Towards commercialisation of vehicle-to-grid

Lessons learned from R&D collaborations on vehicle-to-grid in Denmark and The Netherlands from a dynamic capabilities perspective

By Tim van Egmond

Masters thesis by Tim van Egmond
Student number: 2624574
E-mail: tdvanegmond@gmail.com

Msc Science Business & Innovation
Vrije Universiteit Amsterdam
Commisioned by EVconsult

Supervisor: dr. M.L. Blankesteijn
External supervisor: F. van Herwijnen, Msc.
Co-assessor: prof. dr. ir. B.A.G. Bossink

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Executive summary

To solve the problem of congestion in the power grid, caused by the rise in renewable energy generation, vehicle-to-grid (V2G) technology needs to scale up and become commercially available. The aim of this multiple case study is to learn from R&D collaborations on this technology that contributed successfully to commercialisation. The following research question is answered:

What lessons for commercialisation of vehicle-to-grid technology can be learned from research and development collaborations on vehicle-to-grid technology from a dynamic capabilities perspective?

The analysed cases are the Parker project (Denmark) and the Lombok project (The Netherlands), which both are seen as frontrunning projects for V2G implementation.

The lens through which the research was conducted is a dynamic capabilities approach on the strategic management of open innovation. This idea is proposed by Bogers et al. (2019). The dynamics of dynamic capabilities were constructed with the framework of dynamic capabilities from Schilke et al. (2018).

The data for the analysis was collected through 11 interviews, a V2G conference, and desk research (i.a. project documents, project research, year reports). This data was analysed through coding by hand with a coding scheme that was based on the measurable factors from the conceptual model. This allowed finding concrete success factors for R&D collaboration on V2G.

The findings reveal that by combining specific experience, skills, and resources, actors create the antecedents of the collaboration. These antecedents allow the collaboration to use, develop, and maintain unique dynamic capabilities that could not have been formed by any individual firm. A special focus lies on structuring the anticipation process, which allows actors to sense opportunities and threats. Furthermore, the collaboration is able to build internal capability and perform market introduction activities. Besides, dynamic capabilities are formed that orchestrate the business environment. This results in a direct contribution to the commercialisation of V2G by creating viable V2G solutions, but also adds to the commercialisation by creating innovation outcome, domain-specific performance, resource-base change, growth, and flexibility on the individual actor level. The effect of dynamic capabilities is moderated by organisational factors like company size, strategy, and culture. Besides that, environmental factors as industry sector and geography also have a moderating effect.

This result means that it is not self-evident that R&D collaborations on V2G contribute to the commercialisation of V2G. A collaboration needs to combine the right antecedents to cope with the context of V2G. The final framework of this research is a guideline that allows future collaborations to combine the most important antecedents for successful R&D collaborations on V2G. By creating this framework, this research has contributed to the literature that indeed a dynamic capabilities perspective can be used as a strategic lens to manage open innovation. Besides, this research contributed by showing that an interplay between the dynamic capabilities of the different actors involved adds value to the outcome of the R&D collaboration on V2G.

Future research should focus on how regulations would be able to adapt as fast as a new innovation. At this moment, this is a barrier for optimal use of the technology. Furthermore, the ability of dynamic capabilities to shape ecosystems should be explored to understand how firms could manage towards R&D collaborations. Lastly, the dynamic capabilities seem to have a feedback effect on antecedents and moderators. Exploring this topic will allow for an even deeper understanding of the dynamics of R&D collaborations on V2G technology.

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List of abbreviations

AC	Alternating Current
BRP	Balance Responsible Party
CPO	Charge Point Operator
DC	Direct Current
DSO	Distribution System Operator
EV	Electric Vehicle
EMSP	Electric Mobility Service Provider
EVSE	Electric Vehicle Supply Equipment
OEM	Original Equipment Manufacturer
POP	Preference Operating Point
RES	Renewable Energy System
R&D	Research & Development
TRL	Technology Readiness Level
TSO	Transmission System Operator
V2G	Vehicle-to-Grid

Preface

This report represents the research conducted for the purpose of the master's thesis project for the master's degree Science, Business & Innovation. The research project was supervised by Dr. Marie Louise Blankesteijn from the VU Amsterdam who was also the first assessor. Frans van Herwijnen, MSc, was the external coach who works at the internship company EVConsult. The co-assessor of the research was Prof. Dr. Ir. B.A.G. Bossink.

Acknowledgements

Almost six months ago I started at EVConsult and kicked off the final research project of my study career at the university. Now that I am writing the final words of my thesis, I think it's a good time to thank the people who have supported me during the project. With their contribution, the project not only resulted in this report but also in many teachable moments on a personal level.

First of all, I would like to thank all experts who were willing to find an hour in their busy schedules to cooperate with my investigation.

Furthermore, I would like to thank Frans van Herwijnen and Marlous Blankesteijn for their valuable supervision on the research project and their coaching during the entire process. Especially, I would like to thank Frans for learning me to listen to advise instead of countering every suggestion with a wildfire of words. I have tried my best to improve this. Then I would like to thank Marlous for taking me out of the bubble sometimes. I really enjoyed our meetings and always felt relieved after a meeting with you.

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I would like to thank Bart Bossink for providing me with some valuable feedback during my presentation and I hope that you will enjoy reading this report better than my latest draft version.

Finally, I would like to thank my colleagues at EVConsult, my friends and family. You have made my internship period very enjoyable and besides, you supported me with moral support when I needed it.

1. Introduction

The rise in the usage of renewable energy generation, electric mobility and heat pumps is causing a fast increase in energy usage in the Netherlands (CE Delft & ECN.TNO & SMV, 2019). Subsequently, the capacity of the power grid runs up to its limits. In the province of Noord-Holland, 37% of the current high voltage stations will become a bottleneck in 2020. Normally, transmission system operators (TSOs) lower this pressure on the grid by increasing the capacity of the power cables. Unfortunately, the lead time of new power cables ranges from three to ten years, resulting in an urging problem for the power grid (Tennet, 2019). Vehicle-to-Grid (V2G) technology is seen as a promising new technology that could address this problem (Elaad, 2020).

V2G technology ensures that an electric vehicle (EV) has the ability to charge and discharge energy to the power grid. By using this ability, a fleet of EVs is able to stabilise the power grid by providing different services to the grid operators (Kempton & Tomiç, 2005). At this moment, V2G technology is close to commercialisation with a 7-8 technology readiness level (TRL) (V2G-Hub, 2020). To address the upcoming problem in the power grid on time, it is critical to scale-up the technology and make it commercial.

In line with the trend of the last decade in the automotive industry, original equipment manufacturers are approaching this challenge with an open innovation strategy. OEMs recognize that only using internal sources to come up with ideas for innovation is not sustainable anymore (Wilhelm & Dolfsma, 2018). Because of the traits of V2G technology, OEMs are forced to innovate in areas in which they have minimal specialist knowledge, like IT and the power grid. Research & development (R&D) in these areas require high investments while it is uncertain whether the OEM will be first-to-market. If this is not the case, the desired competitive advantage and many resources are lost. To reduce this risk an OEM performs open innovation. Open innovation is characterized by an R&D department using both internal and external sources to come up with ideas for innovation. OEM's open up their firm boundary for external parties to collaborate on R&D. Through savings on R&D cost, diffused risk and complementary assets, the OEM is ensured to work towards the future with greater certainty (Chesbrough, 2003).

As a result, OEMs are collaborating on V2G technology with the energy and IT sector in R&D collaborations. Since the technology influences the usage of public space and the driving experience of the user, also public parties and users are involved. These collaborations seem to have a positive effect on the commercialisation of V2G technology (V2G-Hub, 2020). This research would like to understand how such R&D collaborations are capable of causing this effect.

To understand the full benefits and possible limits to open innovation and strategically manage this, a dynamic capabilities perspective is proposed by the originators of open innovation and dynamic capabilities (Bogers et al., 2019). Dynamic capabilities are the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. (Teece, 2010). By reconfiguring their dynamic capabilities, an OEM could shape their company to better cope with the challenges of open innovation (Kazadi et al., 2016; Behnam et al., 2018). Kazadi (2016) has identified the dynamic capabilities that are needed to manage the challenges of R&D collaboration as a leading firm. Besides that, Sluyts et al. (2011) have investigated the dynamic capability of a leading firm to manage strategic collaborations. Both Sluyts et al. (2011) and Kazadi et al. (2016) point out the research gap of the lack of an examination of the dynamic capabilities from the perspective of all stakeholders. According to Matthyssens et al. (2009) exploring the bundling of dynamic capabilities in collaboration could be worthwhile.

Behnam et al. (2018) have put in a first effort to explore this possibility to improve R&D collaborations and found out that all key partners should possess certain dynamic capabilities in order to develop an innovation that will drastically change existing systems and consumers' lifestyle, which V2G technology seems to do. However, Behnam also mentions that this combination is partly dependant on the sustainability context.

This research will add to this literature by further exploring the possibility of a fit between the dynamic capabilities in R&D collaborations in the context of V2G technology. Besides that, this research will contribute to the idea of Bogers et al. (2019) by exploring the strategic management of open innovation from a dynamic capabilities perspective with empirical evidence.

This leads to the following research question being answered:

What lessons for commercialisation of vehicle-to-grid technology can be learned from research and development collaborations on vehicle-to-grid technology from a dynamic capabilities perspective?

The sub-questions that will be answered leading to the answer to the main research question are:

- What is the effect of R&D collaborations on V2G on the commercialisation of V2G?
- Which elements of R&D collaborations on V2G define the dynamic capabilities of the collaboration?
- What is the effect of dynamic capabilities on the outcome of R&D collaborations on V2G technology?
- Which factors moderate the effect of dynamic capabilities on the outcome of R&D collaborations on V2G technology?

These questions are answered by conducting a multiple-case study. These cases focus on projects where OEMs collaborate with public and private parties to commercialize V2G technology. These projects are being seen as frontrunners and situated in the Netherlands and Denmark. The stakeholders of these projects will be interviewed, while at the same time desk research is done. Furthermore, an international conference on V2G, where most of the stakeholders were present, is visited. By analysing this information through coding by hand, the complexity of the dynamics of R&D collaboration on V2G technology will become clear while at the same time a better understanding of the success factors is constructed.

Because of the focus of this study on R&D collaborations on V2G technology, this study is limited in that the results are difficult to generalise. Before the results are transferred towards an R&D collaboration project with different technology, the similarity of this other technology to V2G should be analysed first. Therefore, to add more validity to the generalizability of the results, future studies on projects focussing on other R&D collaborations on technological innovations is recommended.

In the following pages, theoretical background on this topic will be given. Subsequently, a conceptual model is constructed. After this, the method used will be stated and results will be presented. The significance and limitations of these results will be discussed in the discussion. The report will end with a conclusion.

2. Theoretical Background

The knowledge base that serves as a justification for this research is derived from a combination of topics. The theory of open innovation within the automotive industry will be addressed first. Thereafter, theory on dynamic capabilities will be connected to this context. This will then lead to a conceptual model.

2.1 Open Innovation

Open innovation originated in 2003 as a new imperative for organizing innovation (Chesbrough, 2003). The main idea behind open innovation is grounded in the belief that firms can and should use external ideas as well as internal ideas to innovate. Chesbrough (2003) makes a distinction between two angles on this belief. When a firm actively searches to obtain knowledge from external sources to implement this in their innovation efforts, there is spoken of inbound open innovation. In the case where a firm shares its knowledge with external sources to let them develop it further, there is referred to outbound open innovation.

In the years after the introduction of this concept, the research on this topic got more diffused. The origin of this diffusion lies in the understanding and conceptualization of the openness construct. For example, Laursen and Salter (2006) equate openness with the number of external sources of innovation, whereas Henkel (2006) focuses on openness as revealing ideas previously hidden inside organizations.

Dahlander & Gann (2010) have analysed this diffusion of research and created a conceptual framework to better conceptualize the openness construct for future research. Their review indicates two inbound processes: sourcing and acquiring, and two outbound processes, revealing and selling. Furthermore, they emphasize the importance of not only state the advantages of open innovation but also acknowledge the disadvantages of implementing open innovation principles.

Chesbrough & Bogers (2014) also observed the diffused definitions used for open innovation. To achieve greater consistency in future research they re-conceptualized the open innovation definition: 'Open innovation is a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization his business model.' These flows of knowledge may involve knowledge inflows to the focal organization (leveraging external knowledge sources through internal processes), knowledge outflows from a focal organization (leveraging internal knowledge through external commercialization processes) or both (coupling external knowledge sources and commercialization activities). An important contribution here is the emphasis that open innovation should be aligned with an organization its business model.

