vehicles (PHEV) that can be charged on a charging station by plugging them in. PHEVs, however, do not need as extensive charging services as BEVs because they have a secondary non-electric power source as well. In this thesis, the term electric vehicle (EV) is used to refer to both BEVs and PHEVs, and the specific terms are used only in case the context requires exact distinction.

In addition to plug-in charging, there are options for wireless inductive charging and battery exchange. However, their commercial deployment is not as wide as plug-in charging and therefore they are not discussed in the thesis (Panchal et al., 2018). Nevertheless, wireless charging can be seen as a new connection type and the theories developed in the thesis can also be generalized to it. On the contrary, business logic of battery exchange differs from charging and the results of the thesis do not necessarily apply in that context.

EV charging differs from ICE vehicle fueling in terms of capacity and speed. The battery capacity in terms of available driving range is less than the equivalent fuel tank capacity and it takes longer to charge an empty battery than to fill an empty fuel tank. Therefore, the design of charging infrastructure cannot follow similar centralized structure as the infrastructure of gas stations for ICE vehicles but it must have longer charging times and smaller battery capacities of EVs as a starting point.

Kley et al. (2011) have identified several choices of design characteristics for three areas: vehicle and battery, charging infrastructure system and systems services that integrate EVs into the energy system. In the context of networked platform business, the most important is to understand the technological differences that affect charging speed, accessibility of charging stations and the connectivity of the charger.

An EV charger can be characterized with three interlinked concepts: level, type and mode. Level refers to the power output range of the charger and it defines how fast a charging event can be. Level 1 charging uses alternating current (AC) and is at maximum power of 3,7 kW, which provides with only slow charging and is thus usually used only as a temporary charging method. Level 2 comprises of AC chargers up to 22 kW and it is common for public chargers because the full charging of an empty medium-sized battery takes a couple of hours. Level 3 covers the fast direct current (DC) chargers until 200 kW. Charging event in level 3 charger typically lasts for a maximum of half an hour. (International Energy Agency, 2018*b*)

Type describes the socket and connector that is used for charging, which means that the EV user must check the compatibility of the vehicle's connection type to the charging station's respective connector. Common types in Europe include e.g. IEC 62196-2 Type 2 for level 2 charging, CCS Combo (level 3, DC) and CHAdeMO (level 3) and their usage varies geographically (International Energy Agency, 2018*b*). Existence of different types relates back to the early development in different countries before standardization (Ferwerda et al., 2018).

Mode means the communication protocol between the vehicle and the charger. An international standard categorizes four charging modes. Mode 1 is used for light vehicles e.g. mopeds, and modes 2-4 are applied in the charging infrastructure of passenger electric vehicles (Rautiainen, 2015). Mode categorization follows same logic as the levels but they include also definitions on safety functionalities.

Another way of classifying EV charging relates to the accessibility of the charger. Kley et al. (2011) distinguish public, semi-public and private charging stations. Public stations are available for anyone, whereas user of semi-public chargers is restricted to a certain group e.g. a charging station for company employees in office building. Private charging takes place at homes and only the charging point owner has access to it. Public charging stations are in the interest of this thesis.

Any of the access options can be provided through a commercial charging operator as long as the charger is "smart" and can be connected to cloud. In the case of platform business, it is essential that the charger is connected to cloud as it would be impossible to remotely operate the charging station without this functionality. In this thesis, the organization of charging stations as a public network is relevant because a platform business model cannot be conducted if the stations are not connected.

2.1.2 EV charging network participants

Electro-mobility industry has been driven by the commonly acknowledged need to decarbonize transportation sector. Thus, there has been regulatory interest towards EVs before they have been attractive for the general public, and the charging business models have not emerged naturally but rather as means to achieve wider deployment of EVs. Establishment of new market roles has been therefore rather free, though taking into account the existing regulated electricity market that is the foundation for any charging service (Eurelectric, 2013).

Gomez et al. (2011) and Madina et al. (2016) have proposed market organization models that cover the existing electricity supply and distribution agents as well as the new roles, e.g. electro-mobility service provider and charging station operator, that are needed in the charging business. Similar model outside the peer reviewed articles has been created by Eurelectric (2013) as well.

In addition to these full market model conceptualizations, Ferwerda et al. (2018) have focused on the concept of interoperability in EV charging.

Next the conceptualizations of these four papers are compared such that Table 2.1 summarizes the work of Eurelectric (2013), Madina et al. (2016) and Gomez et al. (2011), after which the roles are discussed and contributions of Ferwerda et al. (2018) are added to the interoperability discussion.

Table 2.1: Comparison of roles in EV charging network.
Roles of focus are in gray.

Role description	Gomez et al. 2011	Eurelectric 2013	Madina et al. 2016
Responsible for the electricity system operation at regional or national level	Transmission system operator (TSO)	Transmission system operator (TSO)	
Responsible for managing low and medium voltage electricity distribution grid	Distribution system operator (DSO)	Distribution system operator (DSO)	
An agent operating a private network to which the charging stations are connected e.g. home network or shopping mall		Private network operator	
Agent who sells energy to final customers	Supplier or retailer (SA)	Electricity supply retailer	

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Table 2.1 – *Continued from previous page*

<table>
<tr><th>Role description</th><th>Gomez et al. 2011</th><th>Eurelectric 2013</th><th>Madina et al. 2016</th></tr>
<tr><td>Agent that requires electricity for end users and purchases it from a supplier</td><td>Final customer</td><td></td><td></td></tr>
<tr><td>The agent has direct contract with the EV owner and provides services such as charging, information about charging station locations and routing</td><td>EV-supplier-aggregator (EVSA)</td><td>E-mobility service provider (EMSP)</td><td>Electro-mobility service provider (EMSP)</td></tr>
<tr><td>Agent owning the charging station</td><td rowspan="2">EV charging point manager</td><td>Charging station equipment owner</td><td>-</td></tr>
<tr><td>An agent operating the physical charging infrastructure through access control, data collection and maintenance</td><td>Charging station operator</td><td>Charging service operator (CSO)</td></tr>
<tr><td>The person charging an EV and having a contract with the electro-mobility service provider</td><td>EV owner</td><td>E-mobility customer</td><td>EV user</td></tr>
<tr><td>An agent nominating energy on a wholesale level</td><td></td><td>Balance responsible party</td><td></td></tr>
</table>

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Table 2.1 – *Continued from previous page*

Role description	**Gomez et al. 2011**	**Eurelectric 2013**	**Madina et al. 2016**
An agent that markets the difference between actual metered energy consumption and the energy bought from the supplier		Balance supplier	
Responsible for metering allowing a consumer to purchase electricity on the supply market		Metering point operator	
A global platform between charging station operators and EMSPs to organize services for data exchange and clearing		Data clearing processor	Marketplace operator

Table 2.1 shows that Eurelectric (2013) has proposed the largest variety of market roles that overlap with the narrower selection of roles in Gomez et al. (2011). Both take into account the value chain from the actual electricity distribution and supply to the electro-mobility services, whereas Madina et al. (2016) focus solely on the new agents in the commercial electro-mobility field. Despite different approaches, each conceptualization proposes three similar new roles: electro-mobility service provider/EV-supplier-aggregator (hereafter EMSP), EV charging point manager/charging station operator/charging service operator, and the EV user.

EMSP is one of the new key roles in EV charging ecosystem. All three papers provide complementing views on EMSP activities but generally they agree that the role incorporates activities related to end user services. EMSP is the agent that has direct B2C-contract with the EV user and it offers services such as charging, search of charging stations and routing (Madina et al., 2016). EMSP offers EV users access to charging stations of different charging station operators (Eurelectric, 2013). Gomez et al. (2011) perceive EMSP as a retailer that sells electricity for the

EV user and therefore it should not be viewed as part of the regulated electrical power system but as separate competitive entity. Furthermore, the contract of EV user and EMSP is not linked to certain locations or bound to single physical outlets, but EMSP aggregates demand for several charging points.

The second role new role is the agent operating the physical charging infrastructure, and the role consists of two separate tasks: ownership and operation of the charging station. Eurelectric (2013) has separated the charging station equipment owner and charging station operator roles, whereas Gomez et al. (2011) aggregate both tasks into the EV charging point manager role and Madina et al. (2016) do not take a stand on the ownership of the charging station. For the sake of clarity, the thesis follows the separation of the roles as proposed by Eurelectric (2013) because unbundling of ownership and operation of the charging station is relevant when observing existing business models. Hereafter, these roles are called charging point owner (CPO) and charging service operator (CSO).

CPO is the agent owning the physical charging station and also the connection to the grid, which means that CPO is the final customer purchasing electricity from the electricity supply retailer. CSO operates the charging infrastructure from the technical point of view. E.g. it monitors, maintains and controls the access to certain charging stations and has B2B-contract with EMSP through which it offers charging services (Eurelectric, 2013; Madina et al., 2016). All stations operated by one CSO form *a charging network*.

Finally, EV user is the individual who wants to charge their car. Actions required to access the charging station and pay for charging are not standardized and they depend on the organization operating the station. Nevertheless, an increasingly typical way of accessing a smart charger, that is part of a charging network, is with subscription to EMSP service (Ferwerda et al., 2018).

The EV user uses Radio-Frequency Identification (RFID) card or mobile app to authenticate at the charger and the payment is settled as agreed in the subscription model, typically with credit or debit card linked to the account. However, the subscription allows the EV user to access only the stations that are offered in the EMSP network, and to access other EMSPs' networks, the EV user must make separate subscription contracts with them, which may result in a dozen subscriptions in the worst case (Ferwerda et al., 2018).

To address this issue, charging networks have made roaming contracts such that the EV user is able to access other networks with her home network contract (in practice with the RFID card). To enable roaming, EMSPs and CSOs need to form a network interconnection, and Ferwerda et al. (2018) describe two ways of establishing it: roaming hub or bilateral contract.

Roaming hub connects EMSPs and CSOs indirectly such that EV user can charge in different networks with one contract only (see Figure 2.1). Bilateral roaming happens through direct contracts with EMSPs and CSOs.

On more abstract level, Ferwerda et al. (2018) define roaming as interoperability, which is ensured by compatibility standards that *"define the interface between two or more mating elements"*. Technologywise, the interface requires a protocol, and currently there are four different protocols in use in Europe and they do not communicate or exchange data with each other (Ferwerda et al., 2018). Hence, all-encompassing roaming is not available in Europe.

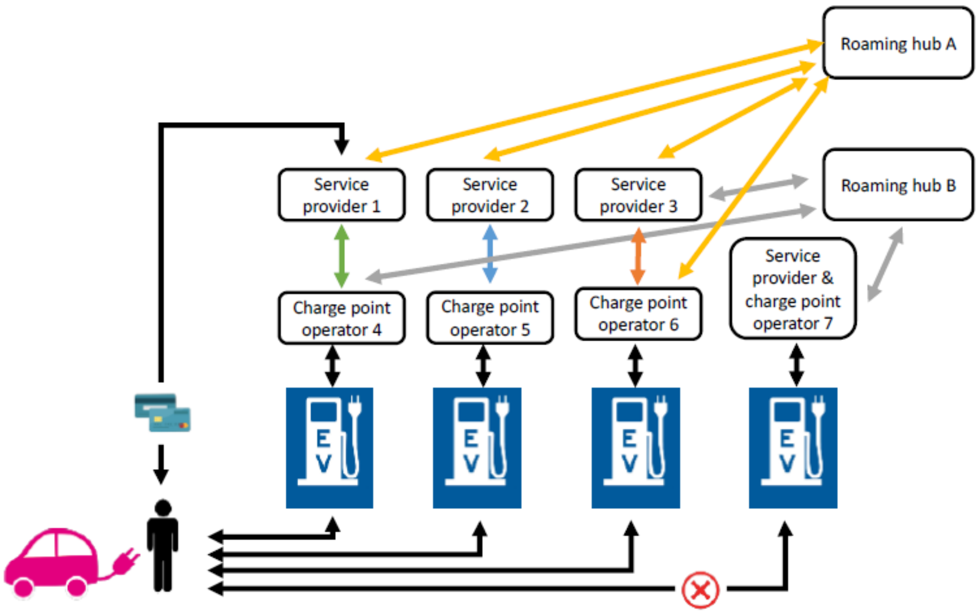

Figure 2.1: Description of a roaming hub (Ferwerda et al., 2018).

Role of roaming hub is also proposed by Madina et al. (2016) in the form of marketplace operator that contracts EMSPs and offers them roaming services, contract clearing and financial clearing. However, the concept allows broader activities than just roaming. Similar but not as comprehensive role is proposed also by Eurelectric (2013) in the form of data clearing processor. Gomez et al. (2011) do not discuss roaming in their paper.

In conclusion, EV charging ecosystem consists of multiple roles from the electricity production until the web-based marketplace for roaming services. For the purposes of the platform economy perspective, this thesis focuses on the division of new roles in the downstream of the electro-mobility value chain: electro-mobility service provider (EMSP), charging service operator (CSO), charging point owner

(CPO), electric vehicle user (EV user) and roaming hub. These roles are not limited by the regulation that concerns e.g. TSO, DSO and electricity suppliers, and therefore they can create new business models.

It is important to note, that the market model (i.e. the collection of roles) described here is not the same as business model (Eurelectric, 2013). The market model describes all roles needed in the EV charging network but in the real world one organization or company can simultaneously act in one or several roles. For instance, a CSO can also own the charging equipment and thus it is a CPO as well. The business model of that company is then the way in which it creates and captures value with its revenue model.

In the next section, I will present a synthesis of platform-based business model research and then apply it to the context of EV charging networks.

2.2 Multi-sided platform economy

Multi-sided platforms are organizations that create value by linking customers together and reducing search and/or transaction costs of the participants (Hagiu, 2014). The value creation logic differs from businesses that are organized as value chains, in which inputs are transformed into products (Stabell and Fjeldstad, 1998). Understanding the structure of the network of the platform and its implications is a key driver in designing multi-sided platform strategy.

Next, the network-based characteristics of multi-sided platforms are synthesized, and subsequently, the strategic decisions resulting from the network and market structure are presented.

2.2.1 Multi-sided platform characteristics

This section introduces the core concepts of multi-sided platforms: the evolution of platform concept per se and who the platform participants are. Secondly, network effects – the logic behind the value creation potential of most platforms – are discussed.

2.2.1.1 Evolution of platform research

According to Gawer (2014), research on platforms has evolved from two main streams: the economic view and engineering design view.

The economic approach sees platforms essentially as multi-sided markets, in which the platform mediates transactions between two user groups (e.g. Caillaud and Jullien, 2003; Rochet and Tirole, 2003; Armstrong, 2006). This stream has yielded insights on platform competition (Gawer, 2014).

The engineering design stream has focused on platforms as modular technological solutions that facilitate innovation (e.g. Baldwin and Clark, 2000; Baldwin and Woodard, 2009). In addition, the engineering design view has been further categorized to internal (product), supply chain and external (industry) platforms based on their openness for external complementors (Gawer and Cusumano, 2014).

Gawer (2014) claims that both streams have valid perspectives but they fail to describe some of the core functionalities of platforms.

The economic view sees both sides of platform as consumers and it does not consider the differing motives of developers of complementary products. It also sees the competitive environment as fixed focusing on the competition between platforms, not ecosystems. Thus, it ignores the competitive factors within the platform between the owner and participants. Fundamentally, economic view does not address why platforms emerge and evolve as it takes as given the existence of indirect network externalities (Gawer, 2009).

On the other hand, the engineering design view puts emphasis on modular platform architecture, in which the innovation happens. The limitations concern the lack of understanding in competition and how the platforms evolve structurally. (Gawer, 2014)

Hence, to bridge the interaction of competition and innovation on platforms, Gawer (2014) has proposed a new conceptualization of platforms that consider the organizational nature of platforms in exploiting economies of scope: *"Technological platforms can be usefully seen as evolving organizations or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply or/and in demand; and (3) entail a technological architecture that is modular and composed of a core and a periphery."*

The new organizational approach allows the platform research to address, first, both inter- and intraplatform competition and, second, it opens approaches for studying platform evolution. Tiwana (2014), for instance, uses the engineering design as the basis when observing platform ecosystems but ultimately, his objective is to describe perquisites of platform evolution.

The organizational approach on platform research by Gawer (2014) will be adopted in this thesis, as the conceptualization captures the competitive, architectural and evolvable characteristics of platforms, which are essential for understanding both the competitive and evolutionary dynamics of EV charging networks.

2.2.1.2 Multi-sided platform business model

Contrary to the general research on platforms discussed in the previous section, I will now narrow the discussion to the business model of a multi-sided platform (MSP). As a business model, MSP is more strictly defined than what e.g. Gawer

(2014) defines for technology platforms. MSP business model can be viewed as a sub-concept of technology platforms, thus, it does not conflict the aforementioned broader definition of technology platforms.

Traditional one-directional value chain business models include reseller model, vertically integrated firm and so-called input supplier (see descriptions in Figure 2.2) (Hagiu and Wright, 2015). MSP business model differs from these with two fundamental requirements.

Firstly, there must be at least two sides who want to benefit from each other, and the platform enables *direct interaction* between them, and secondly, each side is *affiliated* with the platform (Hagiu and Wright, 2015). By affiliation Hagiu and Wright (2015) mean that each side makes conscious platform-specific investments that are necessary for the direct interaction. The investments can be e.g. a fixed access fee, expenditure of resources or an opportunity cost. Tiwana (2014) adds that conditions for MSP business model exist, when two (or more) sides could interact directly but the MSP creates a smoother way for the interaction by reducing costs.

Furthermore, the ownership of residual control rights differs in MSP model compared to the alternatives. In the case of a MSP, the residual control rights over the activities (e.g. pricing of the goods traded) remain among the sides (Hagiu and Wright, 2015). If the focal firm decides on the residual control rights, the business model is not a multi-sided platform but one of the others.

To be precise with the terms, the participant roles related to MSP business model are defined next.

The organization operating the platform has been called e.g. platform owner (Tiwana, 2014), platform sponsor (Parker and Van Alstyne, 2008), platform provider (Eisenmann et al., 2006) or ecosystem's keystone firm (Iansiti and Levien, 2004). Hagiu and Wright (2015) call it multi-sided platform according to the business model.

However, there is a risk for misunderstanding if the concepts of the business model and the organization are not separated. Hence, the term 'platform owner' will be adopted in this thesis to describe the organization or the part of organization that operates a multi-sided platform business model.

Depending on the context and the stream of platform research, the two sides affiliating with the platform owner have been called producers and consumers (Parker et al., 2016), developers and consumers (Parker and Van Alstyne, 2008), app developers and end users (Tiwana, 2014) or sellers and buyers (Rochet and Tirole, 2006).

As most definitions of the sides are specific to certain contexts, such as application development, and are not applicable for more abstract analysis, the broadest definition of platform participants will be deployed in this thesis by calling them

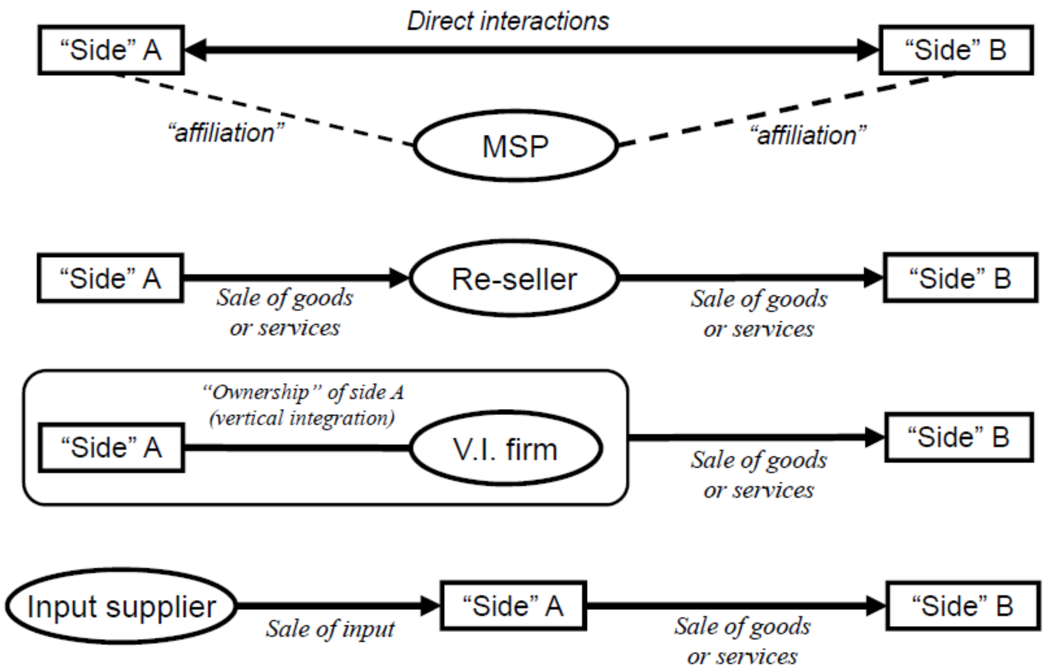

Figure 2.2: MSP vs. alternative business models. Adopted from Hagiu and Wright 2015.

"sides", or in case needed side A and side B, which can be further specified in each context. This definition also allows observation of platforms with more than two sides, and it takes into account that a single user on one side can act also on the other side (Gawer, 2014). E.g. a person can both sell and buy goods on eBay but usually does more of the other.

Together the platform owner and the distinct sides interact through interfaces and shared infrastructure and form an ecosystem. Figure 2.3 illustrates the roles of a MSP business model and links them to the concept of ecosystem. Competing ecosystems exist beside.

2.2.1.3 Network effects

The attraction of multi-sided platform business model arises from the non-linear or convex growth achieved by network effects, which refers to the degree to which every additional user increases the value created for other users (Tiwana, 2014;

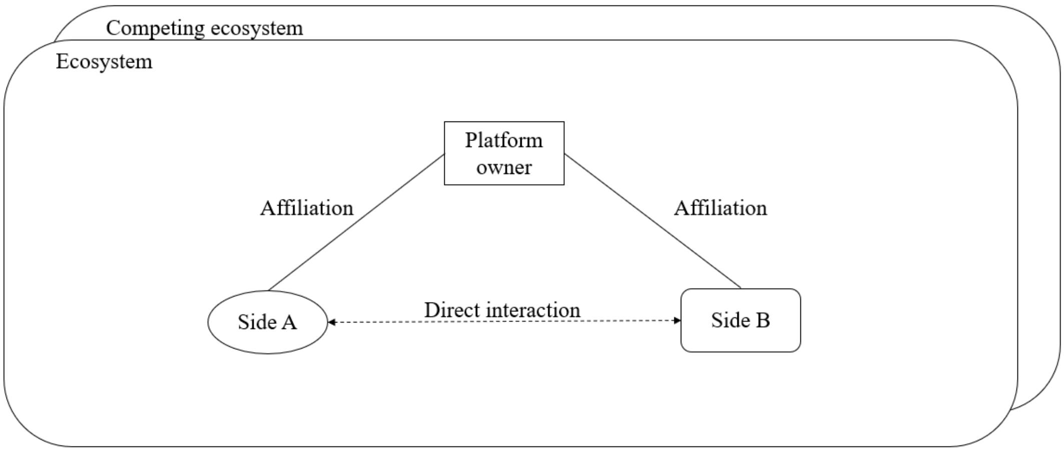

Figure 2.3: Description of multisided platform business model and ecosystem (modified from Tiwana 2014 and Hagiu and Wright 2015)

Parker et al., 2016)[1].

In economics, they are often referred as indirect network externalities (Caillaud and Jullien, 2003; Armstrong, 2006). Each new user increases the potential value dramatically, rather than gradually, by enabling network ties to all existing users. For instance, the value of telephone network increases dramatically the more users are connected to it as there are more people who can be reached through it.

