Taking into account first-mover advantages in the decision to enter the market.

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Taking into account first-mover advantages in the decision to enter the market.

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Executive Summary

When attempting to enter a market, it is of the utmost importance to make a well-thought decision. Numerous academics have examined the first-mover advantage literature to determine whether entering first, second, or late is more advantageous. After many decades, there is still no consensus, and it appears that we are in a dialogue of the deaf. This thesis gives a list of first-mover advantages and disadvantages and discusses the symmetry between first-mover advantages and first-mover disadvantages, as well as first-mover advantages and second-mover disadvantages, in order to extent the topic. The list of first-mover advantages and disadvantages are described in tables 1 and 2.

Technological leadership		
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*Schilling, 2020*
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*Liebermann & Montgomery, 1988*
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	*Liebermann & Montgomery, 1998*
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*Liebermann & Montgomery, 1998*
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*Liebermann & Montgomery, 1998*
Exploiting buyer and switching costs		

Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*Liebermann & Montgomery, 1998*
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	*Liebermann & Montgomery, 1998; Schilling, 2020*

Table 1: First-mover advantages (based on Montgomery & Lieberman 1988; Schilling, 2020).

Free-rider effects		
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*Liebermann & Montgomery, 1988; Schilling, 2020*
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*Liebermann & Montgomery, 1988*
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*Schilling, 2020*
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*Liebermann & Montgomery, 1998*
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*Liebermann & Montgomery, 1988*
Incumbent inertia		

Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*Liebermann & Montgomery, 1988*
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*Liebermann & Montgomery, 1998*
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*Liebermann & Montgomery, 1988*

Table 2: First-mover disadvantages (based on Montgomery & Lieberman 1988; Schilling, 2020).

This list alone is not enough to settle the debate, so we introduce the pattern of development and diffusion. The pattern of development and diffusion contextualises the problem and shows the demonstrates the effect of first-mover advantages on the development of a product category. The relationship demonstrates that a setting can be either dynamic (a market entry has a substantial impact on the product category) or static (a market entry has little effect).

This thesis proposes a model to illustrate the factors that influence the decision to enter the market. Aspects that influence the formulation of a market entry strategy are included in the model. For the sake of simplicity, only the strategy to enter a market has been investigated. Figure 1 depicts a model containing influencing components and relationships.

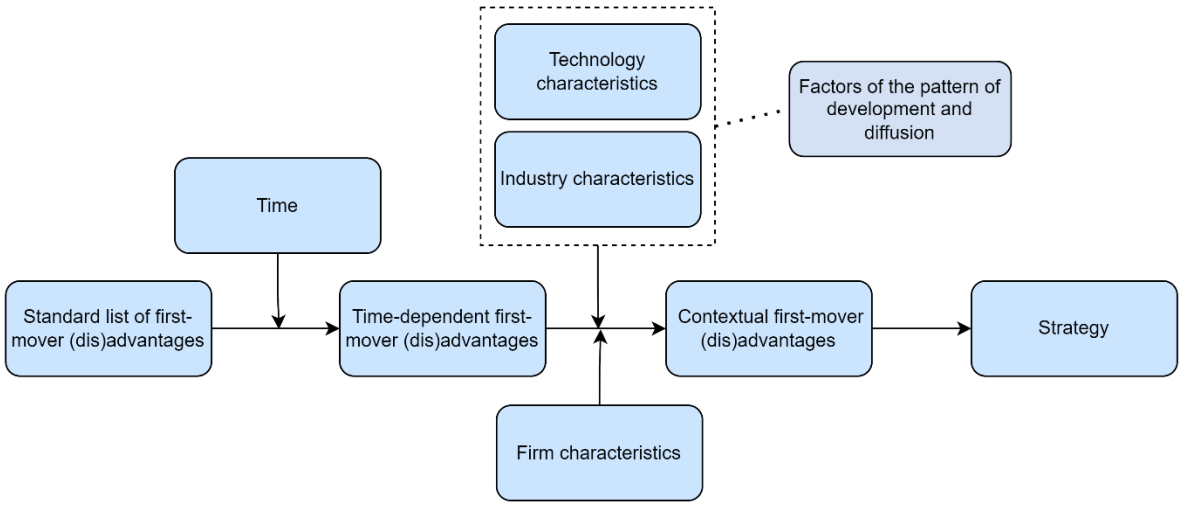

Figure 1: Model to take into account first-mover (dis)advantages in entering a market.