West & Bogers (2014) reviewed both the 'outside-in' and 'coupled' modes of open innovation. They classified 291 papers concerning open innovation. This lead to the founding that most research on open innovation is focussed on obtaining innovations from external resources. Research related to integrating and commercializing open innovation seems to be scarce. The two gaps this research points out, are the exclusion of the end-to-end innovation commercialization process in current research, and an exploration of the limits of leveraging external sources of innovation.

On the basis of prior research, open innovation can thus be conceptualized as can be seen in figure 1 (Armellini et al., 2016). Outside-in open innovation sources or acquires external ideas for use inside the firm. Inside-out open innovation reveals or sells internal ideas for use outside the firm. In coupled open innovation, both of these processes happen at the same time. Since this happens in R&D collaborations on V2G technology, this research fits in the coupled view on open innovation.

Figure 1 Views on open innovation (Armellini et al., 2016).

Core process	Type of openness	Associated issues
Outside-in	Sourcing	External knowledge sourcing and technology scouting
		Early integration of clients in NPD
		Early integration of suppliers in NPD
	Acquiring	Licencing in
		Spin-in and M&A
Inside-out	Revealing	IP portfolio activity
	Selling	Licencing out
		R&D services
		Spin-outs and divestments
Coupled	Sourcing/ Revealing	Co-development and participation at research consortia
		Crowd sourcing and peer production
	Acquiring	Venture Capital (VC)
		Licencing in (within collaboration agreements)
	Selling	Licencing out (within collaboration agreements)
		R&D services (within collaboration agreements)

2.1.1 Open Innovation in the Automotive Industry

Where theoretical research on open innovation was widely popular in the last decade, the concept of open innovation also became very relevant to the automotive industry. Traditionally, the automotive industry is characterized by closed innovation. OEM's use internal sources to come up with ideas for innovation. In this way, intellectual property is gathered and OEM's secure their competitive advantage (Lazzarotti et al., 2013). However, these days, there are different developments in the automotive industry that undermine closed innovation.

First of all, there is growing pressure from society to produce cars with reduced emissions, more active and passive safety features and higher autonomous capabilities (Wilhelm & Dolfsma, 2018). Because of this, OEM's are forced to innovate in areas as IT software and hardware, in which they have minimal specialist knowledge. R&D in these areas require high investments while it is uncertain whether the OEM is first-to-market and reaps the rewards. As a result, the attitude of OEM's towards closed innovation is changing, and actors increasingly recognize 'that not all ideas and innovations must be started by their own capacities' (Ili et al., 2010).

Furthermore, to survive in an oligopolistic industry like the automotive industry, that is disturbed with a potential dominant technology in electric vehicles, catch-up is key for OEM's. Cano-Kollmann et al. (2018) show that rival OEM's need to collaborate in the innovation process on hybrid electric drivetrain automotive technology in order to survive. 'Competitors open up to catch up.'.

Blankesteijn et al. (2019) support these observations by showing that the R&D departments of Tesla, BMW, and Toyota employ a combination of a closed and an open innovation strategy. To develop an autonomous vehicle, OEM's make strategic decisions on which innovation is adopted from outside, and which elements are developed in-house. This gives an insight into how OEM's aim to gain a first-to-market position and sustainable competitive advantage by using open innovation.

The R&D collaborations that result from this transition, like those on V2G technology, create access to unique resources and knowledge bases. However, it also raises new challenges because of the diverse characteristics, interests, and goals of the different stakeholders involved (Waligo et al., 2014). Several challenges have been found in practice. For example, Lazzarotti et al. (2013) found that knowledge obtained from external sources were often seen as 'far from the market'. Wilhelm and Dolfsma (2018) found that when open innovation initiatives are set up, there arise information processing boundaries, interpretive boundaries and political boundaries. This confirms the finding of Schulze et al. (2015) that managing boundaries with external sources outside the automotive industry are in a very nascent stage for the OEM's. This asks for a theoretical foundation that captures these challenges and provides a perspective to manage open innovation.

2.1.2 Management of Open Innovation

There are several theoretical foundations that are eligible for explaining the observed trend of open innovation in the automotive industry. Mousavi (2017) has constructed an overview of various theoretical foundations that could serve as a theoretical lens for innovating towards sustainability. Absorptive capacity is one of the theoretical foundations that is often used. This foundation provides an external analysis of the knowledge sourcing strategies firms use for sustainable innovation. However, this foundation lacks the focus on how companies develop or change their firm to identify, assimilate, and exploit the knowledge from these external sources.

Another theoretical foundation is the evolutionary approach to innovation. This approach rejects the economic motives of a firm and argues that the behaviour of a company is formed by its current decision rules. However, this approach is not comprehensive enough to integrate the literature of strategy and innovation and provide an umbrella framework that highlights the most critical capabilities which companies need for innovating towards sustainability.

Unlike the prior foundations, the dynamic capabilities approach seems to fully explain the observed events in the automotive industry. OEM's find themselves in a business environment where they need to extend and modify their resources and competencies to innovate and create new competitive advantages. Dynamic capabilities theory argues that dynamic capabilities enable a company to reconfigure its resources and competencies to maintain evolutionary fitness. Because OEM's are reconfiguring their closed innovation strategy to a more open innovation strategy to stay competitive this theoretical foundation seems to fit to explain the process of R&D collaborations.

This might explain the recent interest of Chesbrough (originator of open innovation) and Teece (originator of dynamic capabilities) to explore a dynamic capabilities perspective on the strategic management of open innovation (Bogers et al., 2019). They argue that to understand the benefits and limits of open innovation, a dynamic capabilities framework could help to inform strategic management. Kazadi et al. (2016) and Behnam et al. (2018) have already shown that by using part of this theory, R&D collaborations on innovation that will drastically change existing systems and consumers' lifestyle, can be analysed. Therefore the dynamic capabilities perspective will be used as a theoretical lens to understand the benefits and limits of R&D collaborations on V2G technology.

2.2 Dynamic Capabilities

Dynamic capabilities' foundation originated from a paper from Teece et al. (1997) who shows that dynamic capabilities help firms to adjust their resource variety and reconfigure their internal and external competencies for innovating towards sustainability. Dynamic capabilities are about sensing opportunities, seizing these opportunities, and transforming the organization and its strategy as opportunities and threats arise (Teece, 2007). More than 50 per cent of the articles about dynamic capabilities refer to this typology (Schilke et al., 2018).

Dynamic capabilities have become one of the most frequently used theoretical lenses in management research (Schilke et al., 2018). In earlier years the theory is much criticized on the lack of empirical knowledge and the underspecification of the construct of dynamic capabilities. However, in the last years, much research is done on gathering empirical evidence for the conceptual constructs resulting in various measurable factors connected to dynamic capabilities.

For example, Pinkse & Dommisse (2009) show that construction companies that are able to develop dynamic capabilities for the adoption of clean and energy-efficient technologies are successful. It is the combination of information gathering and internal technical capacity that enhances the ability to innovate and the flexibility in adapting to changes in the environment. Furthermore, having the communicative skills to convince internal and external stakeholders of the benefits of clean and energy-efficient buildings is key to success.

Chassagnon and Haned (2015) have done a firm-level empirical analysis of 1180 French firms on the relevance of innovation leadership for successful sustainable innovation. They show that innovation leadership is a dynamic capability for innovative firms to seize innovation opportunities. Furthermore, they argue that when a firm is able to hold this dynamic capability over a longer period of time they will more easily benefit from first-mover advantages.

In the automotive industry, an investigation on 112 Spanish automotive manufacturing firms, showed that having dynamic capabilities have both a positive direct and indirect effect on green innovation performance (Albort-Morant et al., 2016). Many organizations do not have the knowledge and capabilities to foster green innovations. Developing dynamic capabilities will help to positively change this. Such empirical contributions to the conceptual constructs have led to a framework that connects dynamic capabilities with measurable factors.

2.2.1 Framework of Dynamic Capabilities

Schilke et al. (2018) have done a content-analytic review on 298 articles about dynamic capabilities that substantially built on or contribute to the dynamic capabilities literature. This lead to the construction of the framework depicted in figure 2 where dynamic capabilities are connected with surrounding measuring factors. A brief explanation of this framework is given in the following sections.

Antecedents

Antecedents are the organizational, individual/team, and environmental factors that give an insight into where dynamic capabilities are coming from. Because a firm has experience (organizational), human capital (individual/team), and inter-organizational structures (environmental), a firm is able to facilitate the development, usage, and maintenance of certain dynamic capabilities (Eriksson, 2014).

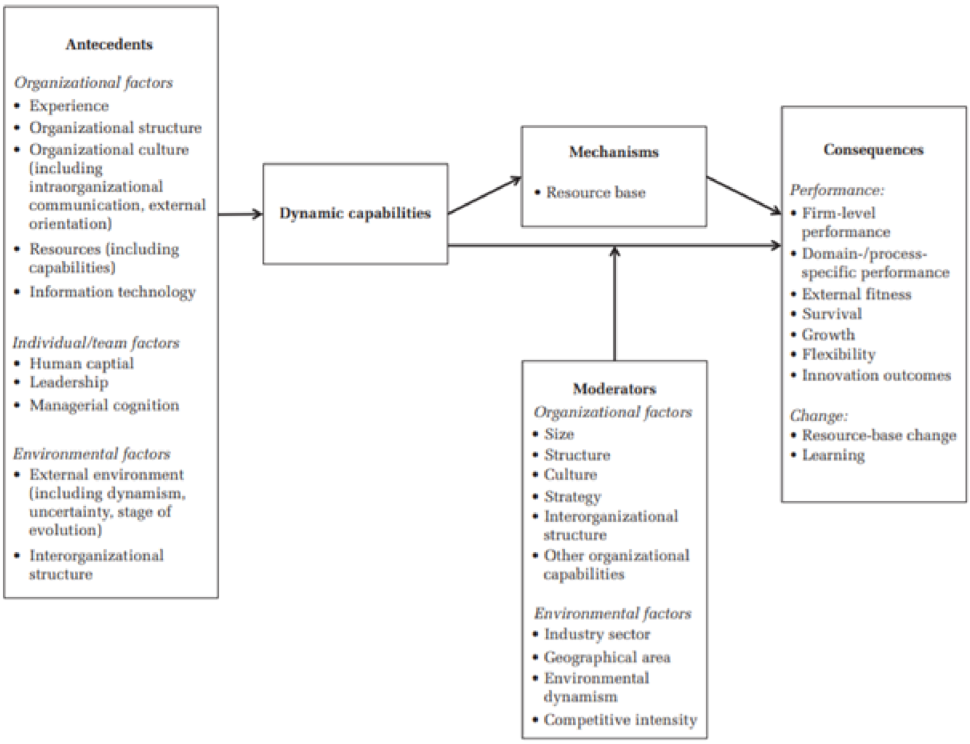

Figure 2 Organizing framework of dynamic capabilities (Schilke et al., 2018).

Consequences

Using dynamic capabilities leads to the development of various consequences. Dynamic capabilities are proposed to develop a competitive advantage and for having a possibility to enhance operational efficiency and reaching alignment with the environment. This leads to various outcomes in performance and change (Di Stefano et al., 2014).

Mechanisms

Some studies believe that dynamic capabilities not always have a direct influence on creating a consequence (Karimi & Walter, 2015). They see resource changes because of dynamic capabilities as causal mechanisms through which dynamic capabilities affect performance outcomes.

Moderators

The effect of dynamic capabilities on creating consequences is moderated by various factors. The consequences of dynamic capabilities seem to be highly context-dependent. Subsequently, researchers have started to follow a contingency approach and have identified relevant moderators of the effect of dynamic capabilities (Aragon-Correa & Sharma, 2003). Hence, various organizational factors, like the size and strategy of a firm, and organisational factors, like geographical area and industry sector, moderated the effect of dynamic capabilities on creating consequences. Table 1 provides an overview of empirical examples of antecedents, moderators, and consequences.

Table 1 Antecedents, moderators, and consequences for dynamic capabilities.