Thus, the high valuations of businesses like Uber and Twitter are based on the vast networks rather than cash flows that have been the method for valuation in the era of one-directional business.

Network effects can be further classified by two properties: sidedness and direction (Tiwana, 2014), which results in four categories. Positive same-side, positive cross-side, negative same-side and negative cross-side network effects each create different feedback loops and require different kind of management from the platform owner. Figure 2.4 summarizes the explanation of each type with examples.

Consequently, positive same-side and cross-side network effects drive the platform growth through positive feedback loops. The more participants from one side are onboard, the more attractive it is for the other side to join. In the case of EV charging, this is assumed to arise such that when there are more EV drivers the more attractive it is for a new CPO to join a charging network.

[1]Even though most multi-sided platforms create and capture value through indirect network effects, Hagiu and Wright (2015) point out that there are MSPs whose value creation is not affiliated with them. Thus, network effects as such do not suffice to define a MSP business model.

	Same-side	Cross-side
Negative	Adding users decreases the value of the platform for users on the same side. E.g. Congestion in the charging stations increases when more EV users join.	Adding users decreases the value of the platform for users on the other side. E.g. More advertisers on internet platform annoy the users.
Positive	Adding users increases the value of the platform for users on the same side. E.g. Skype's appeal increases when more people use Skype.	Adding users increases the value of the platform for users on the other side. E.g. The more credit card owners there are, the more attractive it is for merchants to accept credit cards.

Figure 2.4: Network effects

However, this dynamic makes it hard for the platform to get started as neither side will join unless the other is there – known as the chicken-or-egg problem (Caillaud and Jullien, 2003; Hagiu, 2014). Strategies to address it include starting with one side (Tiwana, 2014), choosing appropriate pricing strategy (Eisenmann et al., 2006), solving an essential business problem and allowing easy connectivity to the platform (Gawer and Cusumano, 2008) or utilizing existing user bases and enveloping a new functionality to an existing platform (Eisenmann et al., 2011).

On the flipside of the coin, network effects may result in so called "winner takes all" dynamics, which refer to the phenomenon when it is difficult to establish competing platforms if there is already a giant existing player who has captured all the positive network effects (Eisenmann et al., 2011; Gawer and Cusumano, 2014).

Afuah (2013) points out that relying blindly on the number of users in the network does not guarantee the growth of the platform alone. Structure and conduct of the network are equally relevant to assess.

Structure refers to the organization of the users in the network and the interaction ties they have. Network effects are largest when every additional participant can make transactions with every member in the network. However, usually in two-sided markets the users interact only with the users on the other side, which decreases the number of ties and the same-side network effects consequently.

Furthermore, physical environment can affect the formation of network ties, if for instance connections require physical contact, the network effects will be local rather than global. In this case, the user is usually more influenced by the platform choice of the closest acquaintances rather than the overall installed base of the platform – a phenomenon called local bias (Lee et al., 2006). This phenomenon can keep the technologically inferior platforms running even though common sense would indicate platform consolidation.

Network effects are equally impacted by the conduct in the network. The platform owner should ensure that opportunistic behavior, negative reputation effects and lack of trust do not hinder network growth. Especially, this concerns facilitation of peer-to-peer platforms. (Afuah, 2013)

If capturing positive network effects reinforces the platform growth exponentially, the negative network effects can respectively lead to a quick collapse, when users on one side are distracted by e.g. advertising clutter, congestion or irrelevant content produced by the other side, and they start reducing the usage of the platform or even abandon it (Parker et al., 2016). Keeping the platform attractive for both sides requires the platform owner to make strategic decisions about incentives, integration and autonomy of the platform participants (Tiwana, 2014). These are discussed in section 2.2.3 Multi-sided platform strategic decisions. Before that, we will review literature that describes how MSP business model affects competitive environment in the industry.

2.2.2 Market structure and competition

Competition in platform markets usually refers to competition between the platform owners of competing ecosystems (e.g. Apple and Android), and the discussions try to understand the competing ecosystems' strategies. Tiwana (2015) refers to this as *inter*platform competition and adds that there is also *intra*platform competition that takes place inside the ecosystem, between the platform owner and the side (e.g. app developer) that is producing complements for the platform.

Interplatform competition intensity depends on the market structure i.e. how many competing ecosystems there are, which again depends on the industry lifecycle phase and the user preferences and costs affiliated with the use of the platforms. Respectively, intraplatform competition depends on the platform structure and the types and sizes of organizations that participate as platform owner and sides. Next, these competitive topics are covered.

2.2.2.1 Industry life cycle

The competitive environment of any industry depends largely on the stage of industry life-cycle, and different strategies are needed in emerging and mature industries. The platform life-cycle can be defined by looking into three dimensions: emergence of dominant design, technology maturity curve and the penetration of the technology in the prospective user base (Tiwana, 2014).

When a technology solution emerges, there are two design phases that it goes through. First, multiple alternative designs compete in the predominant design phase and competitors pursue different alternative solutions to meet the market needs. Different solutions are developed and eventually one of them becomes widely accepted – the dominant design. Usually, companies that produce inferior competing products exit the market at this point of the post-dominant design, and the development focus shifts to cost improvement and incremental development. (Tiwana, 2014)

Second dimension of the life-cycle is the maturity of the technology solution, that resembles S-shaped curve as a function of time. The maturity of a technology increases in a shape of S from introduction to decline. Usually there is a competing inferior technology that attacks the incumbent by suddenly outperforming the mature technology. It is difficult for the incumbents to identify when an inferior technology may actually be a threat that soon will make the incumbent obsolete. To keep up, the incumbents should be constantly observing technologies that may disrupt their domain and evaluate strategies to "leapfrog" to the next technology S-curve. (Tiwana, 2014)

The third life-cycle metric describes the technology diffusion among end users. According to Rogers (1995), the adoption of a new technology takes a form of a bell curve starting with the innovators, who seek completely new solutions to their personal use. Early adopters, who are often thought leaders in their communities, follow the innovators in adoption of the new technology and with their example the technology spreads to the majority of adopters. Laggards are the last 15 % who refuse to use the new solution unless they have to.

Understanding where a technology stands in the adoption continuum helps a company to design e.g. its marketing approach because different user groups appreciate different features in the technology. In multi-sided platform context, there are at least two distinct sides that can vary in their degree of technology adoption.

In conclusion, life-cycle dimensions tell what kind of customers there are in the market, how many competing design standards to assess and the consolidation level of the market as well as the technology maturity. This information is relevant when choosing a strategy to compete in the platform economy.

2.2.2.2 Monopoly market or competitive platforms?

How does the competitive environment in platform industry develop? Why are there multiple competing platforms in some industries (e.g. newspapers), whereas in others there is one monopoly platform serving the market (e.g. Google search)? And how should a platform owner in an emerging industry plan its strategy to ensure its evolution to platform leader? Next, the factors affecting market structure formation are discussed.

A key driver in platform competition is the concept of multihoming, which means a situation in which one or both sides of the platform are participating in more than one platform ecosystem to gain larger network externalities (Armstrong, 2006). For instance, using both Visa and Mastercard is multihoming from the consumer perspective, and if a merchant approves both credit cards as a payment method, she is also multihoming on two platform ecosystems.

The tendency to multihome depends on the costs affiliated with the competing platforms. If costs of multihoming are low, the participant is likely to participate in several platforms. High multihoming costs, on the other hand, are one way of creating lock-in for the platform. Furthermore, multihoming is likely in the early stages of platform life-cycle, if there is uncertainty related to the winning standard and users on both sides do not want to lock in to a single platform that may fail (Tiwana, 2014).

The ease of multihoming is one factor defining the development direction of the market structure. If the costs of multihoming are high for at least one side, and the cross-side network effects are strong and positive for that side, the market is likely to be served with a monopoly platform (Eisenmann et al., 2006).

On the contrary, if there are low multihoming costs for both sides, the customers demand for wide product variety, and the network structure results in local rather than global network effects, the existence of multiple competing platforms has good conditions (Lee et al., 2006; Hagiu, 2009).

The likelihood of the market inclining towards either monopoly or competing platforms acts as the foundation for the platform strategy, which includes choices in pricing, market entry and non-price mechanisms.

If a monopoly platform is the likely market outcome, the platform owner willing to win the game needs to use so called get-big-fast strategies, as the reinforcing loop of positive network effects results in winner-takes-all situation, in which the platform associated with best characteristics attracts most complementarity producers, which in turn improves the attractiveness of the platform and so on (Eisenmann et al., 2006; Gawer and Cusumano, 2014).

The strategies include early market entry to capture customers before rivals, enforcing competition among the complementary product producers and making exclusive contracts with producers so that they cannot supply a rival platform (Cennamo and Santalo, 2013). However, Cennamo and Santalo (2013) point out that using these strategies simultaneously, may lead to trade-offs that actually result in worse outcome. In traditional strategy literature this has been referred as "stuck-in-the-middle" position (Porter, 1985).

In the case of multiple competing platforms, Cennamo and Santalo (2013) suggest a distinctive positioning strategy, in which the platform creates its offering to serve a niche market and tries to have the portfolio of the complements in the platform distinct from the rivals. Benefits of this approach include increased market power, even though pursuing a very differentiated strategy may be risky and resulting in customers adopting a more mainstream platform.

2.2.3 Multi-sided platform strategic decisions

Competing in an industry with multi-sided platform business logic requires successful positioning in the market. Life-cycle stage and the market structure discussed in the previous section define the competitive environment, in which a platform owner has power over deciding on a set of strategic decisions.

In this thesis the focus is on so called tipping strategies for winning the platform competition, and coring strategies that focus on establishing a platform when none existed before are excluded (Gawer and Cusumano, 2008).

Thus, this chapter reviews prior research on pricing, governance and interconnectivity – topics affecting the platform positioning in terms of value capture and its openness in the market. Parker et al. (2016) advise that strategic decisions such as pricing should always be designed such that they support the positive network effects, and if possible, hinder the development of negative network effects.

2.2.3.1 Pricing

Pricing a multi-sided platform is different from pipeline business and it results from the role of the platform as a mediator.

Rochet and Tirole (2006) define *"a two-sided market as one in which the volume of transactions between end-users depends on the structure and not only on the overall level of the fees charged by the platform"*. Thus, the platform owner needs not only to make decisions about the pricing model and level but also about the pricing structure and symmetry to two (or more) directions.

Parker et al. (2016) remind that multi-sided platform monetization is a delicate task because thoughtless pricing models can deter the network effects and reduce activities on the platform. Thus, they suggest deliberately understanding what the value created by the platform is and finding a pricing model that captures that value but does not prevent the value creation process itself.

Typically, a multi-sided platform needs to choose a pricing model for each side, and often, the pricing is not symmetric but the so called 'subsidy side' is charged only a little or nothing at all and the 'money side' pays to get access to the subsidy side and therefore it also acts as the profit center for the platform owner (Eisenmann et al., 2006; Tiwana, 2014).

Asymmetric pricing is closely related to the platform early life-cycle stage and strong cross-side network effects because it is a way to attract a critical mass of adopters on the subsidy side (Tiwana, 2014). However, choosing which side to subsidize is not trivial. Many studies have contributed to this problem and the various dimensions to be taken into account are summarized in Table 2.2.

Price sensitivity and the presence of 'marquee users' are rather intuitive. The platform should charge less from the more price sensitive side and from the side that has 'marquee users' that attract users to the other side. Price sensitivity can be deduced from the amount of substitutes available or from the bargaining power that the MSP has over the participant group (Hagiu, 2014). Marquee users can have strong brand value (e.g. Apple flagship store in a mall) or they are exceptionally big buyers (e.g. government) (Eisenmann et al., 2006).

Other pricing choices are less intuitive. For example, it is not the side that demands for quality that is charged more but the side that must supply quality for the other side. This is because producing quality is expensive and there needs to be confidence that there are buyers who will buy the expensive products. Thus, buyers are subsidized (Eisenmann et al., 2006).

Similarly, user demand for variety usually leads to competing platforms and then the buyer pays for that. However, if there is a monopoly platform, in which a buyer side demands for variety, it is the producer side that is charged more. The reason is that demand for variety means less available substitutes and the producers thus have relative power over the buyers and can extract profits from them, and then the platform is able to charge those from the producer side (Hagiu, 2009). This topic shows that the antecedents of industry competitive dynamics discussed in previous section are not unambiguously leading to either monopoly or competitive industry but both are plausible.

Finally, steering describes a situation of platform structure, in which one side multihomes and the other singlehomes (Rochet and Tirole, 2003). If a multihoming participant wants to interact with an agent in the singlehoming side, the participant must deal with the chosen platform, which gives the platform owner a monopoly power to provide access to the singlehoming participant. Thus, higher prices can be charged from the multihoming side, and actually the seemingly good position of multihoming leaves them with no surplus (Rochet and Tirole, 2006).

Table 2.2: Summary of elements affecting platform pricing structure

Question	Money side	Subsidy side	Source
Which side is more price sensitive?	Less price sensitive	More price sensitive	Eisenmann et al. 2006
Which side is more sensitive for quality?	Must supply quality	Demanding for quality	Eisenmann et al. 2006
Buyer side demands for variety on a monopoly platform	Seller side	Buyer side	Hagiu 2009
Buyer side demands for variety in products on competitive platforms	Buyer side	Seller side	Hagiu 2009
Which side has more power over the other side (in monopoly platforms)? Or can extract value from the other side?	Power side	Side with less power	Hagiu 2009; Hagiu 2014
Are there 'marquee users' that increase the attractiveness of the platform on either side?	Side with 'non-marquee users'	Side with 'marquee users'	Eisenmann et al. 2006; Rochet and Tirole 2003
Which side has lower multihoming costs?	Low multi-homing costs	High multi-homing costs	Rochet and Tirole 2003, 2006; Armstrong 2006

However, the platform owner must pass a greater share of the profits to the singlehoming side to keep them on that platform, so it is the singlehoming side that wins (Rochet and Tirole, 2003; Armstrong, 2006). However, Rochet and Tirole (2006) claim that multihoming usually refers to gaining benefits of non-interconnected platforms, which is not the case in EV charging as some of the charging platforms are connected through roaming services.

Second pricing dilemma concerns the pricing model: should the platform charge for usage or access to the platform or both? This question is not relevant in the case of a monopoly platform but for competing platforms it matters to set an optimal pricing model (Armstrong, 2006). Pricing needs to be aligned with platform life cycle stage (Armstrong, 2006; Tiwana, 2014).

Armstrong (2006) argues that fees based on usage are useful when trying to attract both sides of the platform on board. It is easier to participate in the platform in the absence of the other side, if only per-transaction fees need to be paid. For instance, the EV user is probably happy to pay only when they charge the car if there are not that many charging stations in the network. However, the cross-side network effects are weaker in this pricing scheme because there is always a barrier of the transaction fee to participate in the activities of the platform. So, the benefit of interacting with an additional agent in the other side is diluted with the additional fee.

Tiwana (2014) advises not to combine usage and access fees on the same side of the platform but the pricing models can differ on the distinct sides of the platform.

2.2.3.2 Governance and boundary resources

In addition to pricing strategies, the MSP can use a set of non-monetary strategic instruments to regulate the activities between the platform owner and the participating sides (Boudreau and Hagiu, 2009).

Governance refers to the actions through which the platform owner grants access to the platform and ensures quality of the platform interactions by deciding what the participants on each side are allowed to do (Hagiu, 2014). Governance decisions need to balance between regulation, minimizing negative network effects and fostering innovation. Thus, too strict rules are not good as they do not leave room for platform user innovation. Instead, platform owner should allow the use of the platform in ways that it was not originally designed to or even imagined, in order to allow modular evolution of the ecosystem (Parker et al., 2016).

Governance actions take place in the boundaries of the platform. In software platform research, the concept of *boundary resources* is used to describe resources that facilitate the complementors in their work i.e. *"the software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer"* (Ghazawneh and Henfridsson, 2013).

Even though the focus of boundary resources literature focuses on the interactions between platform owner and third-party developers, the concept can also be extended to understand the governance actions through which the platform owner stabilizes the relationship between itself and the end user of the platform (Ghazawneh, 2012). Thus, the purpose of boundary resources is to provide means of governance for the platform owner as well as stimulate different platform sides' participation in the platform in a controlled way (Ghazawneh and Henfridsson, 2010).

Boundary resources can be technological (APIs, SDKs[2], power socket connections), social (IPR, legal agreements, documentation), informational and other instruments (Boudreau and Hagiu, 2009; Ghazawneh, 2012).

As the name "boundary resources" implies, interactions between the platform owner and the complementors or end users take place in the boundaries of the platform. In the case of EV charging, it is important to note that the platform sides' interaction includes physical elements i.e. charging stations and EVs and is dependent on location. Hence, the boundary resources may differ from platforms that operate purely in the digital world.

2.2.3.3 Interconnectivity and openness of platforms

Thus far the focus of the literature review has been on distinguishing the strategies if there is either a monopoly platform or multiple competing platforms that do not interact. However, what if the competing platforms are not completely isolated but they offer a possibility for interplatform connectivity?

Need for interconnection arises when a network would need to duplicate itself in order to be able to provide larger service for its customers. Instead, it chooses to make a contract with competing network provider, and thus provides its customers access to a wider network without the need to invest in it.

Interconnection can take place between any networked markets but research on it has arisen from the needs of telecommunication industry, since there has been the greatest need for understanding the dynamics of a mobile phone being used outside its home network in another operator's network without a direct consumer contract with that secondary network. Hence, there must be an interconnection agreement between the network operators so that the home network can charge termination fees from its customer if it visits the other network e.g. while travelling abroad.

The interesting questions are, what is the benefit of interconnectivity for the sides of the connected platforms, and how should the termination charge be distributed between the two sides that interact.

Literature on interconnectivity of networks focuses on the theory of pricing and effects on competition when networks connect (e.g. Armstrong, 1998; Carter and Wright, 1999). Early works (e.g. Armstrong, 1998) assume symmetric networks and duopoly market, which seldom reflects the reality because there is usually an incumbent firm that faces competition from smaller entrants. Negotiations on interconnectivity are therefore not equal.

Hermalin and Katz (2011) approach the pricing dilemma by assessing who enjoys the benefits of the internetwork connection and they argue that the cost should

[2] API stands for application programming interface and SDK stands for software development kit.

be divided based on the distribution of the benefits between the two sides, which contrasts the common assumption of one-sided sender benefits (e.g. Armstrong, 1998).

A network's approach to interconnectivity depends on the strategy they want to pursue, as interconnectivity can be a tool to adjust competition between the networks. He et al. (2012) claim that interconnectivity weakens price competition by creating complementarity because the two products share a single network and, thus, they are more valuable than alone. Thus, as long as firms do not pursue predatory goal, it is wise for them to invest in interconnectivity.

Networked markets, e.g. telecommunication, are often regulated. Carter and Wright (1999) claim that regulation is needed because networked markets are not likely to achieve efficient outcomes, as the competitors will find interconnection agreements but those are not necessarily in the benefit of the consumer but rather allow legal collusion. Thus, the problems of interconnectivity are not usually related to agreeing on the price of the connection between the networks but rather to the power that the networks have over consumers.

2.3 Synthesis: Strategic decisions of multi-sided EV charging platforms

Smart, connected EV charging stations can be organized as a network that is possible to operate with the multi-sided platform business model. Two defining factors of a MSP by Hagiu and Wright (2015) – platform enabling direct interaction between two sides, and each side being affiliated with the platform – can be reviewed with the roles of EV charging network provided by Eurelectric (2013). EV users and charging point owners can be viewed as the two sides of the platforms, but to define the platform owner role a more elaborate inspection is required.

EV users are affiliated with the EMSP by signing a contract with them, and they have direct interaction with the CPO when charging. Similarly, CPOs are affiliated with the CSOs. Thus, the direct interaction requirement is fulfilled, and the affiliation seems to hold true as well.

However, the affiliation of each side is connected to different market role, and we have two roles in the place of the platform owner: EMSP on the EV user side and CSO on the CPO side, both of which are enabling interactions between the sides (Figure 2.5). If the definition of an MSP by Hagiu and Wright (2015) is followed further, the EMSP and CSO can fulfill the platform owner role in case they are the same organization.

Eurelectric (2013) remarks that their market model conceptualization is different from the actual business models that can combine several market roles into

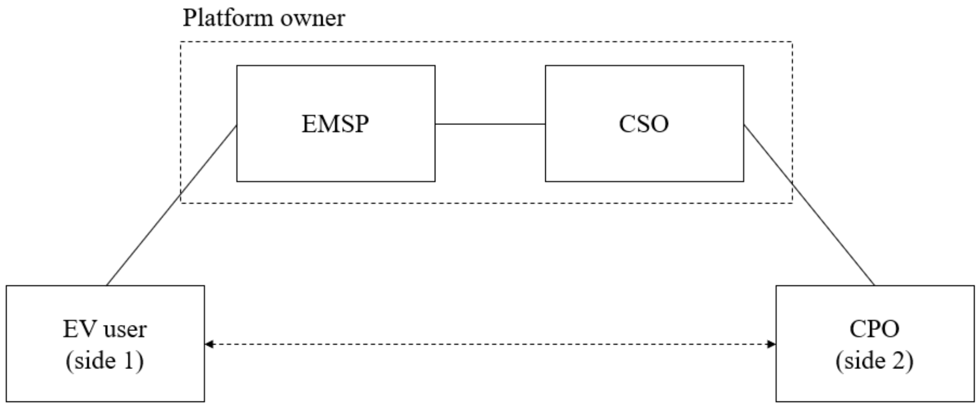

Figure 2.5: EV charging network participants as multi-sided platform agents

one organization, which supports the MSP definition of Hagiu and Wright (2015).

Multi-sided platform business model is attractive because it creates value by reducing transaction costs of the sides (Hagiu, 2014). Network effects is the phenomenon that enables the value creation as the sides are attracted to the platform the more there are participants in the other side.

In the context of EV charging, this would mean that EV users are attracted to the charging platform the more there are CPOs, and thus charging stations, on the other side. Each new member on either side is expected to increase the value of the platform because there are more connections available (Tiwana, 2014).

However, the exponential growth potential can be limited due to structural and local limitations. If there are rather local than global network effects, the users are more likely to use platforms that are nearby or their peers use even though they may be technically inferior (Lee et al., 2006).

The research on multi-sided platforms suggests that the competitive environment in platform-based industries is characterized by three main factors: multihoming, strength of network effects and preference for product variety (Eisenmann et al., 2006; Hagiu, 2009). Changes in these variables predict whether the industry will be served with multiple competing platforms or if the customers will tend to converge on a single platform. In addition, industry life-cycle stage needs to be taken as a frame for the competitive environment analysis (Tiwana, 2014). Synthesis of platform characteristics affecting the competitive landscape is visualized in Figure 2.6. Depending on the direction of market formation, the platform owner has to decide on strategic approach.