Next to the model, we created a flowchart that describes the steps required to develop a market entry strategy. Figure 2 depicts the flowchart, which depicts an action lane and a thought lane. The action lane describes the necessary analyses, whereas the thought lane describes the ongoing reconsideration and intuitive aspect of decision making.

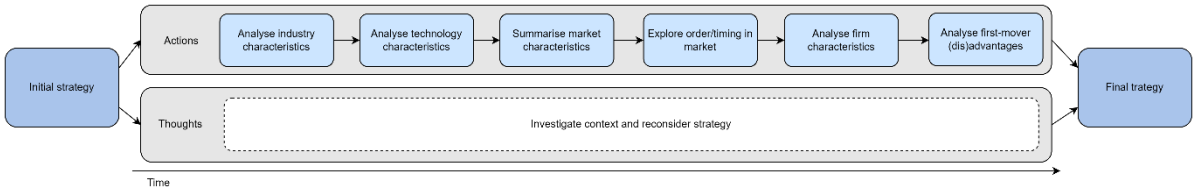

Figure 2: Flowchart to take into account first-mover (dis)advantages in entering a market.

The model presented in figure 1 depicts the relationship between the factors that must be considered while entering a market. In order to evaluate the model, a case study and interviews are conducted. The purpose of the case study is to identify values for the context, and (f)actors of the pattern of development and diffusion are used to help grasp these values. The purpose of the electric vehicle case study is to determine values for the technology and industry characteristics. The interviews are focused on the time-dependent first-mover (dis)advantages from the model. The interviewees assign weights to the standard list of first-mover (dis)advantages provided in table 1 and 2. The results from the case study and interviews yield a score (score = weights x value). The interviews demonstrate that applying merely weights (and not a value or a score) is quickly influenced by the context, which was intended to be only influenced by time. In light of the inconsistency of the results, we propose using a different strategy to gather weights in future studies.

A distinction occurs between the model and the flowchart. The model contains the components that are influential when considering market entry, but it lacks intuition and re-evaluation of the approach. This is indicated by the flowchart, which may explain why the case study and interviewees had difficulties identifying the desired values and weights. Future research may find it intriguing to investigate how analytical and intuitive thinking complement one another in the context of complex decision making. The building blocks of the model that are specified by the flowchart stages in the action lane can be stated, but are not necessarily sufficient to make a well-thought decision. Here, tacit knowledge and experience are utilised.. The highly contextual nature of a market entry decision requires a combination of analytical and intuitive reasoning. This is illustrated by the flowchart, and the problems in determining values and weights for the model reflect this reality.

Eventually the goal is to make a well-thought decision. The dialogue of the deaf on first, second or late being most favourable has been the cause of this thesis but the conclusion is none of those. The most important part of first-mover advantages and disadvantages is the effect they bring along with the entry into a market. This thesis claims that first-mover advantages are advantages and disadvantages that may be evaluated over the development of a product category, rather than belonging to any particular order. The weights of (dis)advantages differ over the course of the development so at different points in time, different advantages can be utilised. The first-mover (dis)advantages present aspects that can be utilised at a particular situation. The decision maker should foresee whether, given the current (dis)advantages, after its introduction the situation is most favourable or if the situation is most favourable when you wait, and competitors have entered the market. The combination of the pattern of development and first-mover advantages show this principle and show why the dialogue of the deaf on market order is not useful. The decision to enter a market has never been simple, and it likely never will be. This thesis offers direction for the decision-making procedure and explains how to comprehend it. The complexities of market entry decision making are not yet resolved, but a well-thought decision is getting closer.

Acknowledgement

I would like to thank my two supervisors, Roland and Haiko. Thank you, Roland, for guiding me through the project and helping me whenever necessary. It was a pleasure to work with you. Thank you Haiko for the insightful feedback which helped significantly improve the project.

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1. Introduction: how first-mover advantages help to make a well-thought decision

Companies that develop products must enter the market at some point in time. The decision to enter a market has never been an easy one. Most of the time there are already existing products within this market but if they are the first to develop this product, they have a choice in when to enter. Is the product good enough and do we know what customers want? Do we enter now, or do we wait until competitors have entered? What if a competitor enters first and we cannot acquire enough market share anymore? All sorts of questions come to mind and must be taken into consideration. The necessity to make a well-thought decision in this situation is of most importance. The process is complex and requires technical analyses and tacit knowledge. Either entering too early, while for example customers are not yet ready, or entering too late and missing an opportunity are situations that should be prevented. From a societal perspective, both types of mistakes are undesired and unbeneficial for everybody.