Antecedents, Moderators, and Consequences for Dynamic Capabilities	
Antecedents	**Example**
Organizational factors:	
Experience	Experience from previous markets in for example sales and production can lead to a dynamic capability to better seize opportunities in new markets (King & Tucci, 2001)
Organizational structure	Multidivisional organizational structures can assist responsiveness to and the seizing of opportunities (Teece et al., 2016).
Resources	Dynamic capabilities are directed at redirecting existing resources or make new resources. To redirect existing resources, existing resources are required and thus define whether an opportunity can be seized because a firm has that resource (Tallman, 2015)
Information technology	Managing endogenous and exogenous knowledge with information technology significantly enhances dynamic capabilities (Sher & Lee, 2004)
Individual/team factors:	
Human capital	Human capital should not only be leveraged for achieving maximum productivity but should also contribute to core competences so that they will become distinctive and can be more easily reconfigured, supporting the maintenance of dynamic capabilities (Wang et al., 2012)
Leadership	Entrepreneurial leadership from top management is critical to facilitate strong dynamic capabilities in firms that focus on new product and process development (Schoemaker et al., 2018)
Managerial cognition	Managerial cognitive capabilities as attention, problem-solving, and communication facilitate the use of dynamic capabilities (Helfat & Peteraf, 2015)
Environmental factors:	
External environment	Dynamic capabilities are used, developed or maintained to match the requirements of a changing environment and, therefore, defines dynamic capabilities (Petit & Hobbs, 2010)
Interorganizational structure	Inter-organizational innovation networks provide opportunities to exploit complementary experience, IT, resources that reside beyond the boundary of a firm and, therefore, facilitate dynamic capabilities (Smart et al., 2007)
Moderators	**Example**
Organizational factors:	
Size	The size of a firm defines the extent to which dynamic capabilities can be used and , therefore, moderates dynamic capabilities (Li & Liu, 2014)
Structure	Firms must align their internal organizational structure with their capacity to sense and seize external opportunities and reconfigure their resource base accordingly (Wilden et al., 2013)
Culture	Organizational culture plays a significant moderating role in converting partner-contributed resources into efficient and fast-responding cross-functional business processes (Fang & Zou, 2009)
Strategy	The choice of strategy defines which dynamic capabilities can be used and, therefore, moderates the effect that dynamic capabilities could have on R&D collaborations (Engelen et al., 2014).
Interorganizational structure	Interorganizational structures can lead to conflict that either stimulates or counteracts the influence of dynamic capabilities (Vaaland & Hakansson, 2003)
Environmental factors:	
Industry sector	The dynamics of an industry sector define to what extent dynamic capabilities have influence on the outcome (Piening, 2013)
Geographical area	The geographic concentration of competition can enhance the effect of sensing opportunities because of knowledge spill overs. However, it could also moderate the effect of seizing because of a higher competition (Deeds et al., 2000)
Environmental dynamism	The extent to which the environment is dynamic defines the positive effect of dynamic capabilities. Dynamic capabilities still could have a positive effect in stable environments (Li & Liu, 2014)
Competitive Intensity	When firms compete in environments with finite resources, dynamic capabilities provide a basis for adapting to competitive pressures and for survival. Greater competitive intensity requires greater adaptation to environmental conditions and thus necessitates dynamic capabilities (Wilden et al., 2013)

Dynamic Capabilities

As mentioned, dynamic capabilities are about sensing opportunities, seizing these opportunities, and transforming the organization and its strategy as opportunities and threats arise (Teece, 2007). However, dynamic capabilities is not a unitary concept. Dynamic capabilities can be put in a hierarchy to better understand the context at hand. Mousavi et al. (2019) give a good example of how the cluster terms of dynamic capabilities, sensing/seizing/transforming, can be translated to second-order themes and first-order concepts. Their translation of sensing capability is shown in figure 3. By creating this hierarchy for the clusters of dynamic capabilities, empirical evidence is easier connected to conceptual constructs.

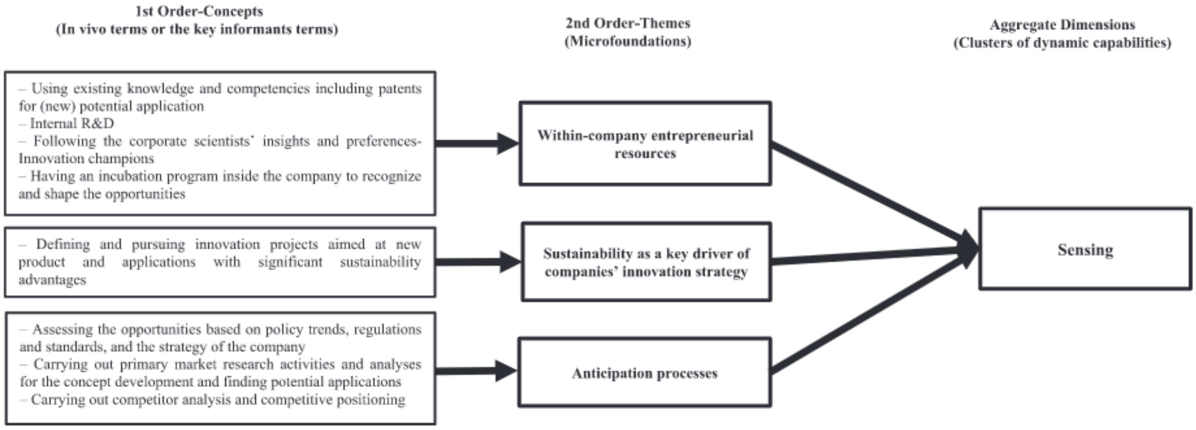

Figure 3 Microfoundations of sensing capability (Mousavi et al., 2019).

2.3 Research Gap

This research will contribute to two gaps in the current literature. Bogers et al. (2019) have suggested that open innovation can be strategically managed from a dynamic capabilities perspective. There is qualitative research that takes dynamic capabilities into account for strategic purposes (Kazadi et al., 2016; Benham et al., 2018), however not to the extent where all the measurable variables surrounding dynamic capabilities are taken into account. By incorporating all these factors, this research will provide empirical evidence to verify the idea of Bogers et al. (2019).

Both Sluyts et al. (2011) and Kazadi et al. (2016) point out the research gap of the lack of an examination of the dynamic capabilities from the perspective of all stakeholders in a collaboration. Generally, the focus lies on an individual company in the collaboration. According to Matthyssens et al. (2009) exploring the bundling of dynamic capabilities in collaboration could be worthwhile.

Behnam et al. (2018) have put in a first effort to explore this possibility to improve R&D collaborations and found out that all key partners should possess certain dynamic capabilities in order to develop an innovation that will drastically change existing systems and consumers' lifestyle, which V2G technology seems to do. However, Behnam also mentions that this combination is partly dependant on the sustainability context.

Since Benham et al. (2018) did not cover V2G technology specifically, this research will add to existing literature the exact influence of this context to the usage and development of dynamic capabilities, thereby supporting the development of commercial V2G. Furthermore, by exploring the complementarity of dynamic capabilities of firms within a collaboration in this specific context, the transferability of the research of Behnam et al. (2018) is verified and extended with a new context.

3. Conceptual Model

This research combines the context of coupled open innovation to the dynamic capabilities approach of managing sustainable innovation. Based on the theoretical background, this leads to the conceptual model presented in figure 4.

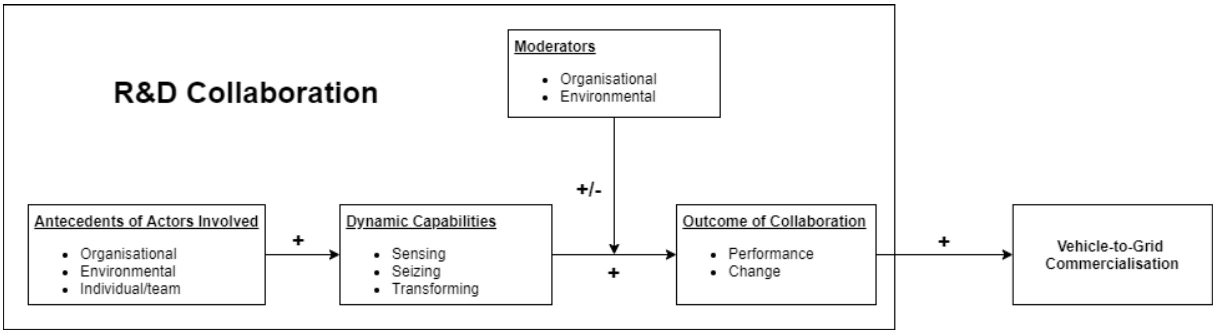

Figure 4 Conceptual model.

Actors are put together into an R&D collaboration where their experience, resources, and other antecedents are combined. These antecedents have a facilitating effect on the development, maintenance, and usage of dynamic capabilities. These dynamic capabilities than have a positive effect on the outcome of the collaboration in the form of performance or change. This effect of dynamic capabilities is moderated by the strategy of a firm, geographical area and other moderating factors. The outcome of the collaboration has a positive effect on the commercialisation of vehicle-to-grid.

3.1 Propositions

This conceptual model is constructed on the basis of propositions that can be seen in table 2.

Table 2 Propositions.

Proposition	Source
The actors involved in R&D collaborations on V2G technology have organisational, environmental, and individual/team antecedents that facilitate the maintenance, development, or usage of dynamic capabilities.	Schilke et al., 2018
Dynamic capabilities have a positive effect on the outcome of an R&D collaboration on V2G technology.	Bogers et al., 2019
The effect of dynamic capabilities on the outcome of an R&D collaboration on V2G technology is moderated by organizational, environmental, and temporal factors.	Kazadi et al., 2016 ; Schilke et al., 2018
R&D collaborations on V2G technology have a stimulating effect on the commercialisation of V2G.	West & Bogers, 2014

4. Methodology

In this section, decisions on how this research is designed are explained. It will involve the research framework, vehicle-to-grid background, case selection, data gathering, data analysis and reliability, transferability & validity.

4.1 Research Framework

To investigate the research question, this research relies on the dynamic capabilities approach to managing open innovation as depicted in the conceptual model. According to Yin (2003) a case study design should be considered when: (a) the focus of the study is to answer 'how' and 'why' questions; (b) you cannot manipulate the behaviour of those involved in the study; (c) you want to cover contextual conditions because you believe they are relevant to the phenomenon under study, or (d) the boundaries are not clear between the phenomenon and context. Since this study complies with b, c and d, there is chosen for a case study design.

A multiple case study enables the researcher to explore difference within and between cases. The goal is to replicate findings across cases. Because comparisons will be drawn, it is imperative that the cases are chosen carefully so that the researcher can predict similar results across cases, or predict contrasting results based on theory (Yin, 2003). This study wants the results to be transferable to other R&D collaborations on V2G to support this technology to commercialization. The study would also like to check theoretical moderating effects of certain factors that require a somewhat different context, like geography. Therefore, a multiple case study design is chosen to conduct the research. This leads to the following research framework in figure 5.

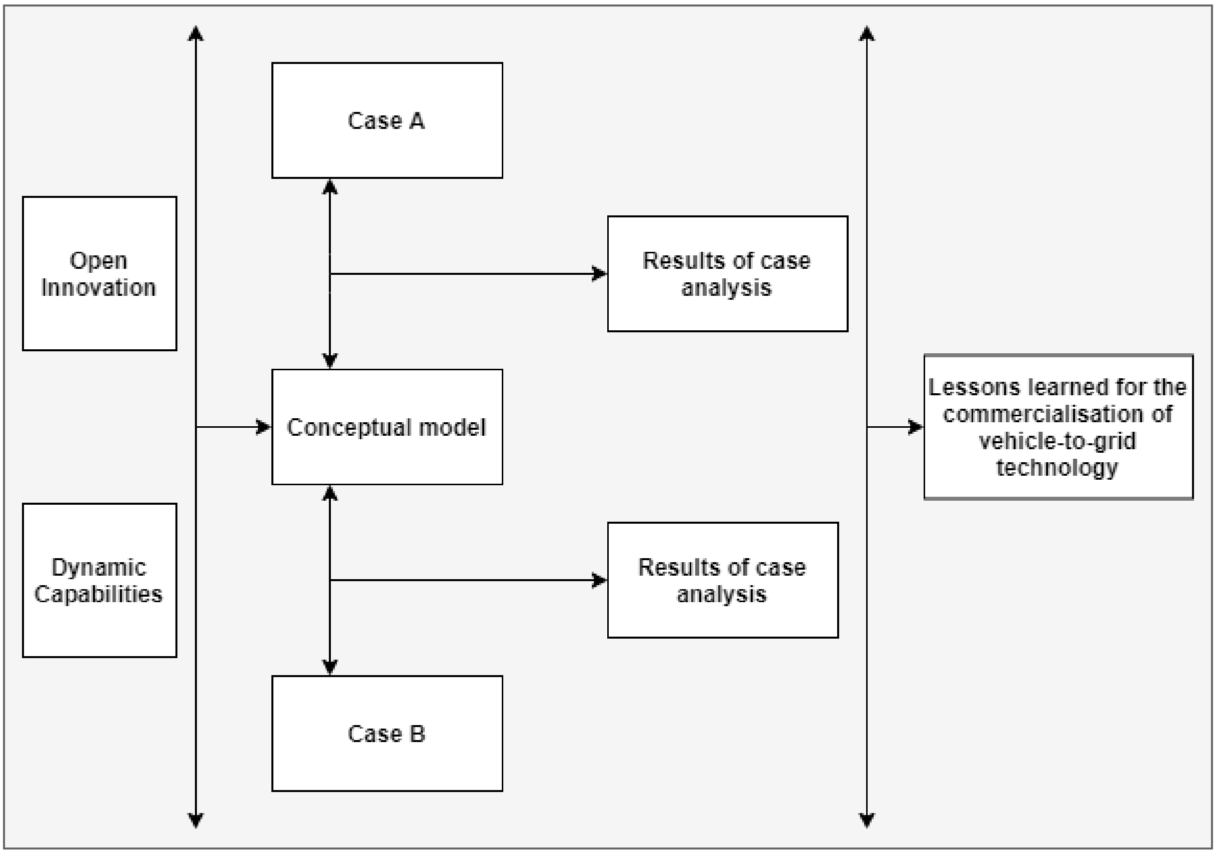

Figure 5 Research framework.