If the likelihood of convergence to a single platform is high, the platform owner

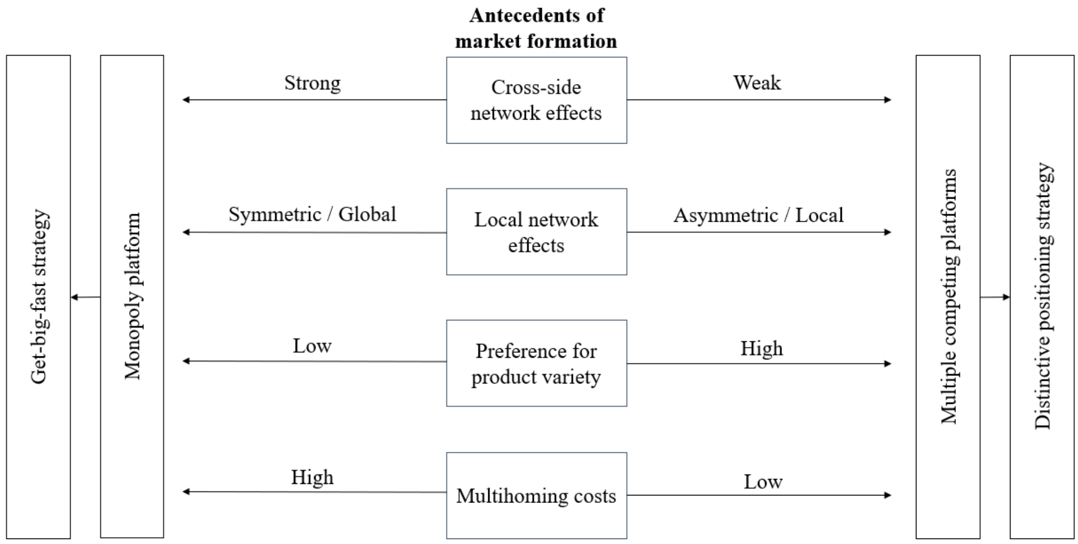

Figure 2.6: Synthesis of competitive characteristics and market formation logic.

should try to win the battle of becoming the market leader, while in opposite case a distinctive positioning among multiple platforms is a desirable direction (Cennamo and Santalo, 2013). There are two important instruments available for multi-sided platform companies to create a strategy for either market model: pricing and governance.

Pricing instruments aim at winning both sides on board quickly by exploiting the asymmetric pricing structures for the sides (Rochet and Tirole, 2006). Basically, the pricing strategy decision can be simplified to the problem of choosing a subsidy side, that is attracted to participate in the platform with low fees or even at no cost, and a money side that must pay more for the access to the platform. Selection of the subsidy and money side is affected by the sides' price sensitivity, quality sensitivity, multihoming costs and relative power over the other side among other things (Armstrong, 2006; Eisenmann et al., 2006; Hagiu, 2014).

Governance instruments aim at controlling the sides' interactions quality and quantity such that the platform remains attractive for all sides. Practically, it means setting of rules to control access to the platform and govern the interactions between the sides (Hagiu, 2014).

In addition to deciding on pricing and governance internal to the platform, the platform owner can decide on the platform's connectivity to other platforms. In EV charging literature this is called interoperability or roaming (Ferwerda et al., 2018), and on abstract level, field of network interconnectivity studies the phenomenon (Armstrong, 1998; Carter and Wright, 1999). The relevance of interconnectivity as a MSP strategy can be analyzed with the following factors.

Firstly, Rochet and Tirole (2006) argue that the rule of making money on the side that has lower multihoming costs does not apply when there are interconnection possibilities between platforms. Hence, platform pricing and interconnectivity decisions should be aligned. Secondly, investing in charging network interoperability or refraining from it is a strategic choice since investments in interconnectivity can reduce competition in the markets or, conversely, no interconnectivity can be a predatory strategy choice (He et al., 2012). Thirdly, there may arise a need for external regulation, as interconnectivity seldom results in the benefit of the consumer, in this case the EV user (Carter and Wright, 1999).

In conclusion, I hypothesize that EV charging company can operate as a multi-sided platform when it mediates transactions between EV users and CPOs.

The literature review reveals that theory on multi-sided platforms is well established and it offers validated insights on strategy development on a general level. However, it is unclear how the theory applies to the context of electric vehicle charging networks as those have been studied mainly from technological perspective and a theoretical gap exists in EV charging business model research.

Therefore, the empirical part of the thesis aims at discovering if and how EV charging networks can be described as multi-sided platforms, and how the identified competitive factors and strategies apply in this context.

Chapter 3

Methodology

The objective of this research is to describe the competitive environment of EV charging networks in the context of multi-sided platform theory. This section explains the research process and justifies the choices regarding applied research methods. Reliability and validity of the research are evaluated in the end of the chapter.

3.1 Research design

Business research design consists of interrelated decisions regarding the research philosophy, approach on theory and empirics, as well as the methodological decisions on research strategy and data collection techniques (Saunders et al., 2009). Philosophical considerations on epistemology – *"what is (or should be) regarded as acceptable knowledge in discipline"* (Bryman and Bell, 2007) – and ontology – what exists? – are important to start with because they influence what research methods are appropriate.

This research contributes to the field of social sciences, which differs – if an interpretivist epistemological position is taken – from natural sciences by taking into account the social action that differentiates people from objects (Bryman and Bell, 2007). Ontologically, the question of existence can be viewed from objectivist or constructionist positions. The former sees reality existing independent of social actors whereas the latter asserts that social phenomena is continually created by social actors (Bryman and Bell, 2007).

In this research, it is important to acknowledge that the studied phenomena relate to organizations and markets that form complex reality. Therefore, recognition of both the structural aspects as well as agency is considered relevant and a critical realist paradigm is adopted. In this paradigm, the researcher's view on reality is objective and reality *"exists independently of human thoughts and beliefs or* *knowledge of their existence (realist), but is interpreted through social conditioning (critical realist)"* (Saunders et al., 2009).

This research follows deductive approach, in which a hypothesis is deduced based on the existing theory and it is tested with empirical data. However, a classical hypothesis is not formulated but rather a series of assumptions and questions are developed from the theories that relate to multi-sided platforms and EV charging, an approach which is supported by Bryman and Bell (2007) when *"the variables are conceptual and do not translate into simple constructs"*.

A qualitative research strategy is chosen because the focus is on understanding the world of EV charging through examining the interpretation of that world by the participants who are constructing it.

3.1.1 Data collection

The primary data for the study was collected through 17 semi-structured interviews. The interviewees were recruited such that all four charging network roles identified in the literature review were represented in the sample (see Figure 2.5). Thus, the sample included altogether 12 representatives of EV charging network companies (EVCC), charging point owner companies (CPO) and individual EV users (EVU). All EV charging network companies selected to the sample had some kind of platform-based business model.

To get general and less company-focused views, two industry specialists (IS) from academia and industry advocacy were included in the sample. In addition, to address specifically the topic of interoperability, three roaming specialists (RS) were interviewed in a separate interview setting. Thus, the sample consists of five categories as summarized in Table 3.1. Complete list of interview details is summarized in Appendix A Interview details.

Table 3.1: Categorization of interview respondents

Interview type	**Interviewee category**	**n**
Cross-sectional interview	EV charging company (EMSP and/or CSO)	6
	CPO	3
	EV user	3
	Industry specialist	2
Roaming interview	Roaming operator or roaming specialist	3

Semi-structured interviews were chosen as the primary data collection technique as its advantage compared to surveys and structured interviews is discovery because the interviewer can enrich the data by asking subsequent questions (Ghauri and Grønhaug, 2010). Additionally, as the research topic is explorative by nature, the semi-structured open-ended questions allow the respondents to answer freely based on their own thinking.

Cross-sectional interview approach was adopted to address seven focus areas that were deduced from the literature review: structure of the platform, network effects, pricing, competition between platforms, governance, interconnectivity and future of EV charging.

A set of questions for each topic was created, and each question was modified to study the topic from the perspective of the respondent category. Different questions were used because respondents' knowledge and perspectives varied by category and not all topics were equally relevant for everyone. Roaming operator / roaming specialist category was treated separately, and interviewees in that category answered only questions regarding roaming.

Appendix B Interview guide clarifies the interview setting by listing first the cross-sectional interview questions in a matrix by focus area and interviewee category (Table B.1), and then it presents the roaming interview guide. The interviews were recorded and transcribed so that the analysis could be done robustly and the data could be revisited in the analysis phase.

3.1.2 Thematic analysis

Thematic analysis methodology of Braun et al. (2019) is adopted in this thesis to analyze the collected data material. According to Braun et al. (2019), *"TA is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set."*

Thematic analysis is chosen as the analysis method because it is flexible yet systematic process for discovering patterns from qualitative data. The thesis follows the six-step process described by Braun et al. (2019) with some modifications which were needed due to the data covering several separate topics, some of which were not thematic by nature but required descriptive processing.

Figure 3.1 summarizes the research process from data collection to conclusions and below is described the six-phase thematic analysis process applied in this study.

1. Familiarizing yourself with the data

The first phase included immersing in the data by reading the interview transcripts and listening to the audio recordings. At this phase, notes on the data were written actively to mark interesting points made by the interviewees.

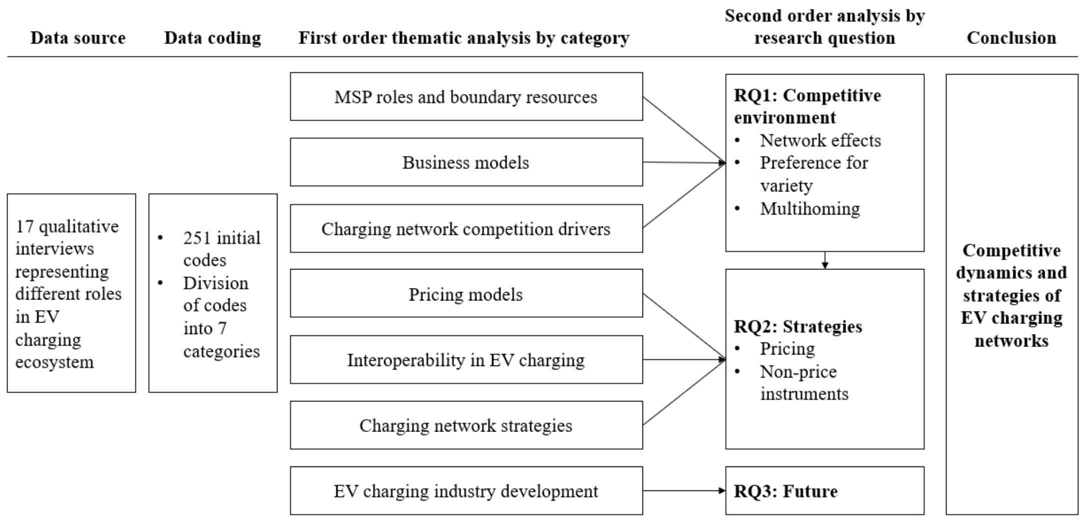

Figure 3.1: Research process

2. Generating initial codes

The second phase consisted of systematic coding of the data transcripts. Deductive approach in generating the codes was used as the seven interview focus areas derived from theory acted as initial code groups, under which codes were added. Data that did not fit into pre-defined groups was also coded and left to wait for later analysis. Some data excerpts were labelled more than once if they fit to several codes. Both descriptive and interpretive codes were used. Altogether 251 individual codes were created at this stage. Next, the codes were reviewed against the pre-defined groups and some second-order coding was done to create clarity in the groups that had most codes.

3. Searching for themes – first order thematic analysis

Due to the large amount of data, the coded data was first organized into seven categories: MSP roles and boundary resources, business models, pricing models, charging network competition drivers, interoperability in EV charging, charging network strategies and EV charging industry development. Formation of the categories started from the initial interview focus area grouping but some reorganization was needed because new categories emerged during the analysis and some codes did not fit to any pre-defined category.

Searching for themes was done separately in each category. Themes were created by grouping similar codes together. Each theme was named and a described briefly but no further analysis was conducted. In some categories thematic analysis was not meaningful due to the descriptive nature of the data. Therefore, the relevant data content was described in free form. Chapter 4 Findings describes the results of this phase.

4. Reviewing potential themes – second order thematic analysis for narrowing the themes to research questions

Now focus was shifted more sharply to the research questions and the initial themes in categories were analyzed with respect to their contribution to the research questions. Data and themes were compared to the literature frameworks with two types of approaches.

Primarily, thematic data was interpreted with the literature frameworks to extend the MSP theories to EV charging context. For example, pricing symmetry strategies were studied by interpreting the data in terms of MSP sides' price sensitivity and multihoming behavior, and a conclusion on suitable strategic decisions was formed. Secondarily, the primary theoretical conclusions were reviewed against the descriptive data (if available) meaning that a cross-check of the alignment of pricing symmetry theory and practice was conducted to validate or contradict the primary conclusion.

Results of this phase are described in chapter 5 Analysis.

5. Defining and naming themes

After analysis of the themes and comparison to prior research, both the findings and the analysis were read through and evaluated by looking whether the analysis was supported by the data. Next, a conclusive synthesis that brought the three research questions together on a general level was produced and the results were evaluated against the original purpose of the thesis. Chapter 6 Discussion and conclusions contains this phase.

6. Producing the report

Finally, Braun et al. (2019) suggest writing the report of the conclusions of the thematic analysis. As described in phases 3-5 this was not a separate phase in this thesis process but each part was documented during the analysis to suit the format of master's thesis.

3.2 Research evaluation and limitations

Reliability and validity are common criteria in research evaluation and their assessment relates to the generalizability of the results (Bryman and Bell, 2007). The concepts have been established for quantitative research and many researchers have modified the concepts to better assess the quality of qualitative research. For example, trustworthiness, rigor or quality are some of the typical conceptualizations that entail elements of validity and reliability in the context of qualitative research (Golafshani, 2003).

The main reason for assessing qualitative research with different criteria than quantitative research is the attitude towards truth. In qualitative research there can be more than one account of truths and thus using validity and reliability is not meaningful (Guba and Lincoln (1994) cited in Bryman and Bell, 2007).

Next, I describe the ways in which I have aimed at improving the quality of the thesis. However, some limitations remain and they affect the generalizability of the results.

Firstly, chapter 4 Findings, which describes the first part of the thematic analysis, is written to provide rich details about the context of EV charging. The purpose of lengthy descriptions is to establish the importance of the context for readers and specify the environment in which the informants operate. This way the behavior and actions can be understood in the social setting of the informants.

Secondly, I have aimed at authenticity (Guba and Lincoln (1994) cited in Bryman and Bell, 2007) by interviewing different stakeholders in the industry and presenting their views equally in the analysis. In some contexts, the views of e.g. EV users are emphasized so that the reader can make a distinction of the customer and company perspectives.

Still, some limitations remain. Firstly, the interviewee sample does not contain any representatives of pure EMSP business model, even though that emerged as an important business model according to other interviewees. Secondly, the interviewed CPOs were all customers of the same EV charging company and thus their motivations and perceptions do not necessarily generalize to all charging point owners. Thirdly, the interview sample consists of six representatives of EV charging companies but four of them represent the same company, so the perspectives may be skewed towards their views. However, this was a purposeful choice because the company operates a MSP model and therefore more focus was relevant to put on them.

Finally, triangulation is a widely used tactic to improve research quality. It means using more than one method or data source in the study (Bryman and Bell, 2007). This research entails only one primary data source – the cross-sectional semi-structured interviews. Triangulation is not used because the scope of the thesis limits the extent to which it is meaningful to apply other methods. However providing ideas for further research, the results of this thesis could be validated by studying the same phenomenon with quantitative approach. For instance, quantitative data on market shares, EV penetration rates, company revenues, mergers and acquisitions etc. could be used to complement the rich qualitative analysis applied in this thesis.

Chapter 4

Findings

This chapter describes the results of the first-order thematic analysis. The chapter is organized according to the seven categories identified in the data analysis process. Each section contains either the discovered themes or the descriptive data depending on the topic. Thematic categories are summarized with preceding codes in table format and discussed briefly afterwards. Categories with descriptive data only are discussed separately. All information in this chapter is based on the interviews unless otherwise stated.

4.1 MSP roles and boundary resources

The informants identified roles of EV user, EMSP, CSO and CPO in the EV charging networks. However, there was a lot of unclarity regarding the separation of EMSP, CSO and CPO roles and some informants considered them sometimes as one entity, which is due to their reflections on prevailing business models in the industry.

EV user role was clear and unambiguous for everyone and it was understood as the end user of the charging service. EMSP role was defined as having the EV user customer relationship, and this was particularly clear for the roaming specialists and EMSP-CSO informants.

Unclarity regarding EMSP role was due to the multitude of organizations that can offer charging services. A CSO can possess the role of EMSP but also supermarkets, energy suppliers and car manufacturers offer EMSP services. Common denominator for them is the organizations' existing customer base that they want to leverage for charging business.

Unclarity was also found on the CSO and CPO side, as very different organizations hold the roles. Thus, the CPO role was often further divided into two categories based on the ambition level of the CPO organization.

Secondary business CPOs were described as organizations that have EV charging as a side business or as means to attract customers to the primary business. Additionally, making profit with charging was not seen as their priority. Typical organizations mentioned were e.g. hotels and supermarkets.

On the contrary, professional CPO category was described as an organization that has strategic ambition with charging and is eager to profit from the charging business. Energy utilities were mentioned as typical representatives of this role. Professional CPOs may even resell the charging services of the CSO to secondary business CPO and therefore some informants perceived these roles as the same. The distinction of professional CPO and CSO was also very fine line in the case where an aggregator role was described as standing between the CSO and bunch of small CPOs.

> *"The idea is that the operator is a company that makes contracts with different small CPOs. So it kind of offers services for CPOs and then somehow aggregates the CPOs and offers EMPs*[1] *access to network that consists of many different CPOs."* (EVCC1)

Responsibilities and decision rights of each role as well as the boundary resources connecting the roles were discovered by asking the interviewees what different roles are able and allowed to do in the platform. Table 4.1 summarizes the activities by role.

The unclarity of EMSP, CSO and CPO roles becomes evident through platform activities. Firstly, interviewees agreed on that CPO can set the charging price. However, in some cases this price went unchanged to the EV user via CSO and EMSP, whereas in other cases EMSP was able to decide on their own pricing, though obviously considering the CPO price that they needed to pay. EMSP could for example decide on fixed price per charging for their customers instead of having the CPO-set prices for the EV users. Control rights regarding roaming were partitioned between CPO and CSO. CPO could decide if the station was available for roaming but CSO controlled pricing of the total network.

Secondly, distinction of EMSP and CSO responsibilities was unclear. This is likely due to the interviewees representing organizations that play both roles simultaneously and therefore the tasks were not clear-cut. However, pure EMSP business models exist. For instance, car manufacturers such as Audi, have published their own EMSP services.

> *"And what is nice for Finnish driver, is of course that Audi guarantees a fixed pricing because price of electricity and price of charging vary across Europe.... Audi kind of solves this problem. They have*

[1]EMP is widely used equivalent for EMSP in the charging industry.

Table 4.1: EV charging network activities and control rights by role.

<table>
<tr><th>Role</th><th>Activities</th></tr>
<tr><td>EV user</td><td>Searches for charging points (CP)
Sees CP status information: free, occupied, offline
Sees charging price (usually available only online)
Controls starting and stopping of charging
Adds payment card to the account
Pays for charging to the EMSP
Sees own charging history
Reports for problems</td></tr>
<tr><td>CPO</td><td>Owns the charging station equipment and is responsible for the grid connection
Purchases electricity for the charging station from electricity supplier
Decides on pricing of the CP
Responsible for the maintenance of the CP
Decides on CP roaming availability
CP description text in EMSP's charging application
Has access to CP usage reports
Pays membership fee or equivalent to the CSO</td></tr>
<tr><td>CSO</td><td>Operates and monitors the affiliated CPOs' charging stations with technological capabilities
Mediates charging payments between EMSP and CPO with agreed revenue share model
Offers EMSPs capabilities to offer e-mobility services for EV users
Access to CPOs' charging stations
White label application (in some cases)
Billing capability
Decides on roaming connections to roaming hubs and other EMSPs and roaming pricing of the CPOs affiliated with it.
Promotes the charging network</td></tr>
<tr><td>EMSP</td><td>Can decide on the EV user charging price in some cases
Has contract with the EV user
Offers mobile app/website/RFID tag or other interface for EV user to find and access the CPs.
Invoices EV user
Contracts CSOs either directly or through roaming hub to get access to charging stations.</td></tr>
</table>

one price, with which you can charge across Europe with Audi's own software." (EVU1)

In addition to established MSP roles, the interviewees were asked about third parties connecting to the platform. Roaming operator was most significant existing role and prospective future roles related to e.g. fleet management and energy markets were discussed. These topics are covered more thoroughly in section 4.7 EV charging industry development.

4.2 Business models

Informants described several business models in EV charging industry. Most of them consisted of combinations of different market roles that focused on different parts of the value chain (Table 4.2). Some specialized business models outside the core roles were also identified.

Table 4.2: Business models as market model integrations.

Business model	**Degree of market role integration**		
	EMSP	**CSO**	**CPO**
Pure EMSP			
EMSP-CSO			
CSO-CPO			
EMSP-CSO-CPO			
CSO			
CPO			

Pure EMSP organization does not own or operate charging stations but they have only an EV user service, usually service is offered through mobile app or website. To offer EV users access to charging stations, the pure EMSP must contract CSOs to get access to charging stations. The connections can be made through a roaming hub or then negotiated directly with a CSO or a CSO-CPO.

In negotiations with a CSO, pure EMSP's main sales argument is the number of users it has registered to its service. Therefore, pure EMSPs are often organizations that can leverage existing customer base from other business. Car manufacturers have, for instance, entered the pure EMSP business model for this reason.

> *"Then there are also other companies, for example like OEMs*[2]*, that offer EMP services because they sell the car and then it is also for them not to lose the customer at the point when they sell the car but to be able to offer continuous services and keep the customer through the EMP service."* (RS3)

EMSP-CSO organization connects with both EV users and CPOs. They offer EMSP services similar to pure EMSP organizations but they also operate their own charging network. However, they do not own the charging stations in the network. EV users, who are customers of this kind of organization, usually get access to the charging stations operated by the organization (home network), and in some cases to other charging stations through roaming (roaming network).

CSO-CPO organization owns and operates its own charging network but does not have EV user front. Thus, CSO-CPO must contract with EMSP and offer its charging stations in exchange for the EV users from the EMSP. The second option is to contract the stations via roaming hub and become part of larger network.

Interestingly, CPO2's organization possessed this kind of CSO-CPO role but they were connected to a larger EMSP-CSO organization. Thus, it seems that there can be further fragmentation and concatenation in CSO and CPO roles as CPOs can connect to small CSO that can connect to large CSO. This finding is also aligned with the previously discovered unclear perception of CSO and CPO roles.

EMSP-CSO-CPO controls the full value chain from charging point ownership to EV user relations. This kind of organizations are typically large and they have incentives to keep the network closed, and thus, force the EV users to register for them instead of letting them roam through different EMSP. Typically, they often have other strategic interests such as selling electricity through the charging network.

> *"If I would own some charging network, I'd like to have a service operator that takes care of the network's openness and compatibility with other networks . . . only if I owned the charging station and operated and maybe even sold electricity to it i.e. I tried to keep the whole value chain proprietary, then I might act differently."* (IS1)

Concept of 'gas station business model' appeared in several interviews to describe the type of business an EMSP-CSO-CPO can run. The concept refers to public charging infrastructure and charging behavior mimicking gas stations and

[2] OEM stands for original equipment manufacturer and in this context the interviewee refers to car manufacturers.

ICE fueling behavior with fast high-power charging stations along the main highways to enable long-range driving. Gas station business model responds to the problem of range anxiety among EV users. High-power charging stations are capital intensive, and especially car manufacturers have started to invest in high-power charging networks alongside main highways in Europe and North America. Tesla Supercharger network is the forerunner and IONITY, a joint venture of BMW Group, Daimler AG, Ford Motor Company, and Volkswagen Group, follows.

CSO organization i.e. operator has only B2B contracts with CPOs and EMSPs. Thus, it does not own charging stations nor EV user contracts. Typical embodiment of CSO organization is a roaming operator that connects with EMSPs and CSOs to enable network interoperability for EV users.