Starting from the second half of the 20th century the theory of first-mover advantages has been well studied in organisation theory, marketing science and strategic management. After all those years there is still no definite consensus on the definition of first-mover advantage. There is no consensus on the definition of first-mover as well as no consensus on the fact that first-movers, second-movers, or late movers gain the most competitive advantage. Some researchers say being first is best, some say late entry is favourable, and others argue it depends on the situation. After all these years the literature exists in a dialogue of the deaf. A situation where people share their views without actually listening and acknowledging each other. In their paper 'First-Mover Advantages,' Lieberman and Montgomery (1988) discuss some of these points of discussion and elaborate on the progress of the first-mover advantage literature along with the still many uncertainties. They argue that first-movers enjoy multiple benefits of entering the market, but it is not clear if they outweigh the downsides. Also, the advantages and disadvantages of second- or late-movers could be more enjoyable.

Ten years later, Lieberman and Montgomery (1998) in their paper 'First-mover (dis)advantages: retrospective and link with the resource-based view' reflect on their original work, update their survey, and suggest opportunities for continuing work. Despite a great expansion of publication on the subject, many of the fundamental conceptual problems posed a decade ago remain unresolved. They themselves argue that opportunities may lie in forging links with the research on the 'resource-based view of the firm,' and describe much other research done on the topic. After ten years their earlier posed issues are still out in the open.

In 2013, Lieberman and Montgomery again published a paper on unresolved problems from the first-mover advantage literature. Their paper 'Conundra and Progress: Research on Entry Order and Performance' describes the still open conundra from the paper from 1988 and the ones that came to the surface over the 25 years of accumulated research. The definition of a (first-mover) "advantage" stays unanswered, how it should be measured, and even when something is a "first-mover" lacks consensus. It is hard to describe what a first-mover is when one has difficulty defining a new market, when a new market truly begins, how finely it should be defined, and market morphing takes place. Is the market a niche-market, new emerging market, or something else? Defining when one is a first-mover or follower also brings some complexity because placing borders on these concepts is not straightforward. Is entering a week, month or year later considered to be a second-mover? Since this is not clear it is safe to assume that research about first-mover advantages is not always researching the same "first-mover" advantages. After all this time and effort, the answers remain to be far on the horizon.

Even though there is a critical view of the continued challenges for researchers' first-mover advantage literature, it is still important to identify, understand and attempt to rectify ambiguities and misconceptions that may arise in strategic theory (Montgomery & Lieberman; 2013). Lieberman and Montgomery saw synergy in the resource-based view literature, VanderWerf and Mahon (1997) applied the technique of meta-analysis, Golder and Tellis (1993) proposed the method of historical analysis, and Szymanski, Troy, and Bharadwaj (1995) tested the linkage with the hierarchical regression analysis to come up with new ways to understand first-mover advantages. These analyses contributed to get the knowledge base to where it stands right now but left space for a combination with a framework that offers a zoomed-out perspective.

Most papers refer to the first-mover advantages and disadvantages from Lieberman and Montgomery's 1988 paper. Scholars use the (dis)advantages in their argumentation but no definite list is provided by Lieberman and Montgomery. Schilling (2022) elaborates on these (dis)advantages and here one can see that the interpretation differs. A first potential solution to accomplish more consensus could start with a clearly explained list of first-mover advantages and disadvantages. This helps with formulating an agreed upon starting point. However, expectations steer into the direction that this will still not resolve the debate fully. A clear list will help with a more equal starting point but does not solve the definition problem or the contingent nature of the (dis)advantages. This thesis will use

the pattern of development and diffusion to help with this problem. A different approach that opens the possibility to zoom out to help solve the definition and context problems revolving around first-mover advantages and disadvantages. The pattern of development and diffusion focuses on the development of an innovation and its diffusion, which helps when one looks at the selection of an innovation. The order a market is entered and the first-mover (dis)advantages it experiences increase or decrease the likelihood of selection of the innovation.