4.1 Vehicle-to-Grid Background

To make a good case selection for answering the research question and ensure the reliability, transferability and analytical validity of the cases, a good understanding of the V2G technology is required. This section will give a background on this technology and the implications for the case selection.

4.1.1 Basic Principle

In the basis, V2G technology allows an EV to have a bidirectional power flow with the grid (Tan et al., 2016). Instead of only getting charged by the grid an EV obtains the ability to discharge energy to the grid. With this ability to store energy and deliver energy back to the grid, EV's can be used as a storage network.

A typical bidirectional EV battery chargers use either AC charging or DC charging. With AC charging, the EV has an on-board charger consisting of two converters: AC/DC converter and DC/DC converter. During the charging of an EV, the AC/DC converter converts the AC power from the grid towards DC power. On the other hand, when delivering back energy to the grid, this converter converts the DC power to AC power that can be used by the grid. The DC/DC converter is used to control the bi-directional power flow. It allows the EV to (dis)charge faster or slower by using current control technique. Because of size constraints, AC charging reduces charging speed. For DC charging the charger is positioned in the charge point. This allows for faster charging but will require more public space. An example of the essence of V2G technology is depicted in figure 6.

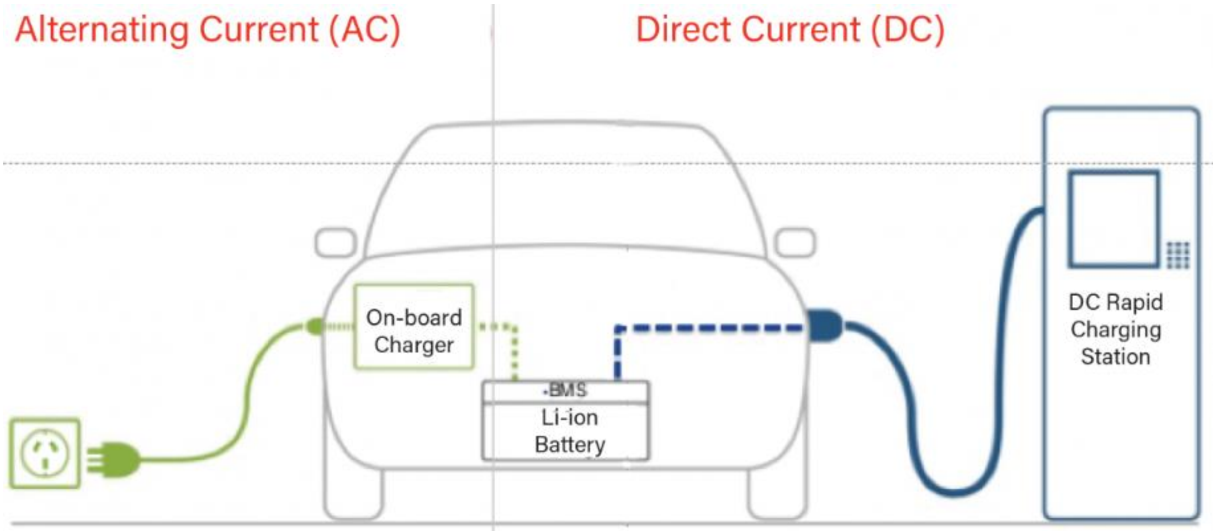

Figure 6 The essence of V2G (Chargenet, 2017).

4.1.2 The V2G System

Zoom in on the details of V2G and a more complex system arises (The Parker Project, 2019). This system is visualized in figure 7. This figure is chosen to show the complexity of V2G technology. Other V2G systems might be different in some aspects, but the complexity stays the same. The following actors play a role in this system:

RES:	Renewable Energy System that generates renewable energy.
TSO:	Transmission System Operator that operates the high voltage power grid.
DSO:	Distribution System Operator that operates the local lower voltage power grid.
EVSE:	Electric Vehicle Supply Equipment that supplies energy to or receives energy from the EV. This equipment is located in the EV or in a charge point.

EV:	Electric vehicle that is able to charge and discharge energy.
Aggregator:	Party that aggregates the information streams in the information path.
CPO:	Charge Point Operator, operates the charge point.
EMSP:	Electric Mobility Service Provider, provides services for the usage of V2G (app).
Clearing House:	Facilitates the sharing of information between EMSP and CPO.
User:	User.
Energy Provider:	Energy provider.
BRP:	Balance Responsible Party, responsible for the balance of the grid.

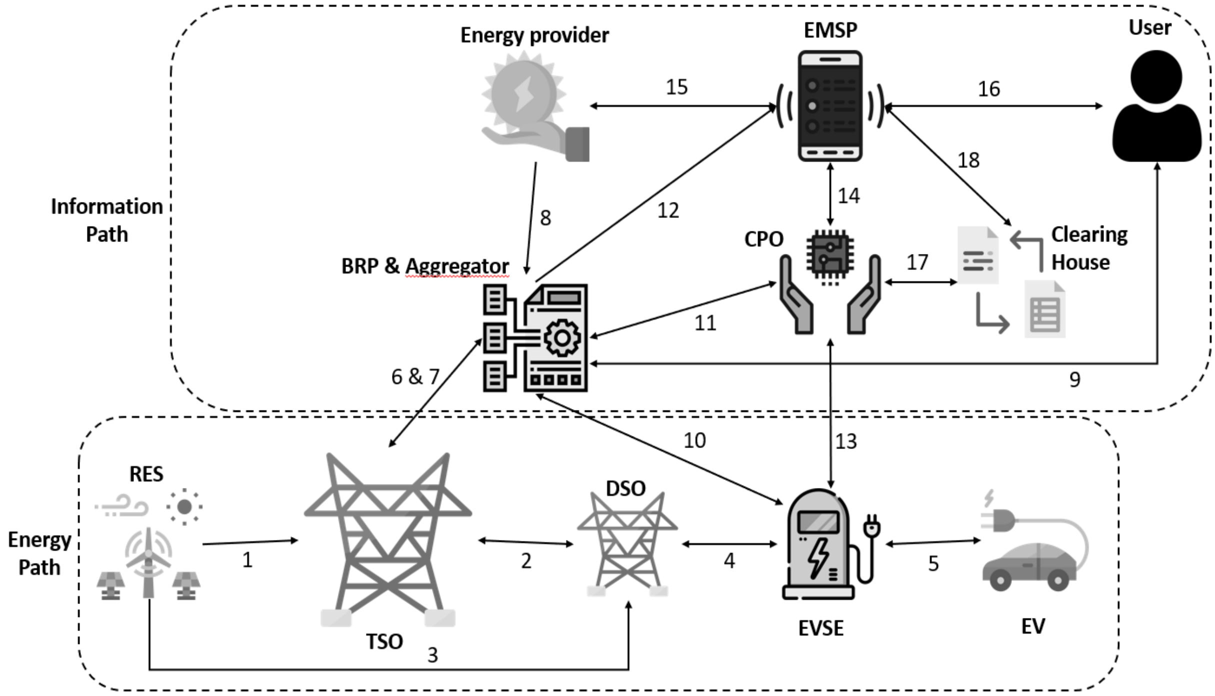

Figure 7 Visual representation of a V2G system (The Parker Project, 2019).

This process can be described by following the numbers in figure 7 (The Parker Project, 2019):

1. In the electricity market from the grid side, electricity producers supply electricity via the transmission grid operated by the TSO.

2. High-voltage electricity is physically transported and transformed through the TSO grid to the DSO grid.

3. Smaller Distribution Generations such as photo voltaic systems can supply medium voltage electricity directly to the DSO grid.

4. To the right: Physical electricity transport and transformation of medium voltage to low voltage electricity is supplied through the distribution grid to the EVSE.

To the left: The EVSE can deliver low voltage electricity to the DSO grid from the EV.

5. To the right: An EV consumes electricity via a charger cable connected to EVSE. Additionally, the EVSE sends signals about start or end of charging to each EV in an EV fleet.

To the left: The EV delivers stored electricity to the grid via the EVSE. In addition, the EV sends measured data about the charging level (SOC) on the battery and technical conditions of the EV to the aggregator via EVSE.

6. The TSO sends information about the frequency level on the transmission grid to the aggregator.

7. When needed, the TSO balances the transmission grid by buying services from BRPs to ensure grid stability. Flexibility service is a supplement to the present approach to balance the transmission grid.

The BRP can take the role as aggregator, and the aggregator can sell flexibility to all markets. Activation of flexibility will be handled internally between aggregator and BRP, as the BRP sends price signals to the aggregator.

8. The energy provider buys electricity to the EVSE for consumers or prosumers from the BRP and electricity is supplied via the distribution grid.

9. To the left: The EV owner provides the aggregator with information about planned availability of the EVs for aggregation. The EV owner can communicate directly with an aggregator or with a CPO.

To the right: The aggregator sends information to the EV owner via a communication platform about SoC-level on EV battery. The aggregator will always fulfil the EV owner's driving needs.

10. To the left: The aggregator controls the active power status of EVs, and analyses performance of each EV by investigating three performance indicators, comprising directionality (Uni- or bidirectional energy transport), granularity (setpoint range [W] & step size) [Var], responsiveness of activation of V2G [W/s], ramp time [Var/s], and accuracy and precision of delivered and requested response rate [%]. The aggregator receives data about SOC-level etc. from the EVs via the EVSEs.

To the right: Based on the information about frequency level on the grid (cf. (6) Red arrow), the aggregator platform regulates the bidirectional flow by sending operation signals to either EVSE or EV. Signals can be sent as required ampere-level [A], effect [kW] or percent [%] to EVSEs depending on the charger.

11. Aggregator and CPO cooperate for securing communication between the V2G software and EVSE software.

12. The aggregator sends the EMSP information about metered data on provided flexibility to grid, and the EMSP can send the information to the EV owner

13. Upwards: EVSE sends metered data about electricity consumption and flexibility to CPO and informs the CPO when it needs service.

Downwards: CPO services the EVSE and maintains the functionality of the EVSE for providing flexibility service.

14. Upwards: CPO informs EMSP about metered data and conducted services for EVSE and EMSP sends EV owner invoices based on consumption and flexibility service provided. In addition, EMSP and CPO can also communicate via a hub called "Clearing House" for roaming service.

Downwards: EMSP contacts CPO, when EVSE needs service beyond regular servicing.

15. To the right: The energy provider communicates with the EMSP and sends information about electricity consumption of the EV fleet metered with the primary meter.

To the left: The EMSP pays the energy provider for the electricity consumed by the EVSE including tariffs to both TSO and DSO.

16. To right: The EMSP communicates and sends the EV owner invoices for used electricity, provided flexibility (revenue stream) and the CPO service. The EV owner can own one or several EVs.

To left: The EV owner pays the electricity bill including tariffs and service costs to the EMSP. In addition, the EV owner contacts the EMSP, when the EVSE needs service.

17. The CPO communicates with the Clearing House for handling clearing of payments for EV roaming at chargers provided by other CPOs. This report does not investigate the impacts of clearing houses.

18. EMSP communicates with Clearing House for securing payment for CPO service, comprising communication between EVSE and EV fleet across borders or communication between other EMSPs and their services.

This shows that V2G technology is not just a technology that allows the charging and discharging of energy. It requires a system of different actors to operate the various information streams. Information streams which itself add extra complexity because there are many protocols to support the different interactions (Elaad, 2016).

To deliver good communication between all the actors, these protocols need to be aligned with each other. In different situations, the use of different combinations of protocols was found, including a number of different protocols for similar functionality (Elaad, 2016). This shows that there are interdependencies between the different actors to make the information system work. What this information system needs to do is dependent on the service that the V2G system would like to deliver to the power grid.