CPO only owns charging stations, and in the world of smart charging, they need to connect the charging stations to CSO's network. Typical CPO organization has the secondary business CPO role described in section 4.1. They do not have strategic interest for charging but see it as an additional service for the main business. Secondary business CPO's interest is to have as many EV users charging at their station as possible and therefore it prefers contracting with CSO that has open network strategy.

Even though these six business models were identifiable from the data, they did not follow strictly the descriptions written above. An element of openness of the business model was often present such that for example organization in EMSP-CSO-CPO business model might also operate charging stations that it did not own.

In addition to business models derived from the combinations of market roles, the interviewees mentioned also other business models that specialize in some technological niche of EV charging outside the direct value chain. For instance, charging station location and POI (point of interest) data services as well as charging point installations and technology came up. One of the interviewed companies provided 'platform of platforms' IT infrastructure for CSOs alongside its own EMSP-CSO business model.

4.3 Pricing models

The informants largely agreed that pricing of EV charging is complicated and not standardized across different service providers. As a result the charging price can be anything from free to 10 € starting price + 1 €/min. Similarly, CSOs' pricing models for CPOs varied. Table 4.3 summarizes all pricing models reported in the interviews. The total price for EV user or CPO can consist either of one component or of combination of several components.

EV user's pricing model selection was affected by location, charging speed and

Table 4.3: Pricing models for EV users and CPOs.

Possible components of the pricing model for EV users	• Fixed price for charging event. E.g. 9 € / charge. • Price per energy consumed. E.g. 0,25 € / kWh • Price per time consumed. E.g. 2 € / h • Fixed starting fee. E.g. 1 € / charge • Free charging • Fixed price for packages of minutes or energy consumption.
Possible components of the pricing model for CPOs	• Fixed price for charging point per month. E.g. 5 € / CP / month • Fixed service fee per month • Percentage of charging revenue • Other one-time service fees

season. Popular locations and fast chargers were set higher prices. Often time-based pricing was also used for fast charging, when it was important to free the charger quickly for new users. CPO3, who had chargers at hotels in northern Finland, had tested also seasonal pricing.

The final EV user price formation varied. In some cases, the price set by the CPO was the one that the EV user paid. In that case the total revenue for charging event was then divided between the CPO and the intermediary organization (EMSP, CSO roles) according to their agreement. In this model CPO has full control over the EV user price. In other cases, EMSP could define the price for charging regardless of the price CPO has set for the charging station. For instance, EMSP can decide that all charging events cost fixed 10 € regardless of the electricity consumed or time spent at the charger. In this case CPO does not have control over the end user pricing and the EMSP takes the risk that its pricing model must cover the costs it has to pay to the CSO.

CPO pricing was usually a combination of all the components listed in table 4.3. The informants of companies with CSO role had tried several pricing models for CPOs to test the price sensitivity.

4.4 Charging network competition drivers

This category introduces the identified MSP competition drivers. Four subsections discuss the actors' motivations to participate in EV charging business, EV users' demand for variety regarding charging services, CPOs' differentiation possibilities and multihoming.

4.4.1 Motivations to participate in EV charging business

The data suggests that each role has distinctive motivations to participate in the charging network. EV user and CPO have needs and characteristics that can be met by the value propositions of EMSP and CSO. Next, the findings are discussed by role.

4.4.1.1 Charging service attractiveness for EV users

The data suggests that convenient charging experience, network size and coverage, service availability and competitive charging market are factors that make charging service attractive for EV users (Table 4.4). Besides these four themes directly related to charging, the general attractiveness of EV driving was also found to affect the willingness to drive an EV and charge it.

The first theme arising from the data was overall convenient charging experience, which covered areas of charging taking place reliably as planned with a good user experience. This theme concerns all phases of charging from finding the charger to reliable and smooth billing.

Reliability and quality problems, e.g. the charging station being off, charging event stopping without an explanation or identification problems, were mentioned but those were said to have improved during the last few years and the system reliability was generally considered good. Also speed of charging was reported several times – the faster the better.

> *"And I don't think people are obsessed with number of chargers but I think they are more obsessed is it working, is it up, is it accessible."*(EVCC6)

Interesting discrepancy appeared between EV user informants and charging company informants as EV users preferred simple identification with RFID card and even credit card payment as opposed to using the mobile applications for payment and finding the charging station. The representatives of EV charging companies, on the other hand, emphasized how their application improves the user experience.

Table 4.4: Attractiveness of charging services for EV users. Number of quotations in brackets. Mentions of EV users marked with *.

Theme	Codes
Convenient charging experience	• Reliability* (12) • Fast charging* (11) • Ease of use* (10) • Ease of finding a charging station* (5) • Quality (5) • Good user experience (5) • Simple charging payment (2) • Reliable billing system (1) • Weatherproof charging stations* (1) • Peace of mind when charging (1)
Network size and coverage	• Location* (26) • Network coverage* (16) • Number of charging stations* (8)
Competitive charging market	• Freedom of choice* (9) • Price* (8) • Inexpensive charging* (8) • Pricing transparency* (1)
Service availability	• Supplementary services available* (5) • Customer service (2) • Inexpensive roaming (2) • Home and public charging through same service (2)
General attractiveness of EV driving	• Number of EV users* (3) • Neighbor has an EV (3) • Access to home charging (3) • Availability of new EV models (1)

Location, network size and geographical coverage recurred throughout the dataset as the second most important attractiveness factors of an EV charging network for an individual user. Locations alongside main highways were considered important especially for fast chargers, and medium power type 2 chargers had best locations in parking lots, shopping malls and other places where people usually park their car. Lack of charging network coverage was the main cause for range anxiety when driving long ranges with an EV.

> *"A very good example of excellent charger location is in Rovaniemi ... The highway runs through the city and there is concrete deck at the city center and when you divert from the highway there is literally 50-meter distance to the fast charger and when you leave the car there you are already in the city center. And the charger is even in the parking hall, so it is covered for the weather. ... It is like a perfect location for the driver."* (EVU1)

> *"Places where people normally move and park. Nobody goes charging somewhere separately."* (EVCC1)

Thirdly, a charging network was considered attractive when there was freedom of choice for the EV user between different charging service providers and the charging prices were low or even free. The freedom of choice was considered to improve the quality and price competition because it increases competition between different charging networks. However, the interviewed EV users mentioned that they seldom checked prices beforehand because they were anyway low and there was not much choice available.

> *"I don't think I really have freedom of choice. I have to take what I get."* (EVU3)

Fourth attractiveness theme arose around services beside charging. Supplementary services, such as ability to have lunch or go shopping while charging, were considered important because charging takes always at least 20 minutes. Especially EV user informants emphasized the importance of supplementary services. In case of problems, a fast customer service hotline was also mentioned to be important.

> *"The key distinction of charging and petrol fueling is that you spend half an hour there [at the charger], so there should be something meaningful to do. In big gas stations there is usually food available and in city centers you can access the city services."* (EVU1)

Access to home charging and roaming with the same customer account were also mentioned as factors improving the attractiveness. However, these were mentioned by the CSO and EMSP-CSO informants, and not the EV user informants, which may indicate that these are not as important for EV users or EV users are not aware of these possibilities.

Finally, general attractiveness of EV driving emerged from the data even though it is not directly related to the attractiveness of public charging services. However, the increasing number of EV drivers around oneself was seen as means to promote the new form of mobility and to get access to new charging locations as other drivers provoked the demand. Moreover, seeing a neighbor driving an EV was mentioned to improve the awareness and interest towards e-mobility and indirectly affecting the charging services. Similarly, availability of home charging options and new EV models were mentioned as important means of gaining popularity for EVs.

> *"The network effect of buying an EV because your neighbor has one. My neighborhood is a good example of that. I'd say there are 10 Teslas within 100 meter range."* (EVCC2)

4.4.1.2 Charging service attractiveness for CPOs

Five general motivations for CPOs to participate in EV charging business emerged from the interview data: reliable and hassle-free CSO services, support for main business, forerunner brand, demand and long-term monetary incentives (Table 7).

Good quality services and charging equipment offered by CSO were mentioned as an important attractiveness factor for becoming a CPO. CPOs appreciate automated and reliable charging services that do not cause any additional work for them. Being part of larger public charging network was also considered as a benefit, as it offers easy access to large base of EV users. It was important for the CPO respondents to be able to serve all kinds of EV users and therefore they called for charging stations that fit to as many EV models as possible, and not for example Tesla Superchargers.

> *"An attractive charging service is smart and does not cause any additional work for the real estate or the company that is operating the real estate."* (CPO1)

The second theme "Support for main business" matches well with the "secondary business CPO" category that emerged from the MSP role analysis in section 4.1. Charging is used as means to attract customers to the core business such as to supermarket or hotel. EV users were perceived as an affluent customer group that is worth targeting by providing inexpensive or free charging.

Table 4.5: Attractiveness of charging services for CPOs. Number of codes in brackets. Mentions of CPOs marked with *.

Theme	Codes
Reliable and hassle-free CSO services	• Access to large number of customers via CSO network* (5) • Good CSO services* (5) • No additional work for the CPO* (4) • Reliable charging stations* (4) • End user friendly charging service* (4) • EV model neutral charging stations* (3) • Smart and automated services* (3) • Possibility to update charging equipment* (2)
Support for main business	• Charging as means to attract (affluent) customers* (14) • Participation in the energy markets through charging* (4)
Long-term monetary incentives	• Ownership of good locations* (5) • Cost parity* (5) • Price of charging system* (4) • Increase in property value (2)
Forerunner brand	• Improve CPO brand value* (7) • Green image / greenwashing* (4) • Provide new forms of mobility* (3) • CPO improving charging network coverage* (1)
Demand	• Number of EV users* (10) • Demand for charging services from customers* (4)

> *"We would like to be the one [hotel] that the customer chooses because she can come there with electric vehicle."* (CPO3)

Similarly, CPO2, who represents an energy utility, perceived charging as part of energy services that they want to offer to their customers and saw there future potential to participate in the energy markets with the EV battery reserves.

Interestingly, profitability and monetary value of charging had less importance. None of the interviewees considered CPO business profitable at the moment due to high installation costs and low utilization rate of the chargers. Cost parity, not profitability, was mentioned as the target with the charging stations. However, willingness to invest in charging stations arose from the perceived long-term benefits of charging, e.g. charging station's effect on property value and ownership of a good location for a charging station that might be of better use in the future.

> *"If it [the charging station] made profit, it would be useful for the charging point owner but I have a feeling that, at least now and it might be in the future as well, the profit is not made by charging but with other services. There can be a cafeteria, a lunch place or a shopping mall."* (IS1)

Offering charging services as a CPO was seen to create forerunner and green brand value for the organization and it was one reason to become a CPO. The theme confirms that EVs still have novelty value and it is possible to differentiate with services related to them and being part of the new mobility trend.

> *"The number of electric vehicles has not had an impact to our decision to offer charging services. We want to be the forerunner and offer the service even though it is not yet for the masses."* (CPO3)

Important driver was also demand for charging services from the customers of the CPOs. This results from the general increase of EVs in the market. However, CPO interviewees mentioned that they do not follow the EV market development per se, but it indirectly affects the demand. As the previous quote illustrates, the demand is not always the most important decision making factor.

4.4.1.3 EMSP's value proposition for EV users

EMSP provides with charging services for the EV user, and to differentiate with relevant value proposition the EMSPs can focus on meeting different needs of the EV users. Providing access to wide and user-friendly charging network with trusted brand and attractive pricing were identified as existing value propositions of EMSPs (Table 4.6).

Table 4.6: EMSP's value proposition for EV users. Number of quotations in brackets.

Theme	Codes
Provide access to wide and user-friendly charging network	• Network coverage (4) • User experience (3)
Trusted brand	• Leverage existing brand value (2) • Offer supplementary services (1) • Show long-term commitment to charging (1)
Attractive pricing	• Price (1) • Inexpensive roaming (1)

Access to wide and end-user-friendly charging network was the most important value proposition of EMSP, and it is well aligned with EV users' needs for network size and coverage as well as smooth charging experience. Many EMSPs are organizations that have business in other areas, such as grocery stores and car manufacturers, and part of their value stems from the existing trusted brand that can be leveraged in charging services.

Finally, attractive pricing was an important part of the value proposition to the end user and it matches partly with EV users' expectations for competitive charging market with freedom of choice and low prices.

4.4.1.4 CSO's value proposition for CPOs

Similar to EV user and EMSP, CPO and CSO are a pair whose needs and value proposition should meet. Data regarding CSO's value proposition was limited but three themes were found (Table 4.7).

Novelty of charging business overlaps the three CSO value proposition themes. CSO's role is to show commitment and provide CPOs long-term expertise in charging service operations. For instance, actively promoting new and better charger types was found as a way to serve CPOs in the quickly developing market.

The second theme, reliable and functional charging service, is closely related to the first one and it shows that it is not given to have technically mature and reliably functioning charging services.

Table 4.7: CSO's value proposition for CPOs. Number of quotations in brackets.

Theme	Codes
Commitment to charging service development	• Promotion of new charging equipment (1) • Long-term commitment (1)
Reliable and functioning charging service	• Technical capabilities (1) • Reliable charging operations (1)
Trusted brand	• Trusted brand (2)

Trusted brand was also important part of CSO value proposition because the operator brand is often[3] visible to the EV user and therefore CPO wants to be part of network that is trusted among the end users as well.

> *"I feel that the [charger] represents the operator and only secondarily the real estate or the business that it is affiliated with."* (EVU1)

4.4.2 EV users' demand for variety

To discover EV users' demand for variety (Hagiu, 2009) in charging services, the interviewees were asked if they can identify any user categories based on charging behavior or user needs. Three general themes emerged from the interviews: vehicle's battery capacity and power input, need for public charging services and level of experience in using public charging services (Table 4.8).

Battery capacity and power input recurred throughout the dataset. Main distinction was drawn between PHEV and BEV owners since they have different charging needs due to the battery size. Quote below describes the differences.

> *"Of course there are people who have a plug-in hybrid that doesn't need to be charged. Usually they are happy to charge if there is a charging point at their parking place but charging is not necessary for them. Then the other end, Tesla drivers, who have big battery and they can drive 300-400 km with one charge. On daily use, they only need to*

[3] The brand visibility depends on the business model. See section 4.2 Business models.

Table 4.8: EV user groups. Number of quotations in brackets.

Theme	Codes

Battery capacity and power input	• PHEV (8)
	• BEV (4)
	  – Large BEV (3)
	  – Small BEV (3)
	• AC or DC capability (2)

Need for public charging services	• Destination charging (6) • Tesla owners (3) • Leasing EV as a company car (4) • Access to home charging (4) • Never charging public (2) • Access to ICE vehicle (3) • Driving patterns: long or short distance (1) • Rare users (1)
Level of experience in using public charging services	• Lead users (8) • Free-charge hunters (4) • Early majority, no tolerance for errors (2) • Professional users (fleet operators) (2) • Active users (1) • First timers (1)

> *charge twice a week. So, if you plug it a couple of times a week at home, you don't need to charge it anywhere else. And then in between there are people, who have a car with smaller battery, so the charging is more critical."* (EVCC1)

The second thematic category formed around the (lack of) need for public charging services. Concept of destination charging was introduced meaning driving behavior, in which the vehicle is mainly charged at the destination e.g. home or workplace, and public chargers on the way are seldom used. EV drivers with access to home charging or ICE vehicle may never use public charging services because they do not need to, or they find it difficult. One special user group is Tesla drivers, who rely on the closed Tesla Supercharger network and seldom use other charging services due to the superior speed of charging in their own network. Also drivers who lease EV as a company car emerged as a special group because they often had a charging opportunity at the workplace and they did not care about the price of charging because it was included in their lease contract.

Lastly, interviewees clustered EV users based on their experience in using public charging services. Lead users are geeks who actively try different charging services because they are interested in new technology and e-mobility phenomenon. However, their driving behavior is not typical even though they may provide valuable feedback for the CSOs and EMSPs as EVU1 explains below.

> *"Then there are people like me who go and try out things. Like there is Hanko-Nuorgam distance, could I make it with an EV? And then I study maps, check chargers and their power and the vehicle's average consumption and even the road profile. ... This group is kind of valuable for charging equipment manufacturers and operators because they give feedback if something doesn't work. ... On the other hand, this kind of driving is very untypical."*(EVU1)

Active users and professional users (e.g. fleet operators) use chargers frequently, whereas first timers were brought up as separate category as they have often problems with the start-up situation. Free-charge hunters emerged as a sub-category of active users, as they are actively looking for charging stations that offer free charging.

New generation of EV drivers was also emerging, namely the early majority who do not tolerate any errors from the charging system as opposed to the lead users who even help the charging service operators to develop their products.

4.4.3 CPO differentiation possibilities

CPOs, the other side of the platform, can differentiate their services in three main areas: service offering, pricing and charging speed (Table 4.9).

First way of CPO differentiation comes through service offering. The offering can be directly charging related, e.g. bidirectional charging that allows vehicle to feed electricity to the grid or offering roaming services and open network, or it can relate to the supplementary services near charging point, which may include sending a discount code to a nearby cafeteria. The former service is less used due to immature technological opportunities in bidirectional charging but it was seen as a future opportunity.

Secondly, CPOs can set the price for their charging station and differentiate by giving free charging, for instance. The concept of membership discount from

Table 4.9: CPO differentiation opportunities. Number of quotations in brackets.

Theme	Codes
Service offering	• Fair and open charging services with roaming possibility (4) • Participation in energy markets through bidirectional charging (3) • Supplementary services (1) • Offers or discounts for EV users for supplementary services (1)
Pricing	• Free charging (4) • Price (3) • Membership discount (2)
Charging speed	• Fast charging (2) • Charging speed (1)

charging with e.g. a grocery store loyalty card was also mentioned, however, this option was not available for the interviewed CPOs. Interestingly, even though CPOs can define the price they want to get from the CSO, EV users pay the price set by the EMSPs. Thus, this kind of loyalty card discount would be an EMSP service rather than CPO service.

Thirdly, charging speed, and especially fast charging, was defined as one way of differentiating the charging service per se. Some interviewees mentioned that there are companies focusing only on fast charging, as it requires special capabilities with grid connections and charging equipment.

4.4.4 Multihoming

EV user multihoming behavior was commonly agreed amongst interviewees. The main reason for multihoming was that no single network had good enough coverage and it was inevitable to use any available charging stations. Multihoming of EV users was generally found easy as there is no or only a minor fixed cost associated with the charging platforms. Though, many interviewees were concerned about the nuisance of having to use several different mobile applications or RFID tags for charging. Moreover, the lack of listing of all charging stations in one place was one reported disadvantage.

Measures for EV user lock-in to single platform were not in place. However, monthly fixed price for charging was mentioned as one measure as well as improving the quality and user experience of the services. However, the low network coverage resulted in not implementing those measures actively as EV users were still forced to use any available charging station nearby.

On the contrary, CPOs were practically forced to singlehome because connecting and maintaining the relationship to several charging services was too laborious and costly. Complicated configurations and connection to the CSO back-end resulted in strong lock-in for the CPO, which was also found to be a problem in a case where dissatisfied CPO wanted to change CSO service provider but felt that the effort is too big. This phenomenon was a driver for CSO competition, in which CSOs rushed to secure CPOs in good locations into their network as this was considered to be advantage in the future when the charging networks are bigger, and the customers may get more locked-in to the services that have best coverage.

> *"In a sense all perquisites [for success] in the public charging network exist, as long as we hold on the position that network grows and develops and that way we remain among the big ones. ...At the moment, EV user has to have an account at all charging services because the network coverage is poor and she cannot focus on one or a few [services]. But she anyway must have the account of the big ones to survive in the traffic, so companies in that position will have quite good position in the markets."* (CPO2)

4.5 Interoperability in EV charging

Network interoperability in EV charging networks is generally called roaming or e-roaming. RS1 describes the history of roaming dating back to the beginning of the modern EV charging when declaration of interoperability was means to make the EMSP-CSO look bigger than it actually was by enabling access to other charging networks beside the home network. Furthermore, proclaiming network interoperability CSOs were able to prove their long-term commitment to network development and gain credibility among investors and EV users.

When the number of charging stations climbed from hundreds to thousands and networks fragmented, the questions of interoperability started to have real importance as each charging station had different means of authentication and payment, and they often required customers to register to several services. Thus, the need to access different charging networks with only one customer account created room for roaming service development.

Roaming hub business model emerged from that need, and its idea was to connect several CSOs and EMSPs via hub and multiply the networks so that EV user who normally had access to charging network of CSO1 via their EMSP, could now access also charging stations of CSO2, CSO3 etc. with the same EMSP account as in not having to register separately for EMSPs that offer access to those CSOs.

The hub contracts EMSPs and CSOs and collects usage and membership fees from both sides. Pricing model of RS3's roaming hub organization is asymmetric such that CSOs have low fixed membership fee independent of the number of charging stations and roaming sessions, whereas EMSPs' fee varies according to usage i.e. how many active roaming sessions their customers have. RS1 clarifies that roaming hub does not interfere with EV user-EMSP-CSO-CPO billing contracts but it only transfers the charging data for EMSPs and CSOs that can settle roaming payments accordingly.

In the early phase, when there was a small number of charging stations in each CSO network, many of them wanted to open the networks via roaming hubs to improve the attractiveness for EV users with better coverage. As the networks have grown in size, the interests have shifted more towards protecting one's own network by setting the roaming prices high, and thus incentivizing the EV users to register directly as customers for that network instead of roaming it via the hub. Large CSOs and EMSP-CSOs have started to evaluate more carefully with whom they share their networks. This has resulted in bilateral roaming business model.

Bilateral roaming model skips the roaming hub as an aggregator and creates the roaming contract directly between CSO, EMSP or EMSP-CSO organizations. Technologywise the connection usually uses OCPI protocol[4]. This model allows the organizations to create strategic alliances between partners who think that their networks would benefit from interoperability and leave out competitors, who offer services in the same market, for example.

RS3 points out that selecting the roaming partners is also possible via hub roaming as the EMSPs can always decline the charging prices offered by CSOs if they feel that they are too high. However, that results in dilution of value proposition of the roaming hub operator, as they cannot anymore claim that all charging stations connected to their hub are available for all EV users connected to the hub.

Both forms of roaming have pros and cons. Advantages of hub roaming rest on the low communication costs of centralized contracting. CSO and EMSP organizations connect only with the roaming hub and have directly access to all charging stations or EV users connected to that hub without having to negotiate separately

[4]The Open Charge Point Interface is an open source protocol for setting up automated roaming between EMSPs and CSOs.

with each CSO or EMSP in the platform. The hub handles the legal framework on behalf of the CSO or EMSP and assures some level of quality in the charging stations. The disadvantage is that the organization loses some decision power to the hub and cannot choose freely with whom they share the network. On the other hand, bilateral roaming allows CSOs and EMSPs choose with whom they contract and negotiate the contract. However, the negotiations become quickly very laborious if the number of roaming partners increase.

Internal roaming appeared as an additional roaming concept in the interviews to describe the connections of CSOs and EMSPs that connect by using the same software platform. One of the interviewed companies acted as a software provider for other companies and all the companies using the same software formed an internal roaming network. However, some informants did not consider this arrangement as roaming because there was no additional price associated with it.

According to RS2, there are three layers that need to be discussed when creating an interoperability connection. Firstly, technology layer defines the type of protocol used i.e. bilateral or hub protocol (or internal roaming). Secondly, legal layer concerns the number of charging stations and EV users brought into the interoperability network. Thirdly, business layer addresses the pricing model, which incorporates both EV user pricing and the pricing between the organizations that form the roaming connection.