The pattern of development and diffusion describes how far a technology is developed and diffused and which factors enable and/or hinder large-scale diffusion (Ortt et al., 2004; 2022). For most technologies it shows multiple entries of companies somewhere in the pattern and how this brings the technology further towards its large-scale diffusion (if the technology ever gets that far). It consists of three phases: the innovation phase, adaptation phase and stabilisation phase. The innovation phase and market stabilisation phase are the period from invention of a technology up to the first market introduction and the period when the diffusion of a product takes off (Ortt & Schoormans, 2004). The market adaptation phase begins after the first market introduction and ends when the diffusion takes off. During the market adaptation phase, market and technology factors develop and once they are matured the market stabilisation phase, and large-scale diffusion, should start.

The extensive view on the process of innovation development and diffusion together with the fulfilment of the technology and market factors poses the possibility of cooperation with the first-mover advantage literature. First-mover advantages are all about when to enter the market and the pattern of development and diffusion indicates a certain development of the market of a product category. The difference between the two is the factors of the pattern of development and diffusion displaying a status quo of the market and the first-mover (dis)advantages being more specific for an individual company. This means that first-mover advantages act on a single organisation entering a market while the pattern of development and diffusion looks at multiple organisations that enter a market and how this contributes to the overall product category.

The research of this master thesis will dive into the link between first-mover advantages and the pattern of development and diffusion, and focuses on the entry time of an innovation. Decades of unresolved issues are viewed from a new perspective which hopefully offers valuable new insights. Below the research objectives, perspective and relevance of this thesis will be described. The specific aim will become clear and what will fall outside the scope.

1.1 Research questions

First-mover advantages and the pattern of development and diffusion are theories that separately from each other are used in innovation management. With first-mover advantages a company can assess its benefits of entering early or late and the pattern of development and diffusion gives an overview of where the development of a technology currently stands. The first-mover advantages use organisational characteristics, and the pattern describes more of a market situation which is why normally the concepts have not explicitly been used together before. Within this thesis an attempt will be made to do this.

First-mover advantages and disadvantages will be evaluated in the decision to enter a market and will use the pattern of development and diffusion as a framework to help with contextual aspects. The main research question of this thesis will therefore be:

How to take into account first-mover advantages and disadvantages in the decision to enter the market?

This master thesis is focused on looking at old literature and combining it with newer literature. For this reason, it is important to place emphasis on definitions and stating them clearly. The ambiguity must be solved as much as possible to progress and be able to combine it with new theories. The definition of a first-mover is important since there is confusion about when something is called first-mover. When we use the pattern of development and diffusion, different market entry points could be a first-mover within this pattern. Along with this, more clarity on the concepts of second- and late-movers will come forward. To illustrate these concepts the first sub question will be

What is a first-mover?

Since there is much literature on first-mover advantages and disadvantages a clear overview of the exact first-mover advantages and disadvantages that will be used must be made. This overview must include second-mover or late entry advantages and disadvantages so the decision of entering a market or not can be assessed correctly. Also, ambiguity between first-mover advantages being second/late-mover disadvantages and vice versa should be discussed. To find this information the second sub question will be:

What are the first-, second- and late-mover advantages and disadvantages?

To assess entering a market there also needs to be investigated which technological and social aspects play a role which are not immediately described by the pattern of development and diffusion. For this reason, it is important to answer the research question:

What are technological, and social aspects that are important to consider when assessing the first-mover advantages and disadvantages?

The usefulness of first-mover advantages and disadvantages to enter a market may differ depending on where in the pattern of development and diffusion a company enters. To find out how the advantages and disadvantages differ the following sub question will be answered:

How do the first-mover advantages and disadvantages change over time?

Apart from how the first-mover advantages and disadvantages change, the weight or importance of aspects of (dis)advantages may also change. At some moments in the pattern of development and diffusion specific first-mover advantages and disadvantages are more important than at other moments. The weights can be used to better assess the possibility of entering a market. The question that will be answered to find this out will be:

How can the advantages and disadvantages be weighed in a particular situation to come to a decision to enter first or not?

Figure 3 shows an overview of the research questions described above. At the top, the main research question can be seen and underneath the sub questions are shown.