4.1.3 V2G Services

This V2G system is able to provide different services to the power grid. The service provided will define how the rest of the system should be constructed. Not all services will be explained. Currently, peak shaving, load levelling and grid regulation have the highest value for the grid (Innovate UK, Everoze & EVConsult, 2018). These services also have the highest maturity level in that they are commercially used in some places. Since this research focusses on supporting the development of commercial V2G, these services will be explained in the following paragraphs.

Peak Shaving and Load Levelling

During the day, there are multiple peaks and lows in the consumption of energy. To maintain a stable grid, V2G technology can perform peak-shaving and load-levelling activities. EV's do this by discharging to the grid during peak loads and charge the battery during low loads. By doing this, the stress that is applied to power system components is reduced. This could be seen in figure 8 (Tan et al., 2017)

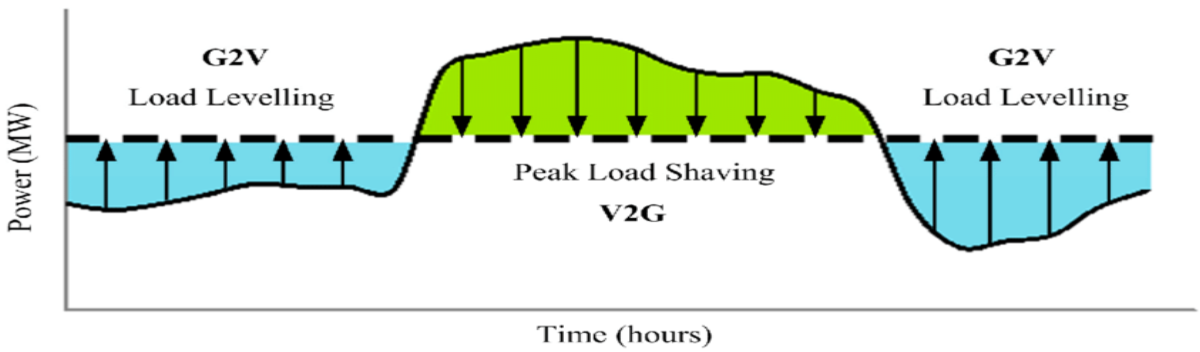

Figure 8 Peak shaving and load levelling (Tan et al., 2017).

Grid Regulation

Figure 9 explains how the charging rates of EV are regulated up and down to meet the Preference Operating Point (POP). The POP is an operating point of the power grid that matches the load demand of the power grid such that the frequency and the voltage of the power grid are regulated. In case A, the basic scenario is presented with a fixed load and a dynamic load of EV charging, which add up to an operating point close to the POP. By using the DC/DC converter, EV loading can regulate down or up to realize two types of ancillary services. In case B, when fixed load increases, EV loading can be regulated down to stay closer to the POP. While at case C, when fixed load decreases, EV loading can be regulated up to remain the same POP. In this way, the frequency of the power grid is regulated.

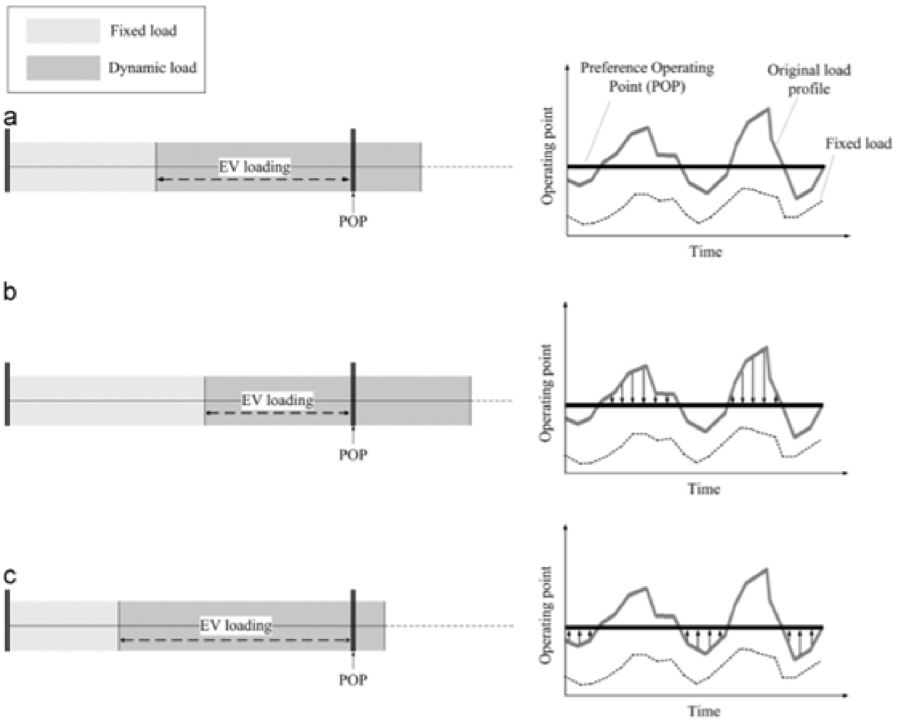

Figure 9 Ancillary services by V2G: (a) basic scenario, (b) regulating up scenario, (c) regulating down scenario (Tan et al., 2016).

To commercialize these services there are several objectives for optimization, which are dependent on various constraints. These will be explained in the next section.

4.1.4 Optimization Objectives and Constraints

To make V2G technology commercial there are several optimization objectives and constraints that belong with these objectives (Tan et al., 2016). These are represented in figure 10. To realise peak shaving, load levelling and grid regulation the preference load profile need to be optimised. Furthermore, cost minimization, revenue maximization, and cost-efficiency are important. Besides that, energy loss minimization and system reliability optimization require attention.

The constraints for achieving these objectives consist of characteristics of the power grid, EV and user. This raises the complexity of the development of a proper working V2G system. There are many actors involved that need to align all the information systems with different protocols for delivering a certain service. Subsequently, to what extent a service can be delivered and in what form is influenced by the capability of the power grid and EV and the preferences of the user. This knowledge gives input for which cases will be suitable for this research.

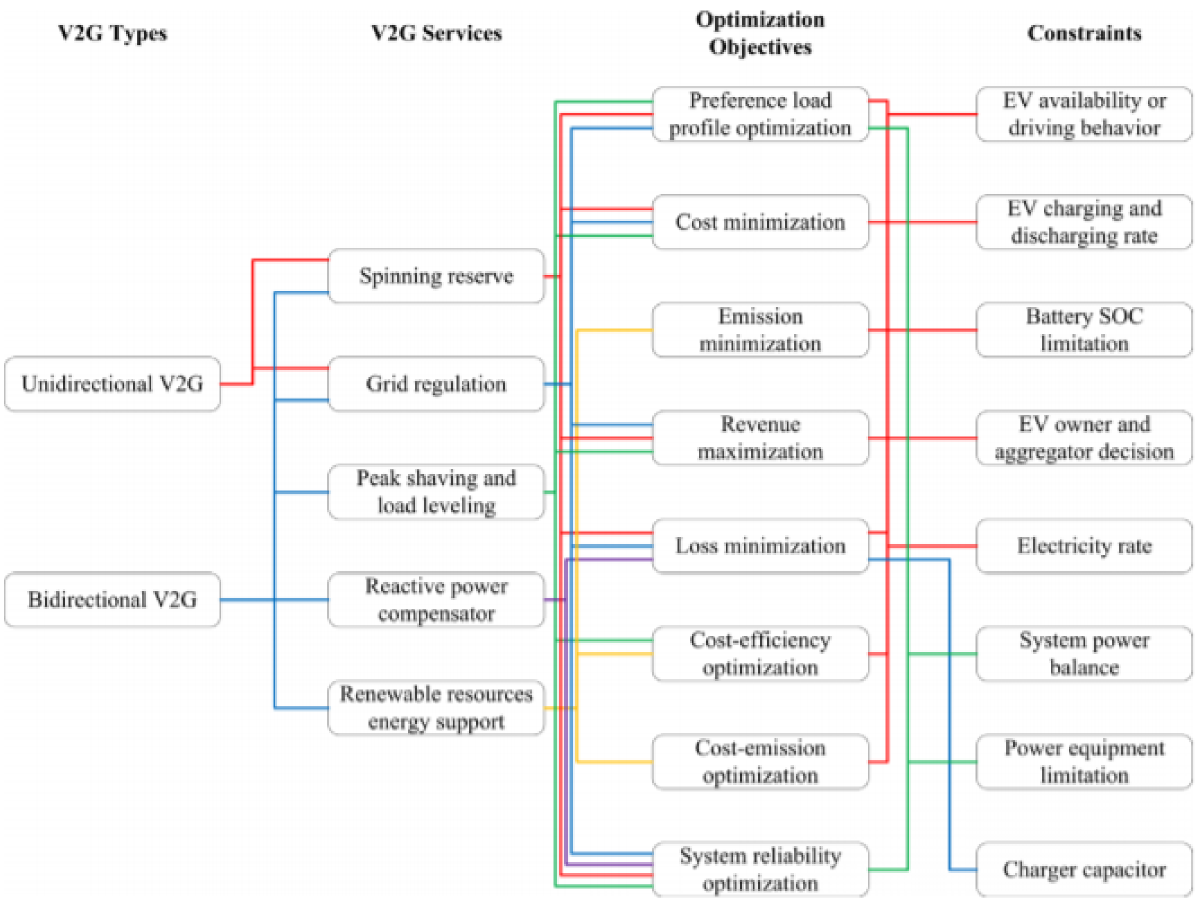

Figure 10 Optimization objectives and constraints for grid services provided by V2G (Tan et al., 2016).

4.1.5 Implications for Case Selection

There are several implications for case selection. First of all, there are many actors involved in the V2G system. Therefore, it is preferred that the selected cases consist of most of these actors to be able to get everyone's perspective. Furthermore, the development of V2G is dependent on the capability of the power grid. To complement each other, the cases should preferably have different power grids, and thus probably different geographical locations. Besides that, the TRL level of grid regulation, peak shaving and/or load levelling is the highest and thus being preferred as the focus of the project.

4.2 Case Selection

A case is defined by Miles & Huberman (1994) as, 'a phenomenon of some sort occurring in a bounded context.'. This case is, 'in effect, your unit of analysis.'. This unit of analysis can be defined by looking at the research question. The research question of this research focusses on the dynamics within the process of R&D collaboration on V2G. Therefore the unit of analysis for this research is the process of R&D collaboration on V2G.

To avoid answering a too broad question, Yin (2003) and Stake (1995) have suggested that placing boundaries on a case can prevent this from occurring. This can be done by time and place (Creswell, 2017), time and activity (Stake, 1995), and by definition and context (Miles & Huberman, 1994). Based on this, implications from the V2G background can be used as input for bounding the case. Therefore the cases should (a) consist of most of the actors involved in a V2G system, and (b) be executed with different power grids. Furthermore, since the development of grid services is close to commercial usage in the areas of peak shaving, load levelling and grid regulation, the cases should at least (c) focus on one of these services. In that case, the research is able to analyse a process that succeeds in (d) becoming commercial. This research would like to investigate the influence of dynamic capabilities on the outcome of the collaboration. Therefore, the cases should (e) be completed or have measurable results, and thus the timeframe should be from the set-up of an R&D collaboration till completion.

These criteria lead to the selection of two frontrunning R&D collaborations on V2G as cases for this research. Both the Lombok and the Parker project are suitable for this research. This choice is visualised in table 3.

Table 3 Case selection.

Case Selection		
	Projects	
Criteria	Lombok Project	Parker Project
(a) Actor involvement	OEM, DSO, CPO, EMSP, Aggregator, municipality and university	OEM's, TSO, CPO, Aggregator, EMSP and university
(b) Different power grids	Dutch grid	Danish grid
(c) Focus grid regulation, peak shaving and/or load levelling	Focus on grid regulation, peak shaving and load levelling	Investigation of all grid services
(d) Commercial focus	Commercial objective	Commercial aspect
(e) Completed or measurable results	Measurable results (2018-ongoing)	Completed (2015-2018)

4.2.1 Lombok Project

The Lombok project is an R&D collaboration on V2G technology in the city of Utrecht in the Netherlands that focusses on the standardization of AC V2G charging (Elaad, 2020). They are doing this with a consortium of multiple actors in the V2G system (a). The project is based on the Dutch grid, which is a different grid than the Danish grid of the Parker project (b). The focus of the grid services is on grid regulation, peak shaving and load levelling (c). The project is not finished yet but has a commercial focus and they have deployed multiple implementations of V2G in a neighbourhood in Utrecht (d/e).