4.5.1 Benefits and disadvantages of network interoperability

The interviewees identified several benefits and disadvantages related to the current roaming market in Europe. Each role in the network has different motivations to participate in roaming and therefore conflicting interests turn up. These are summarized in Table 4.10.

Benefits and disadvantages concern both hub and bilateral roaming. Most attributes apply to internal roaming as well but for example pricing was not higher at least in the interviewed companies.

EV users want to get an easy access to wide network of charging stations wherever they drive, even cross-border. Hence, they benefit from roaming arrangements most, and their needs are drivers for roaming development.

However, roaming does not function ideally, as it can be very expensive, pricing models are non-transparent, it is not regulated, and the user experience fails due to the lack of language support or pricing information. EVU1 describes his charging experiences abroad as "detective work" – a typical situation when cross-border roaming is not available or its user experience has not been poorly designed.

Table 4.10: Benefits and disadvantages of roaming. Number of quotations in brackets.

EMSP	CSO
+ Provide EV users access for larger network (10) + Marketing purposes (3) – Expensive (4) – Cost pressure from CSO and EV users (1)	+ Marketing towards CPOs (5) + Look bigger than in reality (2) + Requirement from EMSPs (2) + Provide EMSPs access to larger network (1) – Expensive (4) – Inflexible pricing (2) – Billing difficulties (1)
EV user	**CPO**
+ Get access to wider charging network (8) + Ease of use (6) + Reduced range anxiety (1) – Expensive (7) – Non-transparent pricing (5) – No regulation (2) – Lack of service (1) – Roaming does not work (1)	+ Access to wider customer base (13) + Higher price from roaming customers (2) + Marketing purposes (2) – Negative reputation due to high pricing (1)

> *"It has been really detective work to check from some kind of public charging service register, which chargers there are. There they tell the company that operates the charger. Then you google that firm. It is likely a central European firm, so it has information in German, Italian or French, but I don't speak any of those languages. So, in the worst case I translate the page with Google translator to find out the authentication method and price."* (EVU1)

The main motivation for EMSP to participate in roaming is to provide its customers as large network access as possible so that they register to that particular EMSP service. If EMSP possesses a pure EMSP role, it practically roams all its charging stations either with direct contracts to CSOs or via roaming hub. If EMSP also operates charging stations, i.e. it is EMSP-CSO, it can access other

CSOs' networks via roaming in addition to its home network.

Disadvantages of roaming concern especially pure EMSPs as they face cost pressure from both sides. CSOs want to charge extra for roaming but EV users do not want to pay extra. Bargaining power of pure EMSPs is dependent on the number of customers they have, which can be a weak argument in price negotiations with CSOs.

CSOs contract with CPOs and EMSPs, both of which benefit from large roaming networks. Pressure for open network access is therefore the driving force for CSOs to participate in roaming. Historically, it has also been a way to easily increase the network size and use the figure for marketing purposes. If CSO organization plays also EMSP role, there is natural interest to provide EV users larger network. However, as for EV users and EMSPs, roaming is expensive for CSOs as well.

Finally, CPO has the strongest motivations for roaming. CPO's main target is to have as high utilization rate as possible in their chargers. Therefore, it warmly welcomes all roaming customers and requires access to roaming networks from the CSO.

A single CPO should not care if the EV users charging at the charging point are home network or roaming customers. However, CPOs often are closely linked to CSOs and it might be in CSOs interest to discourage roaming usage by setting higher prices for roaming and thereby protecting its home network. Deciding on roaming pricing was also recognized as CSO activity in section 4.1, whereas CPO could only decide if they put their charging station available for roaming. Quotations by RS1 and EVCC2 illustrate the strategic issue.

> *"Even though in theory we talk about CPO, often a single charging point owner is bound to something larger. It is cooperation of larger consortiums."* (RS1)

> *"Some biggest CPO-EMP actors i.e. operators feel that they are so big that they should only let their own EMP customers to their network and in that way force the consumers to become their customers. They see that the end consumer has the biggest value in their value chain."* (EVCC2)

4.6 Charging network strategies

Five themes emerged around the strategic decisions that an organization in the charging business should consider: network openness, growth, pricing, specialization and geographical positioning (Table 4.11). The strategies concern organizations who possess the roles and combinations of roles of EMSP, CSO and CPO.

Table 4.11: Charging network strategies. Number of quotations in brackets.

Theme	Codes
Network openness	• Open network (12) • Closed network / protectionism (19) • Alliance (11) • Unidirectional roaming (7) • Platform openness (9)
Growth	• Securing good locations (6) • Aiming at "must-have" membership position (5) • "Winner takes all" (3) • Acquisitions (3) • Fast growth (3)
Pricing	• Pricing (7) • Pricing symmetry (8) • Membership discounts (5) • Price discrimination (2)
Specialization	• Focus (6) • Cost leadership (5) • Differentiation (3)
Geographical positioning	• Geographical positioning (5) • Presence in multiple markets (2)

A recurrent theme in the interviews was a sense amongst interviewees that an organization has to decide on how open charging network they create. An open network strategy means that the organization connects its charging network to other charging networks via roaming.

The opposite for open network is fully closed network i.e. the EV user can access the network only by registering as customer for the EMSP-CSO(-CPO) that operates the network. Thus, no roaming is available, and the network operator aims at protecting its infrastructure and EV users.

Unidirectional roaming is one form of the protectionist strategy. EMSP-CSO-CPO organization can connect only the EMSP side with EV users to a roaming hub and leave the charging station side out. Thus, it becomes more attractive for EV users to register for that EMSP because they have both home network and roaming network access. Normally, CPO would not like this approach because its incentive is to have as high utilization rate on the charging point as possible and limiting roaming reduces the utilization likely. However, if the CPO is part of the same organization as EMSP-CSO then this is a viable strategy.

Alliance strategy fits between these two, and it includes strategic selection of partner networks, to which connections are formed via roaming hub or bilaterally. Usually all strategies are forms of alliance strategy because it is impossible to have fully open network that is connected virtually everywhere, and respectively, fully closed networks are extremely rare[5].

Platform openness refers to opening the platform for other third parties that are not necessarily competing in the charging infrastructure roles but whose activities cover e.g. payment systems, location data or CRM systems. These third parties could connect to the platform via APIs and create modular services on the platform.

The second strategy theme concerns the organization's attitude towards growth. Practically all EMSP and CSO organizations aim at fast growth with their network and those who do not want to grow settle for secondary CPO business models. Mentions regarding growth answered questions of why and how. Awareness of likely market consolidation and "winner takes all" dynamics made organizations think that it is important to grow big fast so that the charging network is eventually so large that it is necessary for EV users to have the account of that EMSP.

The how of growth strategies included securing good locations for charging stations by organic growth and acquiring small CSOs. Importance of securing good locations was due to the strong lock-in of CPOs to CSO. It is difficult and expensive for a CPO to change their CSO, so it is better to secure them to own network quickly.

Pricing decisions formed the third strategy theme. Pricing decisions concerned the symmetry of multi-sided platform pricing, EV user pricing model, CPO pricing model and roaming pricing model. Pricing decisions were closely linked to the network openness decisions. Some interviewees had recognized that some EMSP-

[5]Tesla Supercharger network is a fully closed network as it is currently available only for Tesla drivers.

CSO companies had attracted CPOs to join their platform with low prices, which is an example of subsidization. The opposite, free charging for EV users, also emerged as embodiment of asymmetric pricing. CPO roaming prices were a form of controlling the openness of the platform. High roaming prices make roaming less attractive, and simultaneously they make the network more closed. Discounts for EV users as a strategy reflected the same phenomenon, as their aim is to increase the lock-in of EV users to the charging service.

Specialization and focus of business emerged as the fourth strategic theme and the theme introduces all three generic strategies of Porter (1980): industrywide differentiation, industrywide cost leadership and segment focus. Industrywide differentiation strategies were identified with premium software, excellent charging experience – and with expensive price. On the contrary, cheapest industrywide solutions focused on the minimum costs and requirements: finding a simple low-power socket and installing it without any services. Focused strategies included specialization into single parts of the value chain.

The final theme, geographical positioning, addressed topics of geographical coverage of the network and selecting the markets in which to operate the charging network. For example, EVCC2 reported that their company operated in different geographical markets, which allowed them to understand the industry life-cycle better since EV penetration varied by market.

4.7 EV charging industry development

EV charging industry development emerged from the data as a category that covers current life-cycle stage of EV charging industry, informants' educated views on market development and three futuristic subcategories of the challenges, drivers and opportunities ahead.

4.7.1 Industry life-cycle stage

The informants perceived e-mobility and EV charging industry life-cycle still to be in early stage, depending on the market, however. Reasoning behind this conclusion included immatureness of business models and value chains, low penetration rate of EVs in the market, low availability of EV models and reliability problems with the charging equipment. EVCC1 described the charging industry to reach "the start of the second wave of modern e-mobility" meaning that the first smart charging solutions are coming to the end of their life-cycle, and customers require better modular solutions that can be connected to customer's own IT infrastructure.

> *"The value chain is not yet established and there are very different value chains and ways in which one can do this business and that is one enabler of platform business. So, if you were a vehicle manufacturer you think the business from different angle than if you were an energy utility or if you were a commercial actor that is none of the two. Clearly it [value chain] lives."* (EVCC2)

EV charging is seen as an attractive business, which can be judged from the rate new companies are entering the competition and releasing their charging solutions. The new entrants consisted of chain stores and car manufacturers, and they created more market fragmentation as well as pressure to secure good CP locations in order to have good positioning when the masses start to enter the market. The competition for the best locations has resulted in charging station networks expanding a little faster than what would be required by looking at the number of EVs in the market.

> *"Large companies start to become interested in what kind of [charging] services are offered for companies. Therefore, the charging infrastructure is being built a bit ahead compared to EV market development because companies want to ensure locations in which they can do business in the future and serve customers as well as possible. So, it means that you have to make moves now in order to be able to serve customers when the big boom hits the market."* (CPO2)

Technologywise, the informants' views differed as to whether clear industry standards existed or not. Some felt that standards had been established and their development future seemed predictable while one informant complained that too much variation among charging equipment still exists, and each new charger model must be tested separately because the standards do not specify clearly enough some specifications.

From the EV user point of view, factors hindering EV deployment concerned the difficulties of being "the first settler". The selection of EV models focused on the premium car end and they were expensive. There was no standard process for getting a home charger and the procurement had to be made through the housing cooperative in row houses and apartment buildings, which demanded additional effort from the EV user. Public charging quality varied and EVU1 claimed that there were lots of things "that you just had to know" to be able to solve problems with charging.

Generally, the view on industry development was positive and the EV sales were expected to "kick in to the early majority" in near future. Especially car manufacturers' announcements on new EV models convinced many informants that EVs are going to be relevant options when affluent middle-class people are considering their next car choice.

4.7.2 Market development

Two general themes regarding market development emerged cross-sectionally in the data: regulation and market consolidation. Generally, the market was seen as very fragmented, as stated in the industry life-cycle analysis above. Two alternatives were seen as possible market development directions: further fragmentation or consolidation. However, the consensus of the interviewees inclined towards consolidation that is starting to reshape the industry even now.

> *"The first scenario would be that the market gets more fragmented. The second scenario could be that we have all these little players coming up but then the giants are going to buy them, and in the end, it is the game of a few big ones that have the money and that can rule the market."* (RS3)

RS3 referred to "ones that have the money", and other informants further remarked that car manufacturers and oil companies have entered the charging market with big investments, which may be an indicator of the future consolidation. Secondly, the informants pointed out that the degree of consolidation depended on the market. Some geographical markets were more competitive than others even though EV market penetration was rather similar in both areas.

Lack of regulation, especially in roaming, was mentioned several times. Problems stemming from the lack of roaming concerned complex pricing of charging services and some charging networks being excluded from roaming due to protectionist reasons. The informants anticipated some regulations in European Union level to be put in place in near future. Generally, informants found that the purpose of regulation is to protect EV users from expensive pricing and standardize the industry so that charging is easy to use in the future when the number of users grow from thousands to millions.

4.7.3 Industry challenges

E-mobility and EV charging industry face many challenges. Several different business model challenges were identified by CSO, EMSP and industry specialist informants, unprofitability of the industry receiving the most mentions. According to interviewees, other significant challenges relate to barriers for market growth both on EV market and charging network side. Other themes emerged around reliability and quality problems of charging stations and general bad user experience in e-mobility. Furthermore, attitudes towards e-mobility were still negative, which was perceived to hinder the industry development. Table 4.12 summarizes the themes and codes.

Most prominent industry challenges related to various business model problems faced by CSOs and EMSPs. Common denominator for them was the unprofitability of the industry for any company. The volumes were too small to make profit, and no relief was expected in the future as charging was expected to become commodity which puts pressure on the margins. There was also a fear of wrong positioning and threat of being pushed out of the value chain if car manufacturers and oil companies enter the business and payments are handled with blockchain or via other payment providers.

> *"What I think happens in both cases is that charging becomes more and more commodity. So, company that offers charging by itself as the only functionality cannot survive. It's more about value added services and maybe some other features as well."* (RS3)

Second significant theme emerged from the current situation of not having enough EVs nor charging stations in the market to be able to make viable business. High EV prices, unfavorable taxation and battery technology hindered EV market growth. On the other side of the platform, charging network size was found to be too small, and installation of new chargers was difficult due to difficulties with installation permits and grid connection as well as expensive parking spaces.

Third, bad user experience in e-mobility resulted partly from the aforementioned quality problems. Second big problem in user experience was complicated pricing models compared to fueling of ICE vehicle. Besides non-uniform charging prices, the EV users complained that they seldom knew what the price of charging is because the prices are available in various websites and mobile apps, and they need to be searched separately. Usage of app or website to check the price was considered inconvenient if the EV user had a functioning RFID tag.

> *"Then the second is to have also standardized way of pricing the service. Being able to expect the price. One example, when you drive your combustion engine car today to a fuel station you know that the price is going to be price per gallon or price per liter. That's it. And with e-mobility it can be everything. It can be €/kWh, €/time, €/kWh and time, it can be reservation fee, it can be transaction fee, it can be all combined."* (RS2)

The fourth theme emerged around reliability and quality problems in charging. Uncertainty related to managing to charge successfully was too high according to many interviewees, especially informants in the EV user role. Gladly, many informants said that the quality issues have improved during last few years.

Table 4.12: Industry challenges. Number of quotations in brackets.

Theme	Codes
Business model challenges	• Unprofitability of business (12) • Commoditization (7) • Being left out of the charging value chain (1) • Closed and protected charging networks (1) • Slow decision making in public infrastructure projects (1) • Risk of technological fragmentation (1)
Barriers for market growth	• EVs – EV market penetration (5) – High EV prices (3) – EV taxation (2) – Battery technology (1) • Charging network – Network size (5) – Installation permits (2) – Expensive parking space (1) – Grid connection availability (2) – Charger capacity (1)
Bad user experience in e-mobility	• User experience (9) • Complicated pricing (5) • Range anxiety (3) • EV quality (2)
Reliability and quality problems	• Reliability (7) • Quality (6) • Lack of standardization (5)
Attitudes towards e-mobility	• Attitude (4) • Elitist image (1)

> *"Reliability and user experience are bad. When you go to a charging station you can never trust if the system works or not. They are way better than they were 3-4 years ago but there is still a risk, especially if you drive long distance with an EV and there is one fast charger in the half-way of the trip. There is a little fear of whether it will function today or not and whether the trip ends there."* (EVCC1)

Finally, general attitude towards e-mobility was perceived negative or elitist, which was considered as a remarkable hindrance of industry development from the behavioral perspective.

> *"At the moment, EV driving has this kind of elitistic stain that the cars are expensive and you must be climate-friendly and so on. It has this kind of stain."* (CPO2)

4.7.4 Industry drivers

As an opposite force for the identified industry challenges, there are also positive drivers that are pushing e-mobility and charging industry forward. Increasing attractiveness of EVs, better communication of e-mobility benefits and increasing charging speed recurred across interviews (Table 4.13).

Firstly, EVs are becoming more attractive due to the increasing availability of new models outside the premium segment. Lowering battery costs also decrease EV prices and informants called for temporary subsidies to support transition to EVs.

> *"Now there starts to be cars in each segment: a, b, c, d and e sizes. There are minivans, SUVs, sedans, hatchback..."* (EVCC5)

> *"Technology Industries of Finland estimated that temporary 4-year subsidization solutions can be done because they believe that EV and ICE vehicles are equally priced in 2025. So then temporary [subsidies] lower the threshold of EV purchase until then and we don't need to discuss permanent subsidies because the prices are declining in the course of time."* (CPO2)

Secondly, clear communication of e-mobility benefits was seen to improve attractiveness both in EV user and CPO side. More information about EV operating costs and charging system costs attracts more buyers. Similarly, standard charging solutions and purchase processes make it easy for to-be CPOs to make purchase decisions.

> *"For example, property managers in housing cooperatives are a good target group. So, when they have knowledge, they share it to the housing cooperatives and their knowledge improves and prejudices diminish."* (CPO2)

Thirdly, urgent requirements of climate change mitigation were brought up as a driving force for electrification of transportation. Transportation sector will receive tightening emission limitations and urbanized youth value car ownership less than before.

> *"The pressure is high and it comes from these climate change issues. It drives electric mobility forward with crazy momentum. ... Coercive actions are done and the more CO_2 emission limits are pushed down for the car manufacturers the faster the electrification moves forward."* (IS2)

Fourthly, new technological advances in battery reserve utilization and high-power charging will improve charging times, which in turn will improve the user experience of charging.

4.7.5 Industry opportunities

In addition to potential challenges, the interviewees identified also future opportunities for charging industry (Table 4.14). The most prominent related to third-party integrations, of which participation in the energy markets with EV batteries received most attention. Charging related technological developments emerged as the second theme, and the third one was founded on the data and capabilities that EV charging organizations have. Most ideas in this section came from informants in the CSO-EMSP role, which is presumable as their role and existence is most related to EV charging and to the viability of the business model.

The informants came up with several third-party integrations to counter the risk of charging commoditization. Some of the connections are already in operation, e.g. roaming operator connection, while most focused on far future.

Energy market participation by aggregating EV batteries through bidirectional chargers was mentioned most often in this category. Transition to variable renewable energy sources requires balancing the load in the grid. EV batteries connected to bidirectional chargers can be used to feed balancing load back to the grid when renewable production is low, and in the opposite case they can be used as reserves to absorb peak production. Aggregation and optimization of these energy flows, while not interfering with the charging needs, were seen as an important opportunity for CSO companies in near future. Vehicle-to-grid (V2G) technologies are

Table 4.13: Industry drivers. Number of quotations in brackets.

Theme	Codes
Increasing attractiveness of EVs	• Availability of new EV models (5) • Subsidization (8) • Lowering battery costs (2)
Better communication of benefits	• Consumer education (4) • Clear signals from industry giants (2) • Standardization of charging products (1) • Middle-classification of e-mobility (1)
Being aligned with megatrends	• Climate change (4) • Changing values towards car ownership (2)
Increasing charging speed	• High power charging (5) • Battery reserve utilization (1)

being developed in the industry but notable commercial solutions have not entered the market yet.

> *"EVs are most likely to be 90 % of the time a reserve in the energy system and maybe 10 % it will serve the mobility needs. ... At the moment, the vehicle is not serving anyone because it is standing still 95 % of the time.... It is completely worthless, but in the future it will have two roles and the bigger role is that it is part of the energy system."* (IS2)

Other third-party integrations included EV fleet management integrations (e.g. leasing companies), connections to mobility as a service providers and autonomous car fleet connections. Besides mobility related topics, integrations to CRM, business intelligence and payment systems were mentioned. These integrations would require the CSOs to open their APIs for third party developers, and the decision was seen as strategically delicate.

Table 4.14: Industry opportunities. Number of quotations in brackets.

Theme	**Codes**
Third party integrations	• Energy utilities and grid operators (18) • Fleet management companies (8) • Mobility as a service (3) • Car sharing (3) • Roaming operators (3) • Autonomous cars (3) • Car manufacturers (3) • Electric trucks (2) • Home energy services (2) • Financial services (1) • CRM systems (1) • Installation and maintenance companies (1) • Business intelligence system providers (1) • Navigation services (1)
New technological developments	• Plug and charge (5) • Payment systems (2) • Charging integration to the vehicle (2) • Blockchain (2)
Leveraging data and capabilities	• Data analysis (2) • Advertising (1) • Technical complexity (1)

> *"I believe in third-parties that can create links to their own services from us. For example, CRM systems . . . or fleet systems with big global leasing companies. . . . Automotive industry mentioned the fleets as the next step of electric mobility and we should take this into account in development."* (EVCC2)

The second theme – technological developments in vehicles, charging standards and payment systems – were considered as opportunities to improve the user experience of charging. Especially, improvements in communication between the charger and the vehicle were seen important. For instance, plug and charge technology reduces one step in the authentication process, as the vehicle is identified at the very moment when it is plugged in to the charger and no mobile or RFID identification is required from the user.

On the other hand, some CSO-EMSP informants were concerned about the capabilities shifting towards the car manufacturers, which narrows down their specialization possibilities. Similar concerns were mentioned about mobile payment development and blockchain that, on one hand, create opportunities to expand the services but, on the other hand, may lead to losing the value capture to other parties in the ecosystem.

The third theme arose around the in-house capabilities of CSO-EMSP organizations, particularly charging data. This opportunity stems from seeing the valuable technical capabilities within the company and leveraging those to create new businesses as opposed to the fear of losing parts of the value chain to other parties. EVCC5 brainstormed several ways in which data and in-house capabilities can be exploited: pricing model analysis, consultation, traffic planning and infrastructure planning. EVCC4 believed that complex enough functionalities will be staying in the CSO organizations while commercial functions such as payments will be automated and handled by other parties.

Chapter 5

Analysis

In this chapter the findings of the first-order thematic analysis (Chapter 4) and literature review (Chapter 2) are connected for research question analysis. Research questions 1-3 are analyzed and discussed in sequence as they build on each other.

First, the competitive platform-based dynamics are approached with data and literature frameworks. Second, strategic decisions of multi-sided EV charging platforms are evaluated with data, literature and results of the first research question analysis. Third, the chapter concludes by discussing the future of EV charging with data and the results of the first two research question analyses.

5.1 RQ1: Competitive MSP dynamics in EV charging industry

The first research question of the thesis aims at identifying which factors characterize the competitive multi-sided platform dynamics in the electric vehicle charging industry. Prior studies suggest that network effects, multihoming and preference for product variety define whether the market will be dominated by one multi-sided platform, or if there is room for distinctive competitive platforms.

As a starting point, the analysis reveals that not all EV charging companies are multi-sided platforms. Secondly, no clear direction towards monopoly platform nor multiple competing platforms emerge with the literature framework analysis.

5.1.1 Not all EV charging companies are multi-sided platforms

In the literature review it was hypothesized that the MSP business model in EV charging consists of platform owner, an EMSP-CSO organization, and of two sides of EV users and CPOs that have direct interaction with each other and are affiliated with the platform owner. Also it was assumed that the business models differ from the market roles (EMSP, CSO, CPO, EV user) described by Eurelectric (2013), Madina et al. (2016) and Gomez et al. (2011). The findings confirm that there are market roles of EMSP, CSO, CPO and EV user, of which combinations form organizations that have different business models.

However, a thorough analysis reveals that all six business models do not fulfill the MSP conditions of sides' direct interaction and affiliation with the platform owner defined by Hagiu and Wright (2015). As discussed in the literature review, direct interaction means that the sides retain control over the key terms of the interaction and the platform owner does not interfere in that. Interaction can include pricing, marketing and delivery of the service traded. Affiliation refers to the sides making conscious investments to that specific platform e.g. they pay an access fee or decide to have an opportunity cost.