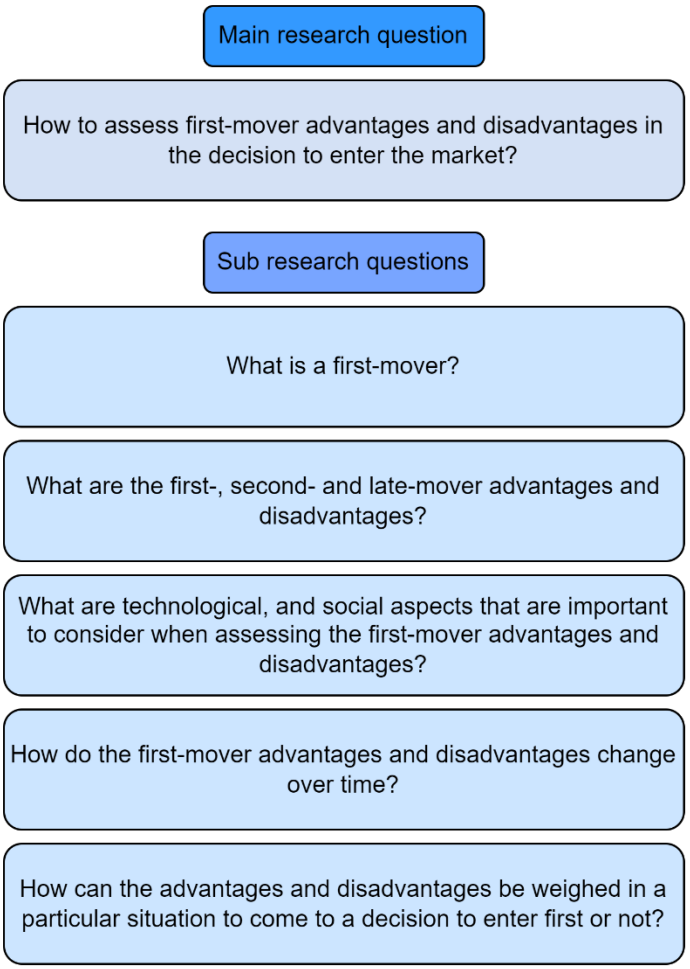

Figure 3: Overview of the research questions.

1.2 Scope

The research will be focused on a technological company that tries to bring a new product on the market. The scope does not entail new services that are brought to market. Data from (high-)technology companies will be used to clarify concepts and to compose a model. Data from companies from other industries, like finance or legal, will not be used. The highly varying contingent nature of the research objectives indicates that old data is less usable. Therefore, only data younger than 50 years will be used. Even though many aspects (market, political, etc.) could be considered when assessing first-mover advantages and disadvantages, the focus will be on technological and social aspects. Otherwise, too many aspects are under consideration for in-depth research.

1.3 Perspective

Since this research is focused on a technological company that tries to bring a product on the market out of its own R&D department, the thesis is written from the perspective of a company with an R&D department. The problem owner who could use the findings from this thesis is a technology development company.

1.4 Scientific relevance

In the first-mover advantages literature a lot of ambiguity exists. For around 40 years a discussion has been going on about entering a market first or later and still no definite conclusion has come forward. Goldis & Teller (1993) show that half of the market-pioneers from five hundred brands in fifty product categories fail, survivors' mean market share is lower, and early market leaders (who entered an average of 13 years later than first-entrants) have much greater long-term success. Carpenter and Nakamoto (1989, 1994), argue there is a pioneer advantage if customer needs are identified and acted upon. A first-mover develops a preference position by influencing the weights buyers use to evaluate the product category, its position, and playing a vital role in consumers' preference formation in the category. Schnaars (2002) clarifies its view by the subtitle of the book 'How later entrants seize market from pioneers". Michael (2003) argues that first-mover advantage exists through franchising. Suarez and Lanzolla (2005) state "*First-mover status can confer advantages, but it does not do so categorically. Much depends on the circumstances.*" Frynas, Mellahi & Pigman (2006) argue that first-mover advantages can exist, but political resources fail to be considered. Pettit & Darner (2012) in their article "The Myth of First Mover Advantage" emphasise the rarity of conditions and short-lived effects of first-mover advantages, and many more contradicting conclusions are to be found in the literature. Part of the problem could be the unclarity of the definition of a first-mover which results in scientists not researching the same properties. Clarification of the definition could help to straighten conclusions on multiple innovations. One study taking into account more or other contextual factors looks to be of importance as well.

Secondly, the first-mover advantages literature has never been combined with the pattern of development and diffusion before. The pattern of development and diffusion explores niche strategies to introduce an innovation to the market despite not all (f)actors being mature (Ortt & Kamp, 2022) and provides information on when to enter the market. However, it does not say if for a specific company the situation is favourable. It elaborates on the maturity and entering of the market as a whole but does not include an enterprise fit with this situation. Within this thesis, this fit will receive more attention.