4.2.2 Parker Project

The Parker project is an R&D collaboration on V2G technology in Denmark that focusses on a fleet scale implementation of V2G with a consortium of multiple actors in the V2G system (1). The project is based on the Danish grid, which is different than the Dutch grid (b). The project validates that series-produced electric vehicles as part of an operational vehicle fleet can support the power grid by becoming a vertically integrated resource, providing seamless support to the power grid both locally and system-wide (Parker, 2020). They incorporate every grid service in this test (c). Furthermore, they seek to ensure that barriers regarding market, technology and users are dealt with to pave the way for further commercialization (d) and not least to provide an evaluation of specific electric vehicles' capability to meet the needs of the grid. The project is completed and, thus, has measurable results (e).

4.3 Data Gathering, Data Analysis, Reliability, Transferability and Validity

The data to answer the research question is mainly gathered through the help of interviews. Interviews are a very common form of data collection in case study research (Hancock & Algozzine, 2017). Interviews of individuals or groups allow the researcher to attain rich, personalized information.

There is chosen to make use of semi-structured interviews. Semi-structured interviews are particularly well-suited for case study research (Hancock & Algozzine, 2017). The researcher asks predetermined but flexibly worded questions which provide tentative answers from the interviewees. Furthermore, by asking follow-up questions more deep issues of interest to the interviewee could be discussed. In this manner, semi-structured invite interviewees to express themselves openly and freely and to define the world from their own perspectives, not solely from the perspective of the researcher.

In total eleven interviews have been conducted, four actors from the Parker project and seven actors from the Lombok project (Table 4).

Table 4 List of interviewees.

List of Interviewees		
#	**Role**	**Project**
1	OEM	Lombok
2	DSO	Lombok
3	EMSP	Lombok
4	CPO	Lombok
5	Aggregator	Lombok
6	University	Lombok
7	Municipality	Lombok
8	OEM	Parker
9	TSO	Parker
10	Aggregator (+CPO+EMSP)	Parker
11	University	Parker

The interviews are held with a script that is based on the central concepts of the conceptual model (Appendix 1). In this way, the research is made more concrete (Verschuren & Doorewaard, 2010). These concepts and indicators with functional interpretations are presented in table 6.

Besides interviews, desk research and case documents (Table 5) are used to elaborate on the results. Furthermore, an international V2G conference (250 participants) with most stakeholders involved present is visited after the interviews to validate the results.

Table 5 Case documents.

Case Documents (Amount)
Year Reports (4)
Project documents (1)
Project research (2)

The gathered data is analysed through coding by hand. The gathered data is coded with the indicators of the core concepts. This allows for a structured approach to coupling different data sources to theory (Hancock & Algozzine, 2017). This approach can be best described as the disciplined iteration between general theory and the empirical data. The results from the different data sources are analysed with existing literature to better validate the results (Verschuren & Doorewaard, 2010). This can also be seen as the search for (dis) confirmation to enhance validity (Creswell & Miller, 2000). By using three different data sources, reliability and validity are ensured through triangulation (Creswell & Miller, 2000). To further ensure validity, the research is reviewed by a peer and a V2G expert (Creswell & Miller, 2000). Also, a thick description is applied to better determine whether findings are valid in other situations (Creswell & Miller, 2000).

Table 6 Central concepts, indicators, and interpretations.

Central Concept	Indicator	Interpretation
Antecedents of R&D Collaboration	1. Experience	Experience of actor that serve the collaboration.
	2. Organizational structure	The structure in which an actor is used to work
	3. Organizational culture	The cultural behaviour that an actor possesses
	4. Resources	The resources of an actor, including dynamic capabilities, that serve the collaboration
	5. Human capital	The employees of an actor that offer value for the collaboration
	6. Leadership	A leader within an actor that offers value for the collaboration
	7. Managerial cognition	Experience in managing people that offers value for the collaboration
	8. External environment	Elements in the external environment of an actor that affect the goal of the firm
	9.Interorganizational structure	The connections of an actor to other firms that might affect the collaboration
Dynamic Capabilities	See Appendix 2	See Appendix 2
Moderators	1. Size	A suggestion that the number of employees of an actor moderate the effect of a dynamic capability
	2. Structure	A suggestion that the organizational structure of an actor moderate the effect of dynamic capabilities
	3. Culture	A suggestion that the culture of an actor moderate the effect of dynamic capabilities
	4. Strategy	A suggestion that the strategy of an actor moderate the effect of dynamic capabilities
	5. Interorganizational structure	A suggestion that the inter-organizational structure of an actor moderate the effect of dynamic capabilities
	6. Industry sector	A suggestion that elements of an industry sector moderate the effect of dynamic capabilities
	7. Geographical area	A suggestion that geographical area moderates the effect of dynamic capabilities
	8. Environmental dynamism	A suggestion that a dynamic environment moderates the effect of dynamic capabilities
	9.Competitive industry	A suggestion that a competitive industry moderates the effect of dynamic capabilities
Outcome of R&D Collaboration	1. Firm-level performance	The actor sees a consequence in their firm-level performance
	2. Domain-specific performance	The actor sees a consequence in the performance of a specific domain
	3. External fitness	The external fitness of the actor is influenced
	4. Survival	The survival capability of the actor is influenced
	5. Growth	The growth of the actor is influenced
	6. Flexibility	The flexibility of the actor is influenced
	7. Innovation outcome	The actor had obtained a certain innovation outcome
	8. Resource base change	The resource base of the actor has changed
	9. Learning	The actor has obtained a learning

5. Results

These results have been formulated by coding the transcripts from Appendix 3 by hand. The resulting coding scheme is then found in Appendix 4. After this, the results have been checked by a V2G expert whether it makes sense.

5.1 Parker Project

The Parker project is an R&D collaboration on V2G technology in Denmark. The purpose of this collaboration is to show that series-produced cars can perform services to the power grid both locally and system-wide. Furthermore, the project tries to pave the road for further commercialization by tackling barriers regarding the market, technology, and users. Lastly, the project develops an evaluation of the technology capability on the OEMs side to meet the needs of the grid (The Parker Project, 2019). The Parker project is a collaboration of various actors: aggregator (+ CPO + EMSP), university, TSO, three OEMs, charge point facilitator, and users. For this research, the aggregator, university, TSO, and one of the OEMs is interviewed.

5.1.1 Antecedents of the actors involved

In this section, the antecedents of the actors involved are presented.

Aggregator (+ CPO + EMSP)

The aggregator has twenty years of experience with V2G technology. The founder of this company is a professor, specialized in offshore wind power, with an entrepreneurial spirit. He has a strong research connection with the Technical University of Denmark (DTU) since the DTU has a strong interest in offshore wind power. He founded the company because he saw the need for balancing the power grid when more renewable energy is generated. From that moment, the company has been very active in the USA to develop software to manage energy in V2G systems. They now have many projects in the USA where they have proven that their software works. However, they found out that to scale their business worldwide, they have to prove that their software works where they would like to scale. Therefore, they are currently conducting demonstration projects all over the world. Denmark generates much renewable energy from wind farms and has a modern digitized power grid. Because of this, the aggregator focussed on Denmark to explore whether they could do a project there to show that their software works in Europe. Through their research links with the university, they got in contact with them and the OEM who were thinking about doing a commercial V2G project. The main antecedents that the aggregator brings to the collaboration are the V2G software, experience in the field, and project management skills.

University

The university has about seven years of experience with V2G technology. In Denmark, universities can get funding when they research technologies that are close to commercialisation. A team at the university decided to put their focus on the technology of V2G. Besides that V2G technology was getting shape at that time, Denmark was also generating much energy from its wind farms. The university figured that with some extra research on V2G they could help to find a solution for stabilising the generated renewable energy, while at the same time getting funded by the government. In the following years, the university set-up the NIKOLA and the EDISON projects in which they explored V2G technology. This lead to the development of a V2G test lab. They also collaborated with an OEM for the first time in the NIKOLA project, since this OEM had the first car that could offer V2G. Thereafter, according to them, V2G was in a phase that it needed to scale-up and they decided that it was time to organise a commercial project with different cars to explore the barriers for commercialisation. Obviously, the OEM joined this project. Subsequently, through their network and reputation, the aggregator, two other OEMs, the TSO and charge point facilitator found their way to this Danish funded project. The main antecedents that the university brings to the collaboration are researchers, V2G experience, project management skills, funding and a V2G test lab.

Transmission System Operator

The Danish national TSO has little experience with V2G technology. However, they do have much experience with the requirements of the grid concerning V2G and the regulatory system around energy. In the last years, the TSO has structured their company to search for solutions regarding the stabilisation of the generated renewable energy from the offshore windfarms. Since the TSO was the operator of the power grid of the project, they got involved with the project through the aggregator. The main antecedents that the TSO brings to the collaboration are their power grid experience and their knowledge about energy regulations.

Original Equipment Manufacturer

This OEM was the first OEM to produce an EV that supports V2G. Since years, their strategy is to connect EVs with the power grid. They have set-up an internal R&D team that develops this technology. They perform pilot projects all around the world to develop the technology and explore the technical value chain and requirements for the user. The OEM already collaborated with DTU in the NIKOLA project and naturally got involved with the Parker project through this connection. The main antecedents that the OEM brings to the collaboration are the EV, technical value chain experience, and a focus on the requirements of the user.

Charge Point Facilitator and User

The charge point facilitator brought in the charger and the user brought in the requirements for the user.

5.1.2 Dynamic Capabilities and Moderators

The antecedents of the actors involved lead to the development of new dynamic capabilities. The collaboration was able to demonstrate V2G technology on a fleet scale at an energy maintenance company. Furthermore, they were able to perform field- and lab tests on hardware and grid services. To achieve this, the university provided project management, testing facilities, and PhD’s to test and analyse the data. The aggregator provided the software, experience from different use cases, and provided training to the university on how to properly perform the tests. The charge point facilitator brought in the charger. The OEMs provided EVs supported for V2G. The interviewed OEM also brought in their focus on the technical value chain and the user. The TSO provided the collaboration with the requirements for the grid. The user brought in the requirements for the user. The main dynamic capabilities that are developed are hardware testing on different EV brands in the lab and the field, grid services testing on different EV brands in the lab and the field, fleet scale implementation of V2G at an energy maintenance company. To disseminate the outcome of these dynamic capabilities, the university supported the project with organising an international V2G conference.

To execute these dynamic capabilities, internal capability needed to be built. In the beginning, there is made a project agreement, this allowed the actors to align with the vision of the project. An important aspect of the project was to have an open culture. Flexibility, a positive mindset, and looking for solutions was expected from the actors. Subsequently, the project was structured into workgroups. Every workgroup had a clear leader and contributor. In this way, responsibilities were clear. This happened because of the project experience of the aggregator and the university. In this way, friction because of cultural and strategic differences is prevented.

During the project, the collaboration discovered a barrier for V2G implementation. For usage in the field, both the energy that goes in and the energy that goes out of the EV need to pay tax. The commercial parties sensed this as a threat to building the business case. Subsequently, the TSO used their connection with the tax department in Denmark to allow the other parties to tackle this barrier through this network.

Despite the project agreement, a factor that moderated the outcome of the project was the sharing of information. The OEM was not allowed to share some information that could have been helpful. However, this does not has a major effect on the outcome of the project and is generally excepted by the collaboration since the OEMs have a competitive environment in which caution is understood. Another drawback of the project was the time it took to align the different technologies. Eventually, it worked, but a longer timeframe or more people is preferred.

5.1.3 Outcome of Collaboration

The project resulted in the successful implementation of V2G in the field. The project has shown that a V2G solution could be viable. Furthermore, there is clear what grid services could be performed and what the requirements for the charging hardware should be. Besides this, the outcome for the different actors is as follows.

Aggregator (+ CPO + EMSP)

The aggregator was satisfied with their outcome that they could show a working V2G concept in Europe. Since Denmark does not have a proper EV penetration, new projects in Denmark are scarce. They do however started a project on the island of Bornholm in front of the coast of Denmark. In collaboration with the university and the TSO, they are trying to stabilize the power grid of this island with V2G. Furthermore, because the aggregator can show this viable V2G concept in Europe, they have landed many projects in France and the UK.

University

The university was very happy that it could show that V2G can provide frequency regulation to the Danish power grid with different EV brands. Besides that, the university published twelve articles, creating intellectual capital on this topic. Furthermore, it is important that by doing this project, the university has positioned itself as a trustworthy partner for V2G research. Because of this, they still work with the aggregator, the TSO, and the OEM to further commercialise V2G.

Transmission System Operator

The TSO is happy that this project showed that V2G is viable. Unfortunately, the penetration of EV is not that good in Denmark because there are no subsidies on EVs. However, with a new rule that in 2030 no cars on fuel can be sold anymore, V2G might become interesting. When EV penetration rises, together with renewable energy generation, the TSO will be ready to introduce V2G.