Observation of which business model meets the requirements of a MSP must start from the market roles and control rights. EV user and CPO are always in the position of a platform side and the MSP mediates their transaction of EV charging. Condition of direct interaction between EV user and CPO is met if they can retain the control rights of deciding on the terms of the transaction. In this case, the activities are pricing of the charging and decision to start and stop the interaction. Condition of affiliation is met if there is an intermediary to which both sides connect.

EMSP and CSO are roles that can play the platform owner role and be affiliated with the sides. CSO is always in a mediation role as it transfers information and payments between EMSPs and CPOs. EMSP has similar role in aggregating EV users and mediating their information to CSO. However, interviewees reported that in some cases EMSP can decide on the end user pricing which violates the control rights of the CPO in the direct interaction with EV user. If EMSP decides on pricing, the organization that has EMSP role is operating a reseller business model instead of a MSP (Hagiu and Wright, 2015). We can think the business model such that EMSP purchases charging from CSO and resells the product to EV users with a price that it has defined itself. In this model CPO acts only as a supplier even though it is CPO's charging station through which EV user gets access to charging but the sale of the good takes place via EMSP channel.

With these preconditions in mind, we can look at the six business models identified from the data and analyze if they are multi-sided platforms (Table 5.1 and Figure 5.1). As defined above, CPO and EV user can never be in the platform owner role, thus CPO business model is not a MSP.

Presence of two or more sides is also a necessary condition for a MSP. If the organization owns its charging stations, it has the role of CPO and thus the CPO

Table 5.1: MSP requirements and EV charging business models.

MSP requirements	**Business model**					
	Pure EMSP	**EMSP-CSO**	**CSO-CPO**	**EMSP-CSO-CPO**	**CSO (roaming hub)**	**CPO**
Platform owner	EMSP	EMSP-CSO	CSO-CPO	EMSP-CSO-CPO	CSO	-
Side A	EV user	EV user	EMSP and EV user	EV user	EMSP and EV user	-
Side B	CSO	CPO	-	-	CSO and CPO	-
Direct interaction	No	Yes, if EMSP does not interfere with pricing	No	No	Yes	No
Affiliation	Yes	Yes	Yes, for EMSP	Yes, for EV user	Yes	No
MSP	No	Yes, if direct interaction condition is met	No	No	Yes	No

does not form a separate side. Hence, CSO-CPO and EMSP-CSO-CPO are not multi-sided platforms. There is an exception when this kind of organization also operates charging stations of other CPOs in addition to its own. One could argue that in this case there exists external CPOs as side B. However, that business model can be reduced back to EMSP-CSO or CSO model and the organization can be analyzed as a hybrid of the two business models.

Now there remains only business models that consist of roles of EMSP and CSO, namely pure EMSP, EMSP-CSO and CSO. All these organizations can take

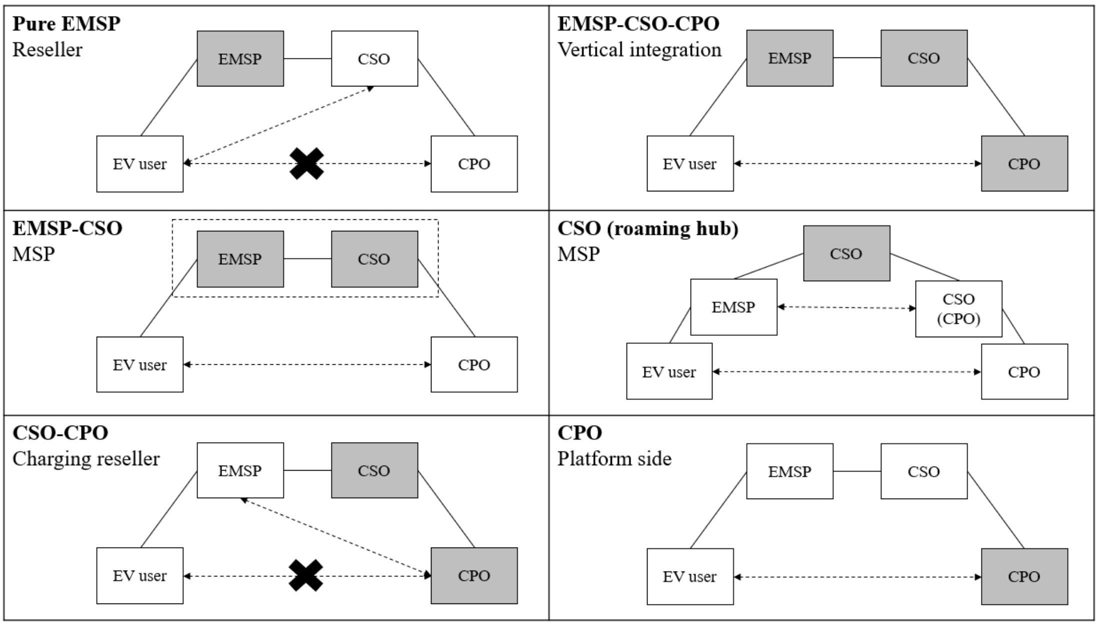

Figure 5.1: The six EV charging business models evaluated by MSP criteria of affiliation and direct interaction.

the platform owner role and mediate transactions of EV users and CPOs. However, pure EMSP has EV users on one side and CSO on the other. Thus, it does not have affiliation with the CPO side as that is mediated through the CSO. Pure EMSP can also violate the control rights condition and set its own price regardless of the CPO price. Therefore, pure EMSP is not a MSP.

On the contrary, EMSP-CSO is a multi-sided platform provided that EMSP does not interfere with the prices set by CPO. EMSP-CSO mediates transactions of EV users and CPOs that fulfill the affiliation and direct interaction conditions.

Finally, we analyze the CSO business model. Side A consists of EMSPs that host EV users. Side B can have direct links to CPOs or then links to other CSOs that host CPOs. Hence, we have a situation in which CSO mediates transactions between different networks of EV users and CPOs – usually referred as roaming. Thus, an organization in pure CSO role is practically a roaming hub.

Usually, roaming hubs operate in a large scale and they do not connect directly to individual CPOs but only access them through CSOs. Therefore, we can omit the direct connection to CPOs in this case. Because a roaming hub mediates interaction of EMSPs and CSOs, it does not have the same activities as normal CSO. Thus, it does not operate and monitor charging stations but it acts as a marketplace for CSOs and EMSPs. In this case direct interaction takes place between EMSP and CSO when the CSO places an offer for roaming prices and EMSP decides if they accept the offer or not. Hence, there can occur a 'platform of platforms' situation if an EMSP-CSO organization with MSP business model participates in CSO roaming hub marketplace.

These results contribute interestingly to the existing gap in the literature that fails to explain the role of roaming in EV charging. Ferwerda et al. (2018) have introduced two ways of organizing roaming: bilateral connections and roaming hubs. Findings from the data confirm the existence of these two but also the concept of internal roaming was brought up as means to connect EMSPs and CSOs with a shared technology platform. What is common for all three ways of roaming, is the connection between EMSP and CSO that are not in the same organization.

To conclude, the findings suggest that on the abstract level, roaming is an interconnection between EMSP and CSO. Bilateral protocol, roaming hubs and shared technology platforms are simply means to implement the interconnection. Strategywise, this implies that an organization considering roaming should make separate analyses for the questions "Why roaming?" and "How to do roaming?". Working with the former question should include assessment of own business model and strategy, and the latter question deals with selection of the roaming method based on the pros and cons of the three ways. These questions are covered in depth in the analysis of research question 2.

5.1.2 Competition drivers

To answer the first research question "Which factors characterize the competitive multi-sided platform dynamics in EV charging industry?", I have first identified that not all business models in the industry are multi-sided platforms. Only EMSP-CSO and CSO as roaming hub fulfill the criteria of a MSP and therefore the competitive dynamics will be analyzed with respect to these models.

Due to CSO roaming hub mediating the interactions on a different 'platform of platforms' level, the analysis will be separated into two streams as different dynamics are expected. Despite the focus on the two MSP business models, some of the concepts, e.g. network effects, may also apply in other business models that are outside the scope of this thesis.

Prior studies emphasized network effects (Tiwana, 2014; Parker et al., 2016) and multihoming (e.g. Armstrong, 2006) as the most important factors defining the competitive landscape of MSPs. Furthermore, the structure and conduct of the network (Afuah, 2013), existence of local bias (Lee et al., 2006) and sides' demand for variety (Eisenmann et al., 2006) were listed as additional factors to be taken into account in competition analysis. Findings in section 4.4 Charging network competition drivers address these themes in the case of EMSP-CSO organization, and the analysis of a CSO roaming hub is based on findings in section 4.5 Interoperability in EV charging.

5.1.2.1 EMSP-CSO organization

This section discusses the dynamics of network effects and their locality, preference for variety and multihoming in the context of EMSP-CSO organization.

Network effects

Interviewees listed several factors that make participation in charging network attractive for EV users and CPOs. These were summarized into themes in sections 4.4.1.1 Charging service attractiveness for EV users and 4.4.1.2 Charging service attractiveness for CPOs. When comparing these themes we can see that most of them match, and thus, they indicate strong and positive cross-side network effects between the sides of the platform (Figure 5.2).

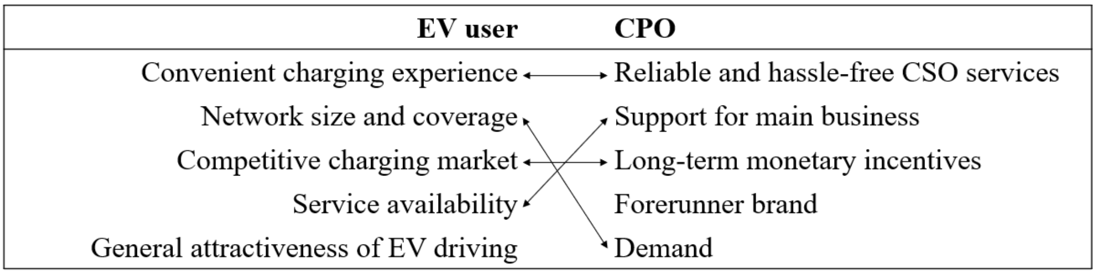

Figure 5.2: Motivations to participate in EV charging ecosystems create positive cross-side network effects between EV users and CPOs.

Same-side network effects seem to be less significant for EV user side. The theme ”general attractiveness of EV driving” included the code ”number of other EV users” but it was reported only a few times to have a positive effect on the attractiveness of the charging system. This is presumable because EV users do not interact with each other in charging. Some informants reported the risk of having to queue for the charging stations if the number of EVs grows faster than the charging stations. However, the risk of congestion was considered very minor or temporary because the increased demand would likely incentivize CPOs to invest in new charging stations.

In addition, locations of the chargers were considered more important than the number of charging stations in the network. People want to charge in places that they normally visit and they do not want to separately drive to a charger just for the sake of charging. This finding implies that there is likely a strong locality factor in the cross-side network effects as EV users choose the available charger along the way regardless of the station branding etc. If the EV users charge usually only at certain charging stations, the number of network ties reduces, and it weakens the cross-side network effects.

On the CPO side, demand for charging services from EV users emerged as a theme, which indicates the presence of positive cross-side network effects. However, there were four other themes that received more mentions.

Interestingly, interviewees did not report that increasing number of CPOs would be a negative issue for a CPO. Thus, no negative nor positive same-side network effects are recognized on the CPO side. A likely explanation for the mild reaction towards increasing competition is that the number of charging stations is still very small and there are seldom two chargers of different CPOs in the same location competing for the same EV users. If the number of EV users increase, this approach might change.

Demand for variety in EV charging

Users' demand for variety was studied by asking the informants if they could identify different user groups of EV users, and if CPOs could differentiate with the charging service they are offering to meet the different needs of EV users. Three themes of EV user differentiation arose: vehicle battery capacity and power input, need for public charging services and level of experience in using public charging services. Each theme can be simplified to a scale of low-high as described in Figure 5.3.

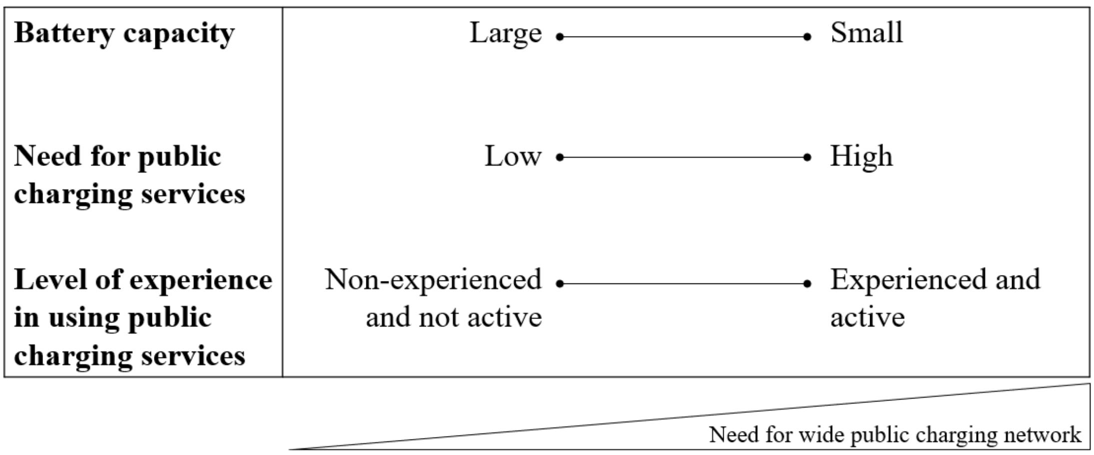

Figure 5.3: EV user's demand for variety in charging services.

Generally, the demand for variety goes to two directions: either the user needs comprehensive public charging network due to e.g. small battery capacity and no access to home charging, or the user does not use public charging stations regularly for opposite reasons. Consequently, this does not imply great demand for variety in the public charging services, if user groups are divided to those who use and those who do not use public charging.

If we take a closer look at the group demanding for public charging services, some variety can be found. Fleet operators, free-charge hunters and BEV vs. PHEV user groups stand out from the data. Thus, different needs in charging pricing, locations and charging speed may exist for these users. Likewise, charging speed and pricing were mentioned as CPO differentiation possibilities. In addition, service offering was the third theme by which a CPO can differentiate. Supplementary service availability was also an important charging service attractiveness factor for EV user informants.

To conclude, grounds for CPO service differentiation may exist if they focus on factors that provide value for some special EV user groups. Fast charging on attractive highway locations, supplementary service offering or low pricing are opportunities on which the distinctive positioning of the platform can be built.

Multihoming

Multihoming patterns turned out clear from the data. EV users multihome in different EMSPs and they have very low costs for it. The opposite holds good for CPOs. They have strong lock-in to the CSO and practically they cannot use any other CSO service simultaneously, not to mention that switching is also costly.

Conclusion

When putting these factors together, we can analyze the competitive landscape of multi-sided EV charging platforms. From EV user perspective the cross-side network effects are positive and strong, yet the charging network structure has a lot of importance which results in rather local network effects. These factors drive the competitive landscape to different directions as Eisenmann et al. (2006) claim strong positive cross-side network effects to converge on one platform but Lee et al. (2006) argue that network structure and the locality of network effects affects competition more than the mere network size such that strong local network effects enable the existence of multiple competing platforms whereas global or symmetric cross-side network effects support monopoly platform formation.

The third factor affecting MSP competition is EV users' preference for product variety. Even though some user groups were recognized, the general conclusion indicates low preference for product variety. This conclusion is also supported

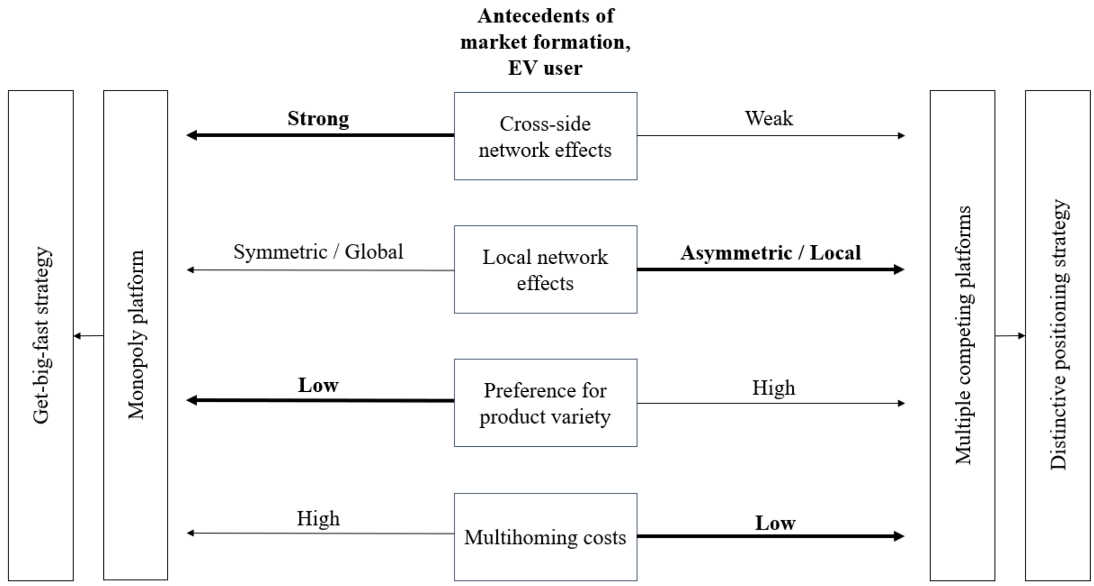

Figure 5.4: Competition drivers in EMSP-CSO multi-sided platform model assessed from the perspective of the EV user side.

by the findings that presume commoditization of charging. Low preference for product variety indicates emergence of a monopoly platform because there are no needs for special features that can be provided by distinctively positioned platforms (Eisenmann et al., 2006).

Finally, low multihoming costs allow EV users to charge in several charging networks, thus enabling competitive platforms. The conclusions are summarized in Figure 5.4, which shows that no generalizing conclusion to either direction can be made, if the antecedents of market formation have equal weights. However, if more weight is put on the locality of the network effects than the strength, it seems that multiple platforms in EV charging can exist and serve different geographical areas. Yet, preference for charging service variety seems low, which does not allow differentiation of the charging services and thus multiple competing platforms do not have high odds.

5.1.2.2 CSO roaming hub organization

This section extends the discussion of competition drivers to CSO roaming hub context. The same factors – network effects, multihoming and preference for variety – apply but internal competition on the platform complicates the dynamics.

Network effects and intraplatform competition

When we observe CSO roaming hub as the platform owner, network effects form between EMSPs and CSOs. However, we can further say that EMSPs are formed of EV users and CSOs are formed of CPOs. As a result, the network effects would be the same but wider than in the case of EMSP-CSO multi-sided platform because the number of EV users and CPOs connected is multiplied. Thus hypothetically, the more CSOs join the roaming hub the better it is for the EMSPs on the other side and vice versa.

However, in practice the materialization of network effects is not as straightforward. Firstly, roaming hubs do not connect only organizations that are on the opposite sides of the platform (e.g. EMSP and CSO-CPO) but there are "two-sided" EMSP-CSO organizations and EMSP-CSO-CPO organizations in addition to the pure one-sided companies. Two-sided organizations may have asymmetric sides such that the relative proportion of EV users is much higher than the CPOs or vice versa. The imbalance may shift the interests of the two-sided company to offer only one side of it to the roaming hub and keep the other side proprietary.

Secondly, even if the sides were relatively equally balanced, there are large variations in the size of the networks that different organizations can bring to the roaming hub platform. Therefore, it may not be attractive for a large EMSP-CSO(-CPO) to connect all their stations to the roaming hub platform, if they get less EV users to charge relative to the investment in exchange.

Thirdly, another competitive level is that CSO roaming hub acts as a platform of platforms, so the EMSP-CSO would rather get the EV users to join directly their platform rather than accessing it via the roaming hub level because then they are forced to share the captured value with the CSO roaming hub. Thus, there are both inter- and intraplatform competitive dynamics in CSO roaming hub business model.

In conclusion, the strength of network effects cannot be deduced from the number of EV users and CPOs (charging stations) under EMSPs and CSOs but the different business models, intraplatform competition and asymmetric networks complicate the analysis significantly. However, evident is that cross-side network effects exist as the business model of a roaming hub would not make sense otherwise.

The question of local vs. global network effects is interesting as the purpose of roaming has often been explained as enabling cross-border travel (Ferwerda et al., 2018). This would indicate that the chargers and EV users connected to a roaming hub platform were located geographically separated. This holds true but it is also possible that the networks are located in the same geographical area. As there are strong local network effects between EV users and CPOs, the attractiveness of cross-border roaming makes sense only in case one lives next to the border and travels regularly cross-border. A promise of cross-border roaming is only a marketing trick for EV users living far from country borders. Two-sided organizations are likely willing to complement their network by roaming EV users and CPOs from different geographical area. CPOs or EV users on the same area are not roamed as willingly due to the same two-level platform competition effect explained above.

Preference for variety

It is not possible to assess CSOs' or EMSPs' preference for variety directly as this was not discussed in the interviews. However, we can interpret from the reported roaming strategies that selection of roaming partners is done strategically such that roaming supports own network development. For instance, roaming can be means to strengthen geographical position in new areas or to add access to attractive high-speed chargers from other network. On a general level, however, the preference for variety is not likely high but rather the number of EV users or CPOs on the other side matters most and not the type of users that there are.

Multihoming

Multihoming in roaming hubs is technically possible for both EMSPs and CSOs. However, the costs increase the more connections EMSPs and CSOs make to different hubs. Pure EMSP business model is an interesting case example as it must roam all its chargers. Thus, if a single roaming hub does not offer attractive enough network, the pure EMSP has no other choice but multihome. A limiting factor in the multihoming analysis is the small number of roaming hubs in Europe. As there are currently only three CSOs operating the roaming hub business model in Europe assessing if EMSPs or CSOs are multihoming or not is difficult. However, at least one of the interviewed companies participated in several roaming hub platforms because they served different geographical markets.

Conclusion

To sum up, CSO roaming hub is a multi-sided platform but analysis of its competitive dynamics is complicated due to the extra layer added with the 'platform of platforms' model. The complexity stems, first, from the multitude of business models of the organizations that act as MSP sides, and second, from platform's internal competition.

CSO roaming hub does not only connect organizations that have EV users to organizations that have CPOs but it connects organizations of which some have both sides. This creates internal competition on the platform because an EMSP-CSO can be affiliated with a CSO roaming hub, a situation in which an EV user can access the same charging station directly via the EMSP-CSO platform but also via another EMSP that is connected to the CSO roaming hub. The latter creates an incentive for the EMSP-CSO not to connect to the roaming hub so that the EV user would have only one option to charge on that charging station.

Hence, due to the additional platform of platforms layer and competition between the platform owner and the sides, it is likely that the number of competing MSPs is going to stay low. However, confirmation of this result would require further research.

5.2 RQ2: Designing a MSP strategy for an EV charging network

The second research question aims at discovering what kind of multi-sided platform strategies an EV charging network should devise in the context of platform industry dynamics. Analysis of this research question is thus dependent on the findings related to the first question.

As no clear direction for the market structure was found for EMSP-CSO organizations, the strategies assuming either competitive market or monopoly cannot be outlined. Thus, both options are still valid: distinctive positioning for fragmented market or "get-big-fast" strategy for monopoly market. CSO roaming hub competition will more likely converge towards one platform, which indicates relevance for the "get-big-fast" strategies. However, the strong intraplatform competition must be considered in that case, too.