1.5 Managerial relevance

A company with an innovation is always trying to figure out what time to enter the market is most favourable. The most profitable option is often pursued, and an estimation is made on the perfect opportunity. Entering first can obtain a company brand loyalty, the acquisition of scarce assets and help steer the product category in a direction favourable for the company. This could lead to an advantage in market share, profitability, or survivability. However, costs belonging to research and development, uncertainty of the market and fixation in assets can endanger the desired market share, profitability, and survivability.

Along with other theories, first-mover advantages can be used to argue the timing of entry. The research of this master thesis will complement this capability of first-mover advantages. By combining the first-mover advantages and disadvantages with the pattern of development and diffusion a more solid estimation of favourable timing of entry can be made. The context of a market, innovation or organisation can be taken into account more rigorously with which a strategy can be obtained. Before, a manager could use first-mover advantages and

disadvantages or the pattern of development and diffusion to see what time to enter is optimal. The combination of the two combines knowledge and provides more than that.

1.6 Outline

This thesis will be divided into three main parts: theory building, design, and validation. Within the theory building, the two literature streams on first-mover advantages and the pattern of development and diffusion are described and combined. After the theory construction is done, the design phase will start in which the conceptual model and case studies are used along with the knowledge gathered in the theory building phase. When the design phase is finished a validation phase will start which comprises the case study and interviews. This will be the main body of the thesis. Before this part, an introduction is given, and the methodologies used are described. After the main body, results are discussed, a conclusion is formulated, and recommendations for further research are given. A brief overview of the outline of this thesis is shown in figure 4.