Original Equipment Manufacturer

The OEM is convinced that Denmark is a good market for V2G. It will be very interesting to sell EVs that support V2G in this country. In the meantime, the OEM has structured their company to further develop its hardware to deliver V2G services more efficiently based on the outcome of this project. In this way, the reliability and the business case will be improved.

5.2 Lombok Project

The Lombok project is an R&D collaboration on V2G technology in the Netherlands. The project is still running but already has reached considerable outcomes. The project focusses on implementing V2G on a neighbourhood scale. Besides that, the project is aiming to develop an international standard protocol for V2G. The Lombok project is a collaboration of various actors: entrepreneur/EMSP, aggregator, CPO, DSO, OEM, university, and municipality. All these actors are interviewed for this research.

5.2.1 Antecedents of the actors involved

In this section, the antecedents of the actors involved are presented.

Entrepreneur / EMSP

This entrepreneur has a background in marketing and knows how to bring people together around a vision. He came up with the idea to store the power of solar panels of his company in an EV by using V2G. During the execution of this idea, he found out that this was not yet done in the Netherlands. He decided to organise this and realised the first V2G implementation in the Netherlands together with the municipality, DSO, CPO, aggregator, and OEM. After this successful implementation, the entrepreneur had the vision to stabilise the grid of his neighbourhood. Together with the municipality and the university, they decided to make a European subsidy project of this and the Lombok project was born. The main antecedents that the entrepreneur brings to the collaboration are his vision, networking ability, and his focus on a business case.

Aggregator

Since five years, the aggregator offers smart charging solutions to electric cars. They always look for projects where they can bring this technology further. Because of this, they got in touch with the entrepreneur who initiated this idea of a V2G project. The main antecedents that the aggregator brings to the collaboration are smart charging software and project experience.

Charge Point Operator

The CPO has more than 10 years of experience in controlling the charge point. They always look for innovative or pilot projects to broaden their own knowledge. Because of this, they got in touch with the entrepreneur who initiated this idea of a V2G project. The main antecedents that the CPO brings to the collaboration are charge point intelligence and project experience.

Distribution System Operator

The DSO has decades of experience with managing the power grid. The main responsibility is connecting people with electricity. Besides that, they feel the responsibility to facilitate the energy transition. They have set up a new department for managing the rise in charge points for EVs. Besides, they are a member of a knowledge and innovation centre in the field of smart charging. Because of this, when the entrepreneur wanted to store the energy from his solar panels and deliver it back to his company he got in touch with someone at this department of the DSO. Since the DSO is a public company, they have developed skills in public relations, communication, and politics. The main antecedents that the DSO brings to the collaboration are requirements for the grid, public relations/communication/politics, energy regulation, and innovation centre around (among which) V2G.

Original Equipment Manufacturer

The OEM is an international renown player in the industry. They have a department that focusses on introducing zero-emission vehicles in society. For them, Lombok is part of a European project with 15 cars AC bidirectional testing in multiple countries simultaneously. Furthermore, the OEM has an R&D lab that is developing V2G technology further. The OEM got in contact with the V2G project when they got approached by the entrepreneur who initiated this idea of a V2G project. The main antecedents that the OEM brings to the collaboration are the electric vehicle, R&D lab, and PR & communication.

Municipality
The municipality has the responsibility to organise the public space to the needs of the society. They have broad experience in doing this and also know their way around subsidies for innovative projects. The municipality believes that they have a responsibility for stimulating innovation that helps accelerate the energy transition. They set-up a department for charging infrastructure and energy transition to support this belief. The municipality got involved with the V2G project when they got approached by the entrepreneur that wanted to use V2G for storing the power of the solar panels of his company in an EV. After successfully implementing one EV, the municipality initiated a subsidy trajectory with the entrepreneur and the university to start off the Lombok project. The main antecedents that the municipality brings to the collaboration are public space experience, funding, politics, and subsidy experience.

University
Besides having the role of conducting research, the university also has a role to translate this research in solutions for society. This university has set-up a department that is responsible for this in the area of sustainability. This department is able to provide project management for innovative projects. When the municipality and the entrepreneur wanted to set up a subsidy trajectory, this department of the university got involved. The main antecedents that the university brings to the collaboration are project management, research, and subsidy experience.

5.2.2 Dynamic Capabilities and Moderators
The antecedents of the actors involved lead to the development of new dynamic capabilities. The collaboration was able to implement V2G technology on a neighbourhood scale. Furthermore, they were able to develop a standard protocol for smart charging. Besides that, several new projects are initiated to explore different use cases.

To achieve this, the entrepreneur set up a company around shared driving in collaboration with the OEM. The aggregator and CPO added their software and project experience. The OEM provided the EV but also collaborated with the CPO on the development of the technology in their R&D lab. The OEM also provided assisting activities by communicating the vision of this project at international conferences. Besides getting the story out, the DSO brought the valuable experience of the power grid and energy regulation. Furthermore, through their links with the V2G innovation centre, they were closely involved in developing the standard protocol for smart charging. The municipality brought in the requirements for the public space and provided funding for writing up the subsidy trajectory. Lastly, the university provided research to support the business case. Besides that, the university was responsible for project management.

To execute the dynamic capabilities it was important to develop internal capability. The municipality and the university had an important role in realising this. They knew with their experience that subsidy trajectories are a great tool to get all the actors aligned. In this trajectory decisions on the openness of the project and the different responsibilities are discussed. This resulted in the actors to get aligned in culture and strategy. The entrepreneur made sure to protect the project exclusivity for every stakeholder. Despite the agreements from the subsidy trajectory, because of misinterpretations or underestimation of the work to be done the project was not always as efficient. The administration of the EU subsidy took much more time than expected for the actors involved. The university took an important role here to support some of the other actors in this. Furthermore, because of the many stakeholders involved, sometimes actors needed to wait for input from other actors. However, by emphasising the need for flexibility and openness this did not result in major problems.

To stay competitive in the automotive industry, to produce new EV concepts, some kind of scale and certainty is the dominant strategy for an OEM. The margins in this business are so small that you cannot just take your risk in producing a couple of EVs with V2G. The DSO, municipality, and the responsible person of the OEM saw this as a threat to the dedication of the OEM in the project. Through their political networks, they were able to organise an economic mission with the king of the Netherlands and the alderman of the municipality to take away the uncertainty at the OEM. This really helped to get the OEM more on board.

The regulations on the Dutch grid also put a tax on energy that goes in and out of the EV. This is not preferred in constructing a comprehensive business case. The entrepreneur is busy to tackle this barrier through his network. However, this barrier is still not solved. The speed in which the regulatory system can be changed seems to be to slow for the development of V2G. Multiple parties within the collaboration mention the lesson to earlier start lobbying for regulations on V2G. You cannot start early enough, because it can take years before the regulation is in place while the collaboration has a working V2G system. At the moment, this cannot be fully exploited because of the limiting factor of regulation.

5.2.3 Outcome of Collaboration

The Lombok project is not done yet. The current results are that the project launched several projects to implement AC V2G in society. These went through a normal concession with the municipality. During these projects, the technology is developed and the charging protocol is in the running to become the official standard in Europe. Furthermore, the individual outcomes are presented below.

Entrepreneur / EMSP

The entrepreneur founded an EMSP during the V2G project that provides shared electric driving. In this way, V2G can reach a bigger scale. The company is still working together with the main actors but also works together with new actors to get the technology out there as fast as possible. Furthermore, it works on a test with flexible tariffs with the municipality to enhance the business model. By collaborating with building companies, the entrepreneur connects his concept to new to be built construction project.

Aggregator

Because of the V2G project, the aggregator learned much about how the power system works. Looking at the development they did not yet get the results they would like to see. However, they are satisfied with the collaboration with the CPO that resulted from this project.

Charge Point Operator

The CPO learned much from the V2G project. They further developed their intelligence for the charge point and the platform and developed some new standard products. They are still working together with the partners from the project. Besides that, the project has been a marketing tool for them. They became visible to the public and are requested for other projects in V2G.

Distribution System Operator

The project is on the way to create a standard for V2G technology. This is something the DSO is very happy with. Now they know that the gird can be balanced, they are also researching whether V2G could be a solution for the warmth transition and capturing the sun peak of RES. Furthermore, the project is a very good example of how collaboration leads to innovation. This is something that they can use in their communication. The project is not done yet, on the basis of the first steps they are now improving OCPE and cybersecurity and are expanding the projects with more cases.

Original Equipment Manufacturer

The OEM is satisfied with the V2G project. They have an EV that can apply AC V2G according to the standard that is created by the project. They are now focussing on further developing the business case to increase the demand for the V2G application and reach a bigger scale such that manufacturing on a bigger scale becomes attractive. Furthermore, they still work together with the entrepreneur as the provider of the EVs for the shared driving concept.

Municipality

The municipality has earned a good reputation in applying V2G in the public space. There are many follow-up projects because of the Lombok project. As long as V2G stays affordable and achievable, the municipality will facilitate this technology and stimulate the energy transition. Besides that, the municipality is doing another project with the DSO to test flexible tariffs. In this way, they hope they can facilitate V2G technology even more in the future by offering an opening for new business cases.

University

The university is happy with another success story. They have, and are still, facilitating to translate research on V2G towards real solutions in society. For the future, they are looking whether they could establish an R&D group on the V2G topic with multiple universities to further disseminate the knowledge and learn from each other.

6. Discussion

From the results a final framework of the dynamics of R&D collaborations can be made (see figure 11).

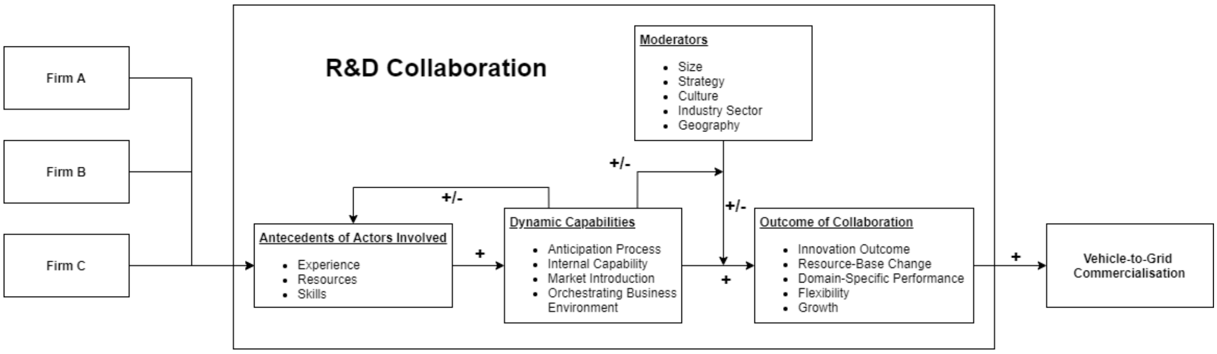

Figure 11 Final framework dynamics R&D collaboration on V2G.

The results indicate that indeed R&D collaborations are a great stimulus for the commercialisation of V2G. The reasons for this are in line with the propositions. By combining specific experience, skills, and resources, actors create the antecedents of the collaboration (Table 7).

Table 7 Antecedents of the final framework.

Antecedents		
Experience	Resources	Skills
Public space	Smart charging software	Project management
Subsidy	Power grid	Political
Funding	Charger	Networking
V2G project	Electric vehicle	PR
Technical value chain	Charge point intelligence	Communication
Power grid	Innovation centre	Visionair
Energy regulation		
User		
Business case		

These antecedents allow the collaboration to use, develop, and maintain unique dynamic capabilities that could not have been formed by any individual firm. A special focus lies on structuring the anticipation process, which allows actors to sense opportunities and threats. Furthermore, the collaboration is able to build internal capability and perform market introduction activities. Besides, dynamic capabilities are formed that orchestrate the business environment. This results in a direct contribution to the commercialisation of V2G by creating viable V2G solutions, but also adds to the commercialisation by creating innovation outcome, domain-specific performance, resource-base change, growth, and flexibility on the individual actor level. The effect of dynamic capabilities is moderated by organisational factors like company size, strategy, and culture. Besides that, environmental factors as industry sector and geography also have a moderating effect. Until this point, there are no differences with the propositions. However, the results show that the dynamic capabilities also have an effect on the antecedents and the moderators. During the collaboration, the actors create shared resources and knowledge that is being used in collaboration to facilitate the development of dynamic capabilities. Besides, for example in the Parker project, through the networking ability of the TSO, the moderating effect of the tax problem was solved. This shows the moderating effect of dynamic capabilities for moderating factors. This is in line with a current research gap, mentioned by

Schilke et al. (2018), that dynamic capabilities might have a feedback effect on connected measurable factors. This seems to be the case, and therefore future research on this topic is suggested.