Regardless of unclarity in the competitive dynamics, prior studies have proposed strategic decisions regarding pricing and governance that are relevant for any MSP (e.g. Hagiu, 2014). In addition, some other strategies were found in the interviews (see 4.6 Charging network strategies).

Next, these strategic topics will be analyzed in the two MSP contexts – EMSP-CSO organization and CSO roaming hub organization. Subsequently, the two contexts are brought together for network interoperability strategy analysis because discussing both business models parallelly captures the interlinked and nested interests of the business models.

5.2.1 Strategic decisions of EMSP-CSO organization

5.2.1.1 Pricing strategies

Pricing strategies assess two dilemmas: how to design the symmetry of MSP pricing model and within that frame, how to set the pricing models for each side. Table 2.2 summarized factors, e.g. price sensitivity, multihoming costs and preference for variety, that need to be taken into account when choosing the money side and subsidy side in two-sided platform pricing. Next, the data findings are reviewed together with the literature framework.

Price sensitivity

General rule is that the more price sensitive side should be subsidized. Price sensitivity can be deduced from the amount of substitutes available or from the bargaining power that the MSP has over the participant group (Hagiu, 2014). From the perspective of EV users, the possible substitutes for public charging are home charging and other means of transportation e.g. access to ICE vehicle. However, when driving long distances with an EV the EV user has no other choice but charge at the available charging stations.

Two divergent findings regarding EV users' price sensitivity emerged from the data. On one hand, the informants considered the charging prices to be so low that they did not affect the EV user's choice of charging place. On the other hand, user group of "free-charge hunters" was recognized.

For CPOs, the question of price sensitivity is more complex because one could argue that CPOs do not have an inherent need to participate in the charging network but it is simply one way of infinite possibilities to invest their money. However, once a CPO decides to invest in a public charger, there are limited number of charging networks in which the CPO can join and once it has made its decision, it does not have anymore substitutes for the platform, or it is at least very costly to change. Therefore, I would conclude that the CPO is more price sensitive side, and thus, it should be subsidized according to Eisenmann et al. (2006).

Sensitivity for quality

The side that is more sensitive for quality should be subsidized and the side that must supply quality is put on the money side (Eisenmann et al., 2006). As EV charging is a service in which the EV user is the final consumer, it is also the side that demands quality from the service as was concluded in the analysis of charging service attractiveness for EV users (see section 4.4.1.1).

Charging station being online, accessible and functioning are factors that CPO can supply together with CSO. CPO also demands for quality but their demands fall upon CSO, not EV user. Hence, this time subsidy side inclines towards EV users.

Preference for variety and relative power of the platform sides

Preference for variety relates to both research questions as it affects the competitive environment but also pricing strategy. In the analysis of the first research question it was concluded that EV users' preference for service variety in public charging services is low, and if some specialized needs exist, they concern pricing, charging speed and locations.

Hence, this attribute does not affect the pricing symmetry, and even if there was preference for variety in EV user side, defining the subsidy side would not be trivial as Hagiu (2009) offers opposite alternatives depending on whether the market is monopolistic or competitive – information that was not possible to deduce in the first research question analysis.

On more general level, preference for variety is part of the question of which side has more power over the other side. The side that has more power can extract more value from the transaction, which should then be reflected in the MSP pricing model such that that side is charged more (Hagiu, 2014).

EV user does not significantly care for variety. If there are two similar charging stations next to each other, EV user will choose the cheaper one. At this development phase of the industry, it seems that EV users do not have freedom of choice and the CPOs could extract value from the charging events by setting higher prices. However, EV users have often substitutes for public charging and therefore they can often avoid the expensive charging stations. In other words, they have more power over the CPO and to compensate that the CPO side should receive subsidization.

Presence of marquee users

Presence of marquee users i.e exceptionally important participant groups in either side of the platform can be a determinant of pricing strategy (Rochet and Tirole, 2003; Eisenmann et al., 2006). The side with marquee users should be subsidized in order to attract more users to the money side.

EV users are rather homogenic, only fleet operators stand up as a group that would be attractive to target with special pricing. The CPO side, on the other hand, may consist of organizations that the platform owner wants to attract with subsidization. For example, getting a chain of gas stations with attractive locations to join the platform might be worth subsidizing.

Multihoming costs

Finally, the side that has low multihoming costs should be put on the money side (Rochet and Tirole, 2003, 2006; Armstrong, 2006). The data shows clearly that the costs of multihoming are low for EV users and high for CPOs. Thus, EV users should be charged higher price and CPOs should receive subsidization.

Conclusion: Subsidize CPOs to win them on the platform

In conclusion, the pricing model indicators rather unanimously suggest that an EV charging platform's money side is EV users and subsidy side the CPOs.

Supply of quality was the only indicator suggesting the opposite pricing structure. However, the quality of the service was largely dependent on the activities of CSO, not CPO. So, no major contradiction exists.

Empirical results support this conclusion because informants in EMSP-CSO role reported that their business model extracts more profits from the EV user side. However, the CPO side is not excessively subsidized as they also pay access and service fee for the CSO services. Putting more emphasis on CPO subsidization might give the platform owner speed in the "winner-take-all" battle. However, considering the industry life-cycle, a fast growth boom is not to be expected in the platform because there are still only a small number of EV users on the other side. EV user side growth is also dependent on other things e.g. the availability and price of EV models.

Pricing model

The second dilemma, pricing model for each side is relevant for competitive platforms and it concerns deciding on usage and access fees for the platform. The data confirms that EV charging industry is still at early life-cycle phase and Armstrong (2006) argues that usage fees are better way of attracting both sides on board because the participants are only paying for the transactions they make.

Findings in section 4.3 Pricing models show that the pricing components for EV users are usage fees that are based on either time, energy or starting of the charging event. Package pricing is an intermediate form of usage and access fees because it gives access to platform's charging stations but does not guarantee unlimited charging. However, an element of lock-in is related to package pricing since once the EV user has paid the package fee, there is an incentive for her to charge only in the chargers that are included in that contract. However, CPO2 reported that that pricing scheme was not popular compared to transaction-based pricing.

Informants in EV user role preferred usage-based transaction fees over access fees because their charging patterns varied a lot and they did not want to bind themselves to certain charging network when its stations were not everywhere they needed. This links back to the theme of platform life-cycle. At the early development phase usage fees seem to be the only acceptable pricing model for

EV users. However, it is relevant to assess whether this should be changed in the future to improve lock-in to the platform.

On the other hand, CPO side pricing consists of both usage and access fees currently. Monthly service fee can be interpreted as an access fee to the platform and charging revenue share model is transaction-based usage fee. These models were often combined, which is not advisable according to Tiwana (2014).

As CPOs are practically forced to singlehome, the selection of pricing model is more critical than in the EV user side. If the set-up and connection fees are set too high even though the operating costs were reasonable, the CPO may choose a competing platform and then it is very difficult to make it change the platform. The selection of CPO pricing model should be consistent with the subsidization decision.

5.2.1.2 Non-price instruments

Besides pricing, four other strategic themes emerged from the data: network openness, growth, specialization and geographical positioning. Furthermore, in literature review it was concluded that the platform owner can decide on governance of the platform i.e. access to platform and sides' interactions (Hagiu, 2014). Next, these five strategic topics will be analyzed in the context of EMSP-CSO.

Governance

Firstly, EV users' access to EMSP-CSO platform is rather free according to the findings. From theory perspective it is wise to let EV users to join the platform freely because they can seldom do any harm on the platform. The only feasible situation would be if the number of EV users exploded remarkably faster compared to the number of CPOs, and all the charging stations would be congested. Then it would make sense to limit the access of EV users to the platform. However, this kind of situation seems very unlikely because the number of EV users is very easy to anticipate from the statistics of EV penetration in the markets.

On the other hand, it makes sense to govern the CPOs' access to the platform more carefully to ensure the quality of the charging service. CPOs are responsible for the maintenance and functioning of the charging station but any problems occurring in the charging process are usually associated with the EMSP-CSO. For instance, if the charging station is inaccessible due to snow being stacked on the parking space, the EMSP-CSO receives complaints from the EV user even though it is CPO's responsibility to keep the charging station accessible. Thus, governing the CPO access with e.g. service level agreements is a way of ensuring good quality on the charging platform.

Secondly, EV users' and CPOs' interactions are strongly governed. Basically, the interaction of EV user and CPO is the flow of electricity from charging station to the vehicle battery. CPO does not know who are the users charging at her station because the EMSP-CSO governs the customer data and all communication and payments go through the platform owner. This kind of governance structure retains a lot of control of the interaction on the EMSP-CSO, which can ensure that the quality of the interaction is on a desired level. On the other hand, EV user cannot give direct feedback to the CPO because all communication goes via the platform owner. This may lead to inertia in the interaction if the EMSP-CSO does not have enough resources to monitor the service process.

At a high level, governance decisions balance the trade-off of quantity in favor of quality (Hagiu, 2014). For an EMSP-CSO this is an interesting analysis because both quality and quantity are demanded by EV users almost at equal amounts (see 4.4.1.1 Charging service attractiveness for EV users).

However, more emphasis was put on the existing charging stations reliability as it is better to have a few reliable charging stations than a mass of ill-functioning stations that cannot be used. Moreover, in the quantity side, location of the charging station matters more than the frequency of them. Thus, it can be concluded that strong governance, especially in the CPO side, is advisable strategy for EMSP-CSO to ensure good quality charging network development.

Network openness

Network openness is mainly related to the roaming strategy of the EMSP-CSO and it will be discussed in section 5.2.3 Interoperability strategies. On a smaller scale, network openness also relates to the business model selection. Basically, an EMSP-CSO is open for any CPOs to join the platform but as concluded in the findings of research question 1, there are business models that have integrated CPOs in their value chain. For instance, EMSP-CSO-CPO organization is not a MSP but it can also have a hybrid business model that includes both own and outside CPOs. This kind of organization needs to assess its strategy by taking both ownership and platform facilitation perspectives into account.

Growth

Consideration of growth strategies is important for EMSP-CSO as they have strategic ambitions to expand the business as opposed to pure CPOs who participate in the charging business often with different aims. Growth strategy is especially important for EMSP-CPO if the market is likely to converge to a single platform. The analysis of competitive drivers did not reveal whether this is going to happen in the charging market. Yet, many of the informants believed in consolidation taking place eventually.

Growth can be achieved either organically or through mergers and acquisitions. Considering organic growth, the EMSP-CSO needs to take into account strong local cross-side network effects and virtually impossible multihoming of CPOs. Thus, it is important to capture quickly CPOs that own good locations for charging stations. In the future, this will secure the position of the EMSP-CSO as one of which account is relevant to have. This strategy is aligned with subsidization of CPO side. Mergers and acquisitions are means to avoid the pitfalls of being the first to create the market. However, once good charging networks have been built, they are expensive to buy.

Specialization

Opposite for fast growth strategy is differentiated positioning. This strategy works in a market where EV users have preference for varied charging solutions. Analysis of RQ1 concluded that EV users' preference for variety is low, and feasible differentiation possibilities lie in pricing, location and the speed of charging.

Differentiation in pricing leads to cost leadership strategy, which is not attractive, at least not at the moment, when charging is generally so cheap that the EV users seldom check the prices beforehand.

Locational differentiation offers possibilities in specializing to e.g. office buildings, home charging or gas station business model. Each of these groups have different user needs and the value proposition can be finetuned specifically for those.

Fast charging seems to offer the best value proposition as it was often demanded by the users. However, fast charging requires often expensive investments on grid connection and charging equipment, for which CPOs are seldom willing to commit. Thus, we see that fast charging networks (e.g. Tesla Supercharger network and IONITY network) are not operated with MSP business model but rather full control over the value chain is preferred e.g. in the form of EMSP-CSO-CPO business model.

Geographical positioning

Geographical positioning is the last strategic instrument relevant for EMSP-CSO. EV penetration rates differ largely by geographical markets due to different governmental subsidy policies. As a result, maturity of charging markets differs and opportunities of EMSP-CSO business vary by market.

Geographical allocation can be a way of balancing the platform, and being present in different markets helps the organization to learn to cope with different environments and cater to customer needs. Yet, there are risks as same strategies may not work in different geographical markets. Interoperability is also one way of geographical positioning, and it will be discussed in section 5.2.3.

5.2.2 Strategic decisions of CSO roaming hub organization

5.2.2.1 Pricing strategies

Pricing strategies of CSO roaming hub are complicated due to the platform of platforms architecture. EV users' price for roaming is dependent on the price set by CPO but also the pricing on the second layer i.e. what the CSO roaming hub agrees with EMSPs and CSOs connecting to it. The symmetry of pricing on the roaming hub level will be discussed first with the literature framework (Table 2.2) and then the analysis continues with the pricing model selection.

Price sensitivity

In the context of EMSP-CSO organization, it was concluded that CPO side is more price sensitive than EV user side because it has infinite number of substitutes available and commitment to the ownership of a charging station is much more expensive decision than EV user's commitment to a charging event.

We could induce that if an EMSP consists of EV users and a CSO consists of CPOs, then CSO roaming hub that has EMSPs and CSOs as its sides would consist of a large number of EV users on one side and large number of CPOs on the other side. If this holds true, we could argue that the CSO side is more price sensitive because it is a bunch of price sensitive CPOs, and therefore it should be the subsidy side.

Sensitivity for quality

The second pricing symmetry attribute is sensitivity for quality. CSOs operate the charging network and their responsibility is to maintain the quality of charging stations so that the EV users can access reliable and functioning charging stations. Part of this responsibility is on the CPOs as well. Hence, following the logic of Eisenmann et al. (2006) CSO side should be put on the money side to supply the quality for the EMSP side.

Preference for variety and relative power of the platform sides

Preference for variety and sides' relative power over each other are interlinked determinants of subsidy side selection. EMSP side is the "buyer" side as it represents the EV users who buy charging services. That side demands variety in the sense that there should be charging stations available in attractive locations with respect to the user locations. However, the needs are even less distinct than in the case of EV users on EMSP-CSO platform because we can assume that the degree of homogenity increase when we look at EMSP level rather than individual EV user level.

CPOs can set higher price for roaming customers. Thus, CPOs can benefit from the power they have over the other side in the form of higher rents. This would indicate that CSOs should be put on the money side in CSO roaming hub's business model as they can extract more value from the EMSP side that cannot negotiate the prices.

Presence of marquee users

The CSO side can consist of very different types of charging networks. For instance, fast chargers on a geographical market that is not included in the coverage of the roaming hub's network could be one marquee customer that would be attractive to subsidize. Also networks that improve the overall network quality e.g. with large amount of chargers or with fast chargers can be seen as marquee users.

On the other hand, EMSP side consists only of EV users, and the more there are them the more attractive it is for the CSO roaming hub. Thus, EMSP side can be a marquee user only in case it has significantly more EV users than other EMSPs.

In conclusion, CSO side is likely to have marquee users, which puts them on the subsidy side (Rochet and Tirole, 2003; Eisenmann et al., 2006).

Multihoming

Finally, conditions for multihoming affect pricing symmetry decisions (Rochet and Tirole, 2003, 2006; Armstrong, 2006). In the analysis of the first research question it was concluded that both sides can multihome in different roaming hubs but it is difficult to address multihoming behavior due to the small number of opportunities in Europe. Thus, due to lack of data the costs of multihoming remain unanswered here as well.

Conclusion: Subsidize CSO side

The analysis in this section allows conclusions to both directions in terms of pricing symmetry. CSO side should be subsidized if we consider price sensitivity, power over the other side and presence of marquee users. On the other hand, monetization on the CSO side is suggested by the need to supply quality for EMSP side. Nonetheless, we see that there are more indicators suggesting subsidization of CSO side. This business model also emerged in the actual business models that the interviewees reported for roaming.

Pricing model

The choice of a suitable pricing model for the sides is important because too expensive or unfair pricing model will easily deter CSOs and EMSPs to form bilateral roaming contracts or internal roaming contracts, if a shared technology platform is easily available.

The data for the analysis of the roaming hub pricing model is limited as only one roaming hub representative was interviewed. However, based on the data we have, the pricing model is clear and follows the principle of Tiwana (2014) of not combining usage and access fees on the same side of the platform. CSO side has a fixed access fee, which makes it attractive for them to keep the chargers connected to the roaming hub even idle. On the contrary, EMSP pays usage fee based on the number of active roaming sessions. The pricing model is supportive for the sides because it encourages CSOs to connect all their charging stations to the roaming hub for fixed access fee, and on the other hand, EMSP can connect as well but it must pay only based on actual usage of the platform.

5.2.2.2 Non-price instruments

CSO roaming hub has same non-price strategic elements available as EMSP-CSO, namely governance, network openness, growth, specialization and geographical positioning. Yet, most of these are irrelevant strategically due to the large scale of operations. Next, we move on to analyze the instruments role in CSO roaming hub's decision making.

Governance

To govern access to and interaction on the platform, CSO roaming hub must first consider who is allowed to join the platform. Theoretically, it is attractive for the CSO roaming hub to allow participants from all identified business models to affiliate with the hub and bring onboard EV users, CPOs or both. Practically however, the perception of fairness among the sides may be violated, if the roaming hub allows unidirectional roaming i.e. an EMSP-CSO(-CPO) organization can leave out its charging point owner side. This may deter the sides from the platform to create bilateral roaming contracts.

Governing the quality of charging is important for the roaming hub as organizations on the EMSP side want to promise their EV users that roaming outside home network is convenient and pricing is transparent. Therefore, the main interaction between the sides concerns agreeing on the charging pricing.

Network openness, specialization and geographical positioning

Network openness, specialization and geographical positioning are less relevant strategies for CSO roaming hubs to consider due to the large scale and low demand for variety in roaming hub services. CSO roaming hub is practically as open network as possible and it wants to connect as many EMSPs and CSOs as possible. Specialization does not make sense on this level of 'platform of platforms' as the EMSPs and CSOs only want to complement their charger network or user base and not find specialized connections as other ways of roaming offer tools for that. Geographical positioning is neither relevant because it is logical to aim at as wide geographical coverage as possible.

Growth

Addressing growth is relevant for CSO roaming hub as it is likely that the market will converge towards monopoly platform as was concluded in the analysis of the first research questions.

A roaming hub that attracts critical mass of EMSPs on one side and CSOs on the other side is likely going to win the market at least on continental level. CSO roaming hub competes also with its customers as some EMSPs and CSOs may grow so big that they start competing from the same end users. Besides, we have identified that there are alternative ways for network interconnectivity in EV charging, thus roaming hubs are substitutable if they do not offer good value proposition.

5.2.3 Interoperability strategies

So far, this chapter has discussed strategies that are feasible for platform owners to execute internally. This section will expand the perspective to discuss interoperability of charging networks, which addresses essentially the question of "open or closed network?"

Returning briefly to the subject of roles and business models, it was concluded earlier that roaming in EV charging is conceptually the connection between an EMSP and s CSO that are in different organizations, and it is not defined by the technology of the connection per se. This section continues the analysis and addresses topics that are essential when choosing a roaming strategy.

The two MSP business models are brought together in this section because they offer complementing views on the subject. EMSP-CSO organization needs to answer the question "Should I connect my network and with whom?" whereas CSO roaming hub is an enabler of interoperability and it must convince EMSP-CSO to join its roaming platform. The analysis is also expanded to cover the other business models than MSPs because interoperability concerns them, too.

This section analyzes the findings with respect to the theories on network interconnectivity. Pricing, regulation and effects on competition were the main affective themes emerging in the literature review.

According to Hermalin and Katz (2011), interconnection cost should be divided with respect to the benefits that the sides receive. In EV charging, the findings indicate that both EV user and CPO benefit from the interconnection on the bottom level, but EV user benefits likely more because it has the freedom to roam while CPO is fixed to waiting if someone comes roaming.

However, stepping on the next level of the platform structure, namely to EMSPs and CSOs, we see from the findings that the benefits of interconnectivity depend on the size of the network, business model and strategic ambitions. Furthermore, He et al. (2012) claim that interconnectivity is a wise strategic move as long as the firms do not pursue a predatory goal. Thus, interconnectivity is affected by many other factors than pure EV user and CPO benefit. The data suggests that business model, network size and strategic ambitions affect the roaming strategy of an EV charging network company.

Business model

Organization's business model is an important determinant of roaming strategy. A pure EMSP has no other option than to roam its stations to offer as wide network coverage as possible for its customers.

Respectively, pure CPO wants to have as high utilization rate as possible on its charging station, so it is open for roaming. However, CPO is always dependent on the CSO in roaming decisions. EMSP-CSO has both EV users and charging stations in the network, so it primarily offers the home network for EV users but if needed, it can also increase the network size through roaming. Same logic applies to CPOs in the network vice versa. EMSP-CSO-CPO organizations may have interest to close their charging stations outside roaming networks, if they consider that most value can be captured by keeping the value chain proprietary.

Network size

In theory, hub roaming creates equal benefits for the contracting parties if both are EMSP-CSO(-CPO) organizations that bring both EV users and CPOs to the network. However, in reality the networks are never equally attractive as they may differ in size, coverage and quality. Therefore, EMSP-CSO(-CPO) with large networks on both sides may not feel content if they share the full network via hub for much smaller organizations that bring fewer charging stations or EV users into the network. As a result, they start deliberately considering with whom they should collaborate, and this leads to bilateral roaming contracts or unidirectional hub roaming.

Interestingly, we notice that the value proposition of CSO roaming hub lowering transaction and search costs is diluted if the connecting networks grow larger. Also, phenomena like unidirectional roaming result from the asymmetric power balance. If allowed, unidirectional roaming also further dilutes the value proposition of CSO roaming hub, as the platform sides start to consider the governance of the platform unfair.

Strategic ambitions

The networks have differing strategic ambitions that are evaluated when choosing with whom to connect. For instance, a large EMSP-CSO(-CPO) evaluates if there is interest for them to protect either side of the network. Attributes that create competitive advantage for a network may be strong geographical position in an area, network of high-speed chargers alongside highways or sale of electricity through own charging network. These might be worth keeping proprietary, or at least complementing but not competing partnerships should be created.

However, closed network strategy is viable only if EV users (and CPOs in the case of EMSP-CSOs) are using the network despite the lack of roaming. There are two distinct cases for this situation: either an attractive and high-quality network or a monopoly. EV users are happy to register for a service that fulfills their needs with inexpensive, attractive location charging, or they simply have no other choice because other charging networks are not available. In the wake of the industry the latter is possible but as competition intensifies, it is only possible to continue closed network strategy if the service is superior to competitors' offering.

Thus, as He et al. (2012) claim, the firm that does not invest in interconnectivity should have a predatory strategy. Hence, closed network strategy requires the company to aggressively grow its charging network to compete with the ones that have interoperability options available.

Conclusion: Interoperability is an important strategic instrument for charging network companies

These findings indicate that it is not straightforward to say who enjoys the benefits of roaming as all four EV charging market roles are involved with slightly different interests. However, it seems that the strategic importance of roaming on CSO and EMSP level is more relevant than the EV user and CPO benefits and thus the cost of CSO-EMSP(-CPO) organization's growth through roaming is paid by the EV users.

The empirical findings confirm that the prices of roaming are high to EV users

– a finding that is theoretically supported by Carter and Wright (1999) who claim that getting to an agreement in interconnection is seldom a problem but rather the inefficient outcome that is achieved at the end users' expense. Hence, interconnection is often governmentally regulated to protect end users.

At the moment, roaming in EV charging is not regulated but the interviewees anticipated regulation on the EU level to be arranged soon. Currently, Directive 2014/94/EU on the deployment of alternative fuels infrastructure only requires that the charging stations must be available on ad-hoc basis without a need to enter a contract with the electricity supplier or operator (European Commission, 2014). In practice, the directive demands that one-time payment must be available on public charging stations but it does not demand roaming. As restricted roaming seems to be an important strategic instrument for EMSP-CSO(-CPO) organizations, all-encompassing deployment of roaming in European level is not likely unless there is compelling regulation in place.