This result means that it is not self-evident that R&D collaborations on V2G contribute to the commercialisation of V2G. The most important thing seems to be the antecedents of the actors involved. The content of these antecedents should be able to use, develop, and maintain dynamic capabilities that are capable of three things, in order of importance:

1. The main activity of the collaboration. Based on the preferred outcome for commercialisation, a certain main activity should be executed. The antecedents of the actors involved should be able to use, maintain, or develop the dynamic capabilities that enable this main activity.
2. Tackling moderating factors. Based on the main activity and the actors involved certain moderating factors will be present in the collaboration. The antecedents of the actors involved should be able to use, maintain, or develop the dynamic capabilities that tackle these moderators.
3. Supporting activities. It is preferred that the antecedents of the actors involved could use, maintain, or develop dynamic capabilities that enable supporting activities like organising a V2G conference.

This outcome contributes to the existing literature in different ways. Bogers et al. (2019) proposed that a dynamic capabilities approach could be used for the strategic management of open innovation. To a certain extent, this research confirms that this hypothesis is right. Through the dynamic capabilities perspective, an understanding of which factors contribute to the success of open innovation is constructed. By answering the question which antecedents are needed to develop the desired dynamic capabilities for executing the main activity and tackling the moderating factors, a firm would be able to analyse what they are missing and find strategic partners that fill in the gaps. However, this only fills in the antecedents that are based on the experience of that one firm. Therefore, it might be interesting to see how this framework could work as a strategic management tool in an iterative process. Based on the first iteration on the focal firms experience crucial strategic partners are selected. For V2G this would mean that parties from the energy, IT, and automotive part come together. Then a second iteration should allow these actors to add strategic partners based on their combined experience, creating a collaboration that can execute the main activity and tackle the moderating factors. This explains the important role of experience in analysed projects. This allows having a realistic view about which moderating factors exist and what is asked from a collaboration to execute the main activity. It would be interesting to understand how this experience is built such that failed collaborations are prevented. The results provide an interesting insight into this question.

What is interesting to see in figure 11 is that R&D collaborations on V2G technology do not just originate. Each of the actors involved grew their firms' resource base through dynamic capabilities. This positions their firm to be more sensitive for opportunities in the field of V2G. It also provides them with the knowledge that realising this technology needs collaboration of actors and certain requirements of the environment. If then one actor establishes the idea where these elements come together, because of their sensing capabilities, in combination with their resource base, these actors will come together. This suggests that actors did not just come together but that strategic actions from firms eventually leads to such collaborations. Future research on the dynamics of this process is suggested. This is in line with the research gap that Schilke et al. (2018) mentions about the ability of dynamic capabilities to shape ecosystems or in this case collaborations.

Another contribution to the literature is made by exploring whether a fit of dynamic capabilities creates more value in R&D collaborations. Earlier research (Kazadi et al., 2016; Sluyts et al., 2011) proposed that exploring a fit between dynamic capabilities in an R&D collaboration could be interesting. This research shows that interplay between dynamic capabilities from different actors is key to create more value in the collaboration. In the Lombok project, the DSO and municipality sensed the threat of a strategic moderator for the involved OEM. By organising an economic trip to Paris with the king and alderman they provided certainty for the OEM which resulted in a more dedicated OEM for the collaboration, improving the outcome of the collaboration. In the Parker project, the commercial parties sensed the threat of double tax for the business case. They were not able to tackle this challenge because they did not have the network to know who to talk to. Through networking, the TSO provided the collaboration with a contact that allowed the commercial parties to tackle this moderating factor. This shows that within a collaboration not only one actor need to be dynamically capable of managing the collaboration. Each actor on its own can have dynamic capabilities that can complement the dynamic capabilities of other actors. In this way, the collaboration is more prepared for tackling moderating factors and/or provide supporting activities for the collaboration, making the collaboration more robust.

The last contribution to the literature is the addition of the V2G context to open innovation. The results show that the context of V2G is a complex and unique context. V2G requires experience and resources in the areas of energy, IT, and automotive. Since TSOs have a monopoly on managing the power grid, this actor always needs to be involved. Hence, if TSOs do not decide to make EVs and chargers, those actors need to collaborate with the TSO. This could have been an OEM that creates the whole package of an EV, charger, and smart charging software, but the competitive environment of the automotive industry does not support this. Since the automotive industry does not naturally possess this knowledge it is a high risk to invest in the development of this knowledge since the OEMs are in a race for reinventing themselves for future mobility solutions in which strategic mistakes could be fatal. Besides that, the introduction of V2G influences the use of public space, which results in that collaboration will need to work with public parties to arrange this. Therefore, to introduce V2G in society R&D collaborations with 5+ actors involved seem to be unavoidable because of the unique context of V2G.

This focus on V2G, therefore, limits the generalisability of the results of this research. Hence, it is interesting to explore whether there are other contexts that are comparable to the one of V2G. The world seems to show an increasing overlap between sectors. For example, agriculture is getting in contact with the built environment with urban agriculture ideas for cultivating crops in flats in the middle of the city. The automotive industry is not only getting in touch with the energy sector but also touches upon artificial intelligence with the development of autonomous driving. This allows the car to become a space for to be decided activities. The telecom sector has already shown interest in the increasing digitization of the car which subsequently asks for an introduction of privacy security. Research that compares such overlaps of sectors with the context of V2G could explore the generalizability of this research.

The results show another interesting event. In both projects, regulations do not seem to keep up with the pace of the development of V2G. It would be interesting to research how regulations could adapt faster to upcoming innovations like V2G. Who is responsible for making sure that this happens on time? Does a collaboration need to take the lead in this or is it preferred that someone from a public actor takes this responsibility? This is important because this seems to be a bottleneck for the introduction of V2G. R&D collaborations have developed working V2G systems but are not able to fully exploit the service because there is a lack of regulation. Research on this challenge is therefore recommended.

7. Conclusion

This research started with the problem that the power grid will get congested on the short-term because of the rise of renewable energy generation and EV usage. V2G can be a solution to this problem if the technology successfully reaches commercialisation on a large scale. R&D collaborations on this technology show promising contributions to commercialisation of V2G. This research has tried to learn why these R&D collaborations contribute to the commercialisation of this technology to advise future collaborations and accelerate the commercialisation of V2G.

Based on the analysis of the Parker and Lombok project there could be concluded that, within the context of V2G, R&D collaborations are unavoidable. To make these collaborations a success and implement V2G on a larger scale, R&D collaborations on V2G technology should know that moderating factors, like company size, strategy, culture, industry sector, and geography, need to be overcome. This is to a greater extent possible by making sure that the actors involved in the collaboration possess complementary antecedents that are able to facilitate the use or development of dynamic capabilities that tackle those moderators. Not every actor needs to possess every dynamic capability since an interplay of dynamic capabilities in the collaboration can reach this goal. The final framework offers input for successful factors for R&D collaborations on V2G. In this way, future R&D collaborations will successfully contribute to the commercialisation of V2G.

This conclusion was reached by taking a dynamic capabilities approach to the strategic management of open innovation. A literature study on dynamic capabilities and coupled open innovation resulted in the formation of propositions of the dynamics of open innovation. This allowed the construction of a framework that explains the dynamics of R&D collaborations with measurable values. Since the answer to the research question was believed to be dependent on the research context a case study analysis was chosen. The traits of the V2G system provided the case selection with criteria for the case selection. Hence, two cases were selected that complement each other on the dimensions of geography and power grid. The data was gathered through interviews, V2G conference, and desk research. This data was analysed through coding by hand with a coding scheme that was based on the measurable factors from the conceptual model. This gave direction to what to look for in the data.

By doing this, several contributions to literature have been made. By successfully applying dynamic capabilities as a strategic lens for R&D collaborations, this research has confirmed that a dynamic capabilities approach is capable of strategically managing open innovation. Furthermore, by exploring a fit between the dynamic capabilities of the actors involved, this research has shown that an interplay between dynamic capabilities in an R&D collaboration adds value. Besides, this research has increased the understanding of the V2G context.

This has led to a satisfying answer to the research question. This research allows firms working on V2G to understand why collaboration is necessary and what the dynamics are of such a collaboration. Subsequently, the final framework should allow them to pursue success for their collaboration. Therefore, my belief is that this research will contribute to an acceleration of the V2G commercialisation. However, the challenge is far more complex than I had imagined. Such collaboration requires openness and flexibility in which many actors, who aim for profit from this V2G system, have little experience. Besides working on new technology, an actor also need to work on an unknown way of collaborating. Hence, to strengthen the reasons for executing R&D collaborations further research is recommended.

To understand what a firm can do to prepare themselves for collaboration, research on the ability of dynamic capabilities to shape ecosystems is recommended. Furthermore, the dynamic capabilities show a feedback effect on antecedents and moderators. A better understanding of why and how this happens is preferred and can take away unknowns in the current dynamics of R&D collaborations. Furthermore, research on the adaptation of regulation to new innovations is proposed to understand the current biggest barrier for proper implementation of V2G.

Luckily, these limitations do not seem to hold back current activities for promoting commercialisation of V2G. All actors involved seem to be very optimistic about the future. I hope that my final framework will help these actors in scaling V2G technology and solve society's power grid congestion problem and hereby facilitate the energy transition.

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9. Appendices

9.1 Appendix 1

Interview protocol (English)

Introduction

Hi (Name), thank you for taking the time to speak with me about the (Project Name). Shall I first do a little introduction, before we start of with the interview?

I am Tim van Egmond and currently graduating from my MSc in Science Business & Innovation at EVConsult. For my graduation thesis I got really curious about the trend in R&D in the automotive industry. The industry is getting much more complex now manufacturing of cars is combined with telecom, energy and IT. Because of this you see multiple parties from different sectors collaborating on innovation. To most of these parties, this is a new experience and it becomes a learning experience in how to handle this in the best way. My goal is to understand the dynamics of such collaborations and find how the process can be improved for better performance. The collaborations on V2G are a good example of these collaborations, therefore this interview about the (Project Name).

Am I right that I have 1 hour?

Are you ok with me to record this interview?

Do you have any questions before we begin?

Interview questions

1. Can you tell me something about yourself? (Name, company)
2. What does your company do? (Antecedents, moderators)

   -What is your role in the company?

   -What was your role in the Parker project?
3. Can you briefly tell me about the Parker/Lombok project? (Antecedents, moderators)
4. How did you/company get involved with this project? (Pre-project, antecedents, moderators)

   -How did this process go? Clear initiator/core group?

   -According to you what is important in this stage? (Dynamic capabilities)

   -Did the collaboration come across any barriers during this stage? How were they tackled? (Moderators, dynamic capabilities)
5. What was your company's role during the project? (Antecedents)

   -Was there a clear division of roles and did this change through the project? (Antecedents, moderators, dynamic capabilities)
6. What was the company's motive for the project? (Moderators, innovation outcome)

   -Aligned with project and its partner? (Antecedents, moderators, innovation outcome)

   -Long-term/short-term? (Moderator, Innovation Outcome)

7. What stages did the project go through to get to the desired outcome? (During project, Antecedents)
   -According to you what is important in this stage looking at the collaboration? How did you take this into account? (Dynamic capabilities, innovation outcome, moderators)
   -Did the collaboration come across any barriers during this stage? How were they tackled? (Moderators, dynamic capabilities, innovation outcome)
8. The project has run for a few years. Has there been anything of a follow-up? (After-project, antecedents)
   -Yes? What did this follow up look like? (Antecedents)
   -According to you what is important in this stage looking at the collaboration? How did you take this into account? (Dynamic capabilities, innovation outcome, moderators)
   -Did the collaboration come across any barriers during this stage? How were they tackled? (Moderators, dynamic capabilities, innovation outcome)
9. What was for (Company) the outcome of the project? (Innovation outcome)
   -Knowledge you can directly implement (Exploitative knowledge)
   -Information that triggers new research (Exploratory knowledge)
10. How does (Company) look back on this project? Would you collaborate again? (Everything)
   -Positive, Why? Any room for improvement? How?
   -Negative, Why? How can this be changed?
11. What will be important for you in future collaborations? (Everything)
12. Thank you for this interview. Do you have anything you would like to come back to (check whether all questions are answered)? Do you have any questions for me?

Wrap Up

- My research will be shared with you
- Preference privacy
- Check results? validity
- Ok to contact you if I have any further questions?

9.2 Appendix 2

Coding scheme for dynamic capabilities (Mousavi et al., 2019)