In conclusion, EMSP-CSO(-CPO) organizations can use roaming connections as strategic instruments. For small organizations interconnectivity through roaming hub is an attractive choice as it weakens price competition by creating complementarity. However, when the network size increases hub roaming becomes less attractive due to intensifying internal competition and likely shift to predatory strategies.

Interestingly, CSO roaming hub has a relevant value proposition only if it can reduce transaction and search costs of the EMSPs and CSOs who want to meet. Therefore, roaming hub business model works well when there are lot of small networks that want to have a single point of contact to all other networks, but if the participants on the sides grow bigger, they have more strategic incentives to arrange roaming more specifically to their needs. Lowering the transaction costs does not provide as much value anymore and internal competition strikes harder.

5.3 RQ3: Future development opportunities for EV charging companies

Due to the young age of EV charging industry, there is a lot of uncertainty related to what kind of future development paths are likely. The third research question was developed to formally map the alternative directions the companies in the industry can take and to address potential challenges and opportunities that will shape the competitive environment.

In addition, thus far the thesis has discussed two-sided EV charging platform that has EV users and CPOs in the sides but there is interest in adding new sides to the platform. This research question attempts to structure what kind of third parties could benefit from the existing charging platforms.

The analysis in this section is mainly based on the findings in section 4.7 EV charging industry development and the research question is approached fully with empirical evidence as opposed to the two previous research questions, of which analysis has involved referring to the literature review. Yet, as some of the themes overlap with the topics of the other research questions, some comparison of empirical views is conducted where applicable.

The informants believed in consolidation taking place in charging markets, and especially acquisitions made by oil companies BP and Shell were seen as supporting evidence for that.

Analysis of RQ1 did not conclude market consolidation nor fragmentation by looking at the multi-sided platform competitive characteristics. However, it was noticed that looking only at multi-sided platform dynamics is not sufficient as many companies in the charging industry operate non-platform business models. Therefore, the informants' views of oil companies' and car manufacturers' increasing interest towards EV charging are relevant observations when considering the future of EV charging. It seems that oil and ICE industries are seeing a great threat of disruption in the electrification of road transportation, and currently we see responses from them.

Moreover, regulation emerged frequently in the interviews as a factor that shapes market formation. Since EV charging is related both to traffic and electricity production and supply – infrastructures that are heavily regulated – it is likely that the legal framework will also affect business opportunities in EV charging – as it partly does already. Most likely the regulation aims at enabling easily accessible and reasonably priced charging for EV users, hence EV charging companies should be prepared for regulated environment.

The informants strongly believed in the fast development of electrification of road transportation both in EV and charging infrastructure sides due to increasing public pressure for climate change mitigation actions. Nevertheless, a lot of challenges overshadowed the trust for positive development. Informants complained that charging is unprofitable now, and it gets commoditized in the future which is likely to keep the margins low. Opportunities for value creation and capture were perceived thin, as actors such as payment providers and car manufacturers were seen to enter the value chain and narrow the value creation opportunities of the charging companies. Many informants pondered what are the unique and non-replaceable capabilities of charging companies that should be leveraged in the commoditizing industry.

As a response to the narrowing value capture space, the informants came up with several expansion opportunities that leverage the multi-sided platform business model. Energy utilities and grid operators were perceived as the most promising third-party integrations because they are facing balancing need due to the increase in fluctuating renewable energy production. Grid operators need to keep the frequency of the grid stable and energy utilities have to match the demand and supply of electricity. EV batteries can act as a power reserve for peak consumption and respectively they can be filled with excess renewable production when there is less demand.

Energy system integrations would require participation from both existing sides of the platform. EV users need to allow that their batteries can not only be filled but also discharged – with recompense as incentive. CPOs have to invest in bidirectional chargers in order to be able to participate in the system.

Fleet operators, mobility as a service providers and autonomous cars were another often mentioned third-parties that reflected the interviewees' beliefs and world view. Some of them thought that in 10-15 years only a few people will own cars since mobility services and even autonomous vehicles take over. Thus, the platform should then coordinate more comprehensively the needs of the transportation infrastructure and not just charging.

Both of these third-party developments and others that emerged in the interviews leave room for further research that could examine more closely the viability of the solutions and how a two-sided platform can transition to multi-sided.

Chapter 6

Discussion and conclusions

This chapter summarizes the thesis and discusses the most important results obtained. First, the objective of the thesis is reintroduced and the results to research questions are concluded. Second, the theoretical contributions of the thesis are summarized. Third, managerial implications are drawn to point out the relevance of the results for industry and companies. Finally, the chapter concludes by setting avenue for future research.

6.1 Conclusion

In the context of alarming threat of climate change, nations and industries have started to develop decarbonization strategies. Road transportation is a major sector producing greenhouse gas emissions due to fossil fuel burn of ICE vehicles. Electrification of transportation has emerged as a solution to decarbonize transportation sector and in recent years a lot of new business has emerged around electric vehicles – evolution of EV charging industry being an essential part of the development. Many companies in the charging industry have adopted platform-like business models to mediate transactions between EV users and charging point owners, and currently several charging networks compete in Europe.

To understand the competitive development of EV charging networks as multi-sided platforms, this thesis has attempted to answer three questions: (1) which factors characterize the competitive platform industry dynamics in EV charging networks? and (2) in the context of platform industry dynamics, what kind of multi-sided platform strategies should an EV charging network company devise? and (3) what future development opportunities exist for EV charging companies?

The thesis was conducted as a qualitative study and the data was collected with 17 semi-structured interviews from people representing different roles in the charging industry across Europe. The data was analyzed with thematic analysis

Table 6.1: Thesis conclusions

RQ1	MSP business models*	**EMSP-CSO**	**CSO roaming hub**
	Competition drivers	Strong but local network effects Low preference for variety in EV user side Low multihoming costs for EV users	Asymmetric network effects Internal competition
RQ2	MSP strategies	Subsidize CPO side Govern CPO access to ensure quality	Subsidize CSO side Ensure fairness by governance
	Other strategies	Network openness Growth Specialization Geographical positioning	Growth
	Interoperability	Business model, network size and strategic ambitions define company attitude towards interoperability	
RQ3	Future	*Driver:* Climate change mitigation *Threat:* Commoditization and intensifying competition *Opportunity:* Flexibility of MSP business model to evolve with third party integrations	

*Other non-MSP business models are pure EMSP, EMSP-CSO-CPO, CSO-CPO and CPO

method. I shall now discuss the most important results of the thesis (summarized in Table 6.1).

To answer the first question, I first found out that there are multitude of business models in operating EV charging networks but not all of them are multi-sided platforms. Business models in the industry consist of combinations of market roles of electro-mobility service provider (EMSP), charging service operator (CSO) and charging point owner (CPO), who aim at fulfilling the needs of EV users – the end users of the system. The first finding is that an established perception of the market roles nor business models does not exist yet in the industry, which is understandable due to the young age of the industry. I found out that two business models, EMSP-CSO and CSO as a roaming hub, operate as multi-sided platforms. The former mediates interactions of EV users and CPOs, and the latter functions as a 'platform of platforms' by mediating the interactions of EMSPs and CSOs. Hence, the analysis of both research questions was split to two streams to assess the competitive dynamics and strategies of both the business models.

Starting with EMSP-CSO, I discovered that the competitive MSP environment is characterized by, first, strong but rather local cross-side network effects between EV users and CPOs, second, low demand for variety in charging services, and third, high multihoming costs on CPO side and low on EV user side. These factors do not predict the competitive environment consistently, as some factors forecast convergence to one platform and others presume multiple competitive platforms.

MSP strategies available for EMSP-CSO platforms, the interest of the second research question, relate to pricing and governance of the platform. The analysis suggests that EMSP-CSO should subsidize CPO side in order to win the market. However, this should be done carefully as the number of EV users in the other side does not immediately follow the increase in CPO side due to the small pool of EV users, of which amount in the market is dependent on EV prices and availability. Advisable governance strategy is to control the access of CPO side to ensure that the charging service quality for EV users remains high. In addition to strategies specific to MSP business model, EV charging companies should consider strategies on specialization, growth, geographical positioning and network openness.

Continuing with the CSO roaming hub, I concluded that asymmetry of network effects and intraplatform competition affect the competitive environment of roaming hubs most. Multihoming costs and preference for variety that emerged significantly in the EMSP-CSO stream were less relevant for CSO roaming hub. The factors characterizing competitive environment differed because EMSP-CSO and CSO roaming hub mediate transactions of different types of users. EMSP-CSO has consumers on the EV user side and small-scale companies on CPO side, whereas CSO roaming hub only contracts organizations that themselves have strategic interest in EV charging.

The second research question, strategies for CSO roaming hub, include pricing and governance similar to EMSP-CSO. Data and theories do not indicate consistently subsidy and money sides but more indicators inclined towards subsidizing CSOs and monetizing on EMSPs. Governance of CSO roaming hub must focus on ensuring perception of fairness in the platform such that all participants in both sides feel that the activities on the sides are fair. Otherwise they may abandon the platform and create roaming contracts with other means.

Finally, interoperability i.e. roaming emerged as a strategic instrument that concerns both EMSP-CSO and CSO roaming hub. Roaming has emerged from the needs of EV user to charge her car with single contract easily across networks. However, it seems that the strategic relevance of roaming for EV charging companies sometimes overrides the end-user benefits.

I have found out that business model, network size and strategic ambitions of the EV charging company affect its roaming decisions. Small companies benefit from network interoperability generally but when the network size and ambitions grow, the companies start to consider deliberately with whom they want to enable interconnections because keeping one's network proprietary is a predatory strategy. CSO roaming hub, a MSP business model specific to arranging roaming between EMSPs and CSOs, is treading a tightrope when internal competition with platform sides intensifies. Consistent with the literature, roaming in EV charging networks exists but the cost of it is borne by the EV users. Regulation from governmental and EU level authorities is likely to be put in place soon for the benefit of end users.

To create visibility to future of the rapidly changing industry, the third research question was set to identify the challenges, opportunities and drivers affecting EV charging industry development. Threat of climate change has put a lot of public pressure to electrify road transportation, which has enabled a lot of development in the EV charging networks. However, the competition in the industry intensifies and many charging companies fear that commoditization narrows the space of value capture, if payment service providers, car manufacturers and oil companies gain ground in the value chain of charging. The benefit of multi-sided platform business model is, however, its flexibility and ability to adjust to the changing requirements of the industry. For example, transition from two-sided platform to multi-sided by integrating electricity suppliers and grid operators with vehicle-to-grid technology is an opportunity for platform-based company. These opportunities provide interesting seeds for further research.

6.2 Theoretical contributions

This thesis has created several contributions to the understanding of the theoretical grounds of EV charging network business model development by utilizing multi-sided platform theories. The thesis confirms the existence of market roles identified in previous research on EV charging networks and clarifies the activities of each role (Gomez et al., 2011; Eurelectric, 2013; Madina et al., 2016). The empirical findings in this study provide new understanding of business models that consist of different combinations of established market roles. The new insights of business models should help when studying the competitive strategies in the industry as opposed to the market models that do not reveal the combined motives of the organizations.

Secondly, this thesis contributes to the understanding of interoperability in EV charging networks by introducing an abstract conceptualization of roaming being a connection between an EMSP and a CSO that are not in the same organization. Prior studies have addressed roaming only from technological and practical perspectives of how a network interoperability connection can be formed either through roaming hub or with bilateral agreement (Ferwerda et al., 2018). The new conceptualization addresses better the strategic aspect of interoperability by focusing on the question of when interoperability is a desirable choice for an EV charging network. As the focus shifted from technologies to strategy, I found out that in addition to two common roaming technologies (hub roaming and bilateral roaming), there is also a third technology, a shared technology platform, that has not been perceived as roaming before but it fulfills the new definition.

Thirdly, the analysis of EV charging networks undertaken in this thesis, has extended the knowledge of multi-sided platforms by offering a new context for the theory. The thesis has found two business models in EV charging network industry that pursue multi-sided platform business model. As EV charging is bound to physical locations, the thesis has extended the body of research that traditionally studies digital platforms. Constraints of the physical world must be considered in the research of multi-sided platform dynamics such as network effects and multihoming. The insights of this thesis can also be applied in other industries that combine physical and digital world in platform-based markets.

6.3 Managerial implications

In addition to theoretical contributions, the thesis offers valuable information for companies operating in the electro-mobility industry. Firstly, the empirical findings offer interesting perspectives on the motivations of EV users and CPOs to participate in charging activities. Data on the preferences helps managers design EV charging services that cater the needs of the end users. Secondly, profound business model descriptions help companies interested in EV charging to evaluate the typical business models in the industry and choose the one that fits their strategic ambitions best.

Companies involved in CSO and EMSP roles will find interesting insights for their strategic analyses. Especially, contributions in the area of roaming strategies hopefully bring clarity for companies that aim at growing their charging network. Even though the thesis has focused on multi-sided platform dynamics, companies operating other business models can also benefit from learning the rules that shape the platform-based markets. Conversely, MSP companies should note that there are different business models in the industry and the success cannot be created by following the MSP strategies alone.

All in all, when reading the thesis one should note that even though roles and business models were identified, they do not depict all the complexity in the industry. Actual business models are not as clear-cut as the simplified conceptualization here might indicate. For instance, companies may use hybrid business models or two distinct business models for different types of business.

Finally, the thesis provides a snapshot of an interesting industry that is evolving extremely rapidly. As in any emerging industry, there is a lot of uncertainty regarding future development. The results of the final research question provide intriguing ideas for companies to develop their charging business to new directions. Leveraging existing capabilities and exploring open-mindedly synergies in new areas may create sustainable competitive advantage in the middle of commoditizing development of EV charging.

6.4 Future research

This study has touched many areas that would offer interesting topics for further research. Firstly, more knowledge on how to transition a two-sided platform into multi-sided platform would help not only companies in EV charging industry but organizations in similar industries. More information would be needed to understand how the MSP dynamics change when a third side is added, for example.

Secondly, dynamic capabilities theory (Teece et al., 1997) could be studied in the context of EV charging network companies that have developed capabilities in the emerging industry but are now facing intensifying competition from incumbents. Ways to exploit existing capabilities would be interesting areas of research in the development of new competitive advantage for these organizations.

Finally, electro-mobility industry is trying to disrupt the fossil-dependent transportation industry. Oil companies and car manufacturers have recognized the speed at which e-mobility is occupying the space in which they have traditionally been strong and established their positions. Car manufacturers have historically refrained from the motive power business but after introduction of EVs they have made vertical integrations to charging network. Respectively, oil companies have taken steps towards horizontal integration when they have acquired e-mobility and renewable energy start-ups. These moves act as fruitful foundation for research of technological disruption and its mitigation as well as platform envelopment strategies (Eisenmann et al., 2011).

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Appendix A

Interview details

Table A.1: Interview details

Interview	Code	Interviewee position	Interview date	Length (min)
1	EVCC1	EV charging company: technology	29.11.2018	68
2	EVCC2	EV charging company: business	29.11.2018	70
3	RS1	EV charging company: roaming	3.12.2018	35
4	EVCC3	EV charging company: CEO	3.12.2018	63
5	IS2	Industry specialist	10.12.2018	67
6	EVCC4	EV charging company: CEO	10.12.2018	52
7	RS2	EV charging company: roaming	11.12.2018	60
8	RS3	Roaming operator	11.12.2018	57
9	CPO1	Charging point owner	12.12.2018	21
10	CPO2	Charging point owner	17.12.2018	50
11	IS2	Industry specialist	18.12.2018	67
12	EVCC5	EV charging company: services	18.12.2018	67
13	CPO3	Charging point owner	31.1.2019	35
14	EVU1	EV user	12.2.2019	56
15	EVCC6	EV charging company: CEO	25.2.2019	53
16	EVU2	EV user	8.3.2019	25
17	EVU3	EV user	11.3.2019	32

EVCC = EV charging company
RS = Roaming specialist
IS = Industry specialist
CPO = Charging point owner
EVU = EV user

Appendix B

Interview guide

The interview questions were designed to study seven focus areas cross-sectionally. The focus areas are platform structure, network effects, competition, pricing, governance, interconnectivity and future of EV charging. The interviewees represented four roles: EMSP and/or CSO, CPO, EV user and industry specialist. In addition to the primary cross-sectional interview, a separate set of interview questions were developed for roaming experts, who were interviewed only on that topic.

Each interview started by introductions of the interviewer and the interviewee. The purpose of the thesis and confidentiality issues were also discussed prior to actual interview questions.

Table B.1: Interview guide

	EMSP and/or CSO	CPO	EV user	Industry specialist
Platform structure	• Please describe the service that you offer for your customers • What do you offer for EV users? • What do you offer for charging point owners? • (What do you offer for electro-mobility service providers?) • Besides EV users and charging point owners, are there any other parties that participate in your platform? How? • Which other groups would you like to integrate in your platform? • (Do you see your service as a marketplace that connects CPOs and EV users or do you see it as an innovation ecosystem in which third parties develop complementary services?)	• Please describe the charging service ecosystem in which you participate. Which other organizations are there and in which roles? • Who are your customers? • How many customers do you have, for whom you offer charging point service? • Who owns charging points and is responsible for their operations and maintenance? • Are the charging stations in your properties public or private? • Besides EV charging, are there other services that you would like to have in the platform?	• Where do you charge your car? At home, at workplace or at public charging stations? • How often do you use public charging services?	• Please describe how the public charging of EVs is organized in Finland and which companies and organizations are involved in it?

Table B.1 continued from previous page

	EMSP and/or CSO	CPO	EV user	Industry specialist
Network effects	What makes charging service attractive for EV users? • How does the number of other EV users affect? • How does the number of charging points affect? • Does the structure of the charging network affect? E.g. the locations of the charging stations. • How do the needs of EV users differ from one another? What makes charging service attractive for CPOs? • How does the number of other CPOs affect? • How does the number of EV users affect? • Does the structure of the charging network affect? • Can a CPO differentiate as a charging service provider?	• Why do you want to offer charging service? • What makes a charging station attractive for you? • What is important when you choose the charging service operator? • Do you consider the number of other charging stations in the network when you choose the operator? • How does the number of EVs in the market affect your choice to become a CPO? • What makes charging service attractive for EV users?	What makes public charging service attractive in your opinion? • Number of chargers in the network? • Locations of chargers? • Number of other EV users? Can you cluster EV users to different user groups based on their needs or charging behavior?	Same questions as for EMSP and/or CPO

Table B.1 continued from previous page

	EMSP and/or CSO	CPO	EV user	Industry specialist
Competition	How would you describe the life-cycle stage of the charging business in your market? Do your EV user customers use other similar charging services provided by other charging networks? How about CPOs? • How can you as an operator increase the lock-in of the EV user to your particular service and prevent them from using the competitors' services? • How can you as an operator increase the lock in of the CPO to your particular service? • How does it affect your operations that the EV user can use other charging services as well? • How does it affect the CPO's operations that the EV user can use other charging services as well? Who are your most relevant competitors?	• Why did you join this particular charging network with your chargers? • How does it affect your operations that the EV user can charge their car also in other charging points in other networks?	• Which different public charging services have you used? • Which service/app do you use the most often? Why? • Are there any other charging services that you have used? E.g. non-smart • Which factors affect your decision when you are choosing a public charger? • Do you feel that you have freedom of choice regarding the charging services? • Do you identify as a customer of a certain charging service when you use that service provider's app/service? • Which one of the following you associate the charging station to represent: the charging service provider, charging service operator or the charging point owner?	• How would you describe the life-cycle stage of the charging business in your market? • Which companies are the most relevant EV charging network providers in Finland? • How does it affect CSO's operations that the EV user can use other charging services as well? • How does it affect CPO's operations that the EV user can use other charging services as well?

Table B.1 continued from previous page

	EMSP and/or CSO	CPO	EV user	Industry specialist
Pricing	CPO pricing • What kind of pricing model do you have for CPOs? Why? (subscription fee, pay-per-use or combination) • How much does the pricing affect the demand? EV user pricing • What kind of pricing model do you have for EV users? Why? (subscription fee, pay-per-use or combination) • How much does the pricing affect the demand? In two-sided platform business, it is typical to have the other side as a "money side" that pays for the service and the other side as a "subsidy side" that gets the service for lower price or even for free. Do you have symmetric pricing for EV users and CPOs in terms of profit generation or do you subsidize either side?	CPO pricing • What do you think about the pricing model between CSO and you? • How does the pricing model affect your way of operating the charging stations? EV user pricing • How do you price your service for EV users? Why?	What is your opinion on the pricing of public charging? • Is it transparent and clear? • Cheap or expensive? Do you think that charging prices are easily accessible? How much does the price affect your choice of charging station?	• What kind of pricing models for charging exist? • In platform business it is possible to have asymmetric pricing model. Are this kind of pricing models in use?
Governance	• How do you govern the CPO's and EV users' access to your service platform? • What decisions are the CPOs and EV users allowed to do in the platform? Which actions can they decide on? • How do you as the service provider govern the interactions of CPOs and EV users?	• How do you monitor charging stations activities and condition? • Which activities regarding the charger and charging service you can control? • Are there things that you would like to control but cannot?	• Could you describe what you do when you visit a public charging station? • What kind of problems can occur during the charging process? How do you react in case of an issue?	• Not asked

Table B.1 continued from previous page

	EMSP and/or CSO	CPO	EV user	Industry specialist
Inter-connectivity	• Are you part of EV roaming networks? Which ones? Why? • What are the benefits of roaming for CPOs and EV users? • What are the disadvantages of roaming for CPOs and EV users? • How does the roaming pricing model work? • How do you see roaming affecting the competitive situation of charging networks?	• Do you think that roaming services are important in EV charging?	• Have you driven EV abroad? • Have you used roaming in EV charging? If yes, how was the experience?	• Why are roaming services offered in EV charging? • What are the benefits and disadvantages of roaming for (a) EV user, (b) CPO, (c) network operator? • How will roaming affect the competitive environment of charging networks?
Future of EV charging	• What are the greatest challenges of the charging industry today? • What needs to change in order for these challenges to be solved? • Do you see new business models emerging as a response for these challenges? • What does the industry structure look like in next 5 to 10 years?	• Are there other services related to EVs that you would need in addition to charging? • What are the greatest challenges of the charging industry today? • What needs to change in order for these challenges to be solved? • What does the industry structure look like in next 5 to 10 years?	• What are the greatest challenges in EV charging industry at the moment in your opinion? • What changes should happen in order for the challenges to resolve? • Do you see that new business models will emerge in the industry? • Are there any other services that you would need related to electric vehicles? • How does the industry look like in 5-10 years?	• Same questions as for EMSP and/or CPO

Interview guide for roaming specialists

Questions 1-5 are only for the interviewee representing roaming operator

1. Please describe the service that you are offering to your customers. What is your role in the EV charging ecosystem? Who are your customers?
2. What do you offer for EV users?
3. What do you offer for charging point owners?
4. What do you offer for EMSPs and charging operators?
5. Are there other parties or organizations that participate in your platform some way? How?

Questions 6-12 are for all roaming specialists

6. What is roaming? How does it work?
7. In which ways it is possible to organize roaming between two operators?
8. Why is your company participating in roaming networks?
9. What are the benefits of roaming for CPOs, EV users and EMSPs?
10. What are the disadvantages of roaming for CPOs, EV users and EMSPs?
11. How does the roaming pricing model work?
    - Who pays the price premium of roaming in the end? Is it the end user, CPO, EMSP or operator?
12. How do you see roaming affecting the competitive situation of charging networks?