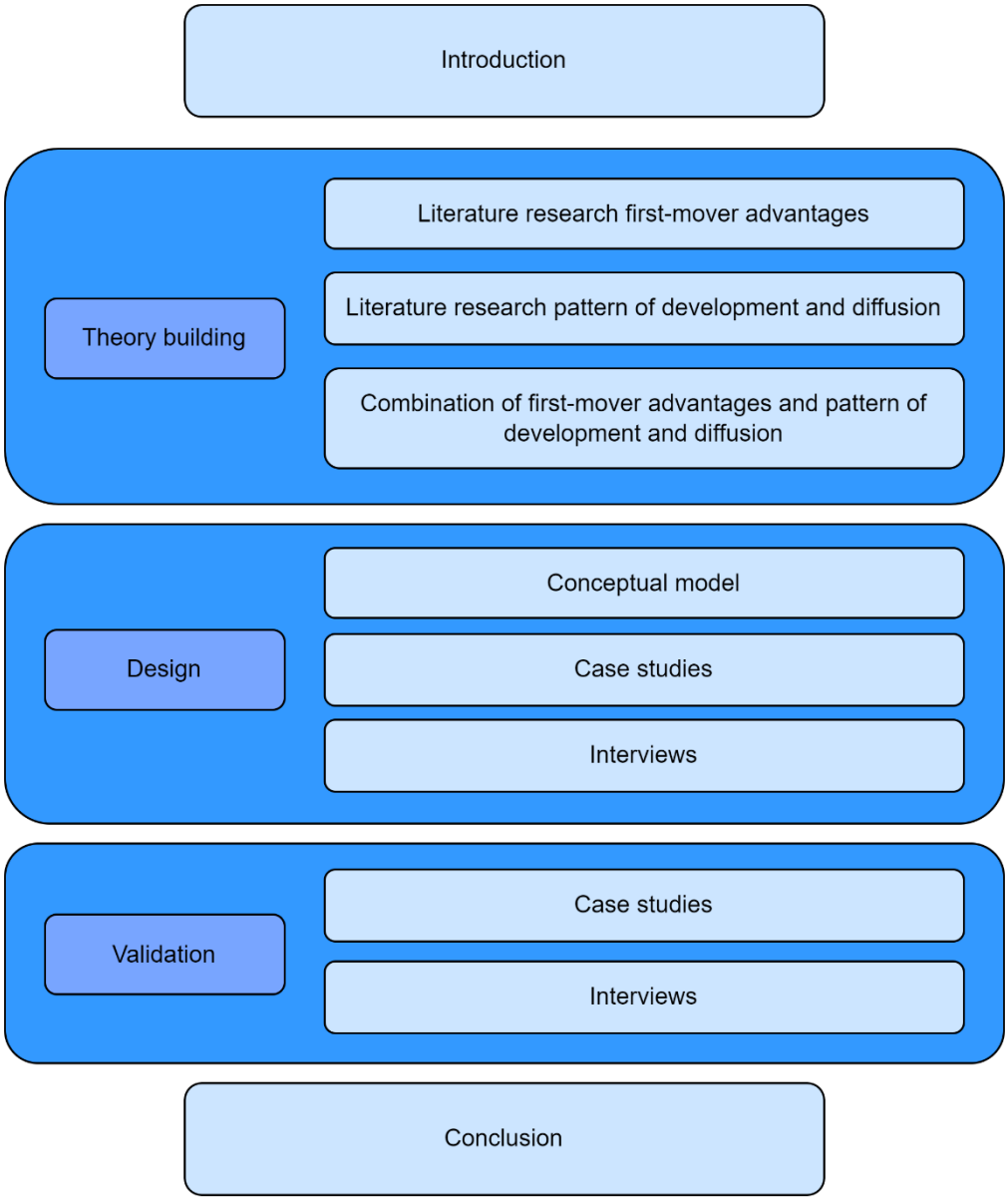

Figure 4: Outline of this master thesis.

2. Methodology: a multi-method approach to understand first-mover advantages

Finding out the answers to the questions posed above can be done in several ways. The methodologies that are going to be used in this thesis are described in table 3. For the first question, literature research fits best. The definitions that are used in other research can be gathered and with the literature of the pattern of development and diffusion a clear description can be given. Also, the accompanying advantages and disadvantages can be obtained by performing a literature research. The variation of the first-mover advantages and disadvantages over the time axis cannot be researched by literature research alone. For this a case study must be done. A case study captures a range of perspectives which will help describe the dynamic behaviour. The last two questions will be answered by doing interviews. These questions ask for an experienced view on the topic where added information is sought. The opinion of people on the topic can strengthen the desired outcome which can best be gathered through interviews.

Sub research questions	**Methodology**
What is a first-mover?	Literature research
What are the first-, second- and late-mover advantages and disadvantages?	Literature research
What are technological, and social aspects that are important to consider when assessing the first-mover advantages and disadvantages?	Literature research + case study
How do the first-mover advantages and disadvantages change over the time axis?	Conceptual model + case study + interviews
How can the advantages and disadvantages be weighed in a particular situation to come to a decision to enter first or not?	Conceptual model + interviews

Table 3: Sub research questions and accompanying methods to answer them.

2.1 Literature research approach

The first and second sub question will be answered by conducting systematic literature research and the third sub question will partly be answered by a systematic literature research. In her book "Conducting Research Literature Reviews," Fink (2019) defines a literature review as a systematic, explicit, comprehensive, and reproducible method for identifying, evaluating, and synthesising the existing body of completed and recorded work produced by researchers, scholars, and practitioners. The goal of writing this systematic literature review is to reconstruct the abundance of accumulated knowledge in a specific domain. It does this by taking notes of what is researched, and which database is used as well as inclusion criteria and keywords. The literature research on first-mover advantages also contains a more narrative literature review at the end where a distinct gap is identified. The literature review will help to find the knowledge to derive a consensus on what a first-mover could be, which first-mover advantages and disadvantages are accompanied by it, and if symmetry can be found. Also, it will provide the information needed to build the foundation for the model that will answer the sub questions that follow.

2.2 Conceptual model approach

A conceptual model helps to answer the fourth and fifth question. A model will be built to illustrate what all can influence a company's strategy, of which one thing will be first-mover advantages and disadvantages. A comprehensive model is needed to explain what factors are taken into consideration in other research and how those influences outcomes. The conceptual model will consist of two figures, a model, and a flow chart. The model is used to

illustrate how distinct parts influence each other and the flowchart will help to illustrate how one can use a variety of characteristics in combination with first-mover advantages to decide whether to enter the market or not.

2.3 Case study approach

The third and fourth sub question will be answered with the help of a case study. A case study allows the researcher to explore individuals or organisations, simply through complex interventions, relationships, communities, or programs (Yin, 2002) and supports the deconstruction and the subsequent reconstruction of various phenomena (Baxter & Jack, 2015). 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. These are exactly the aspects that need to become clear in the third and fourth question.

Type of case study

The type of case study that will be used to build the theory and conceptual model is a single case study. Limiting to one case study enables the researcher to explore more in depth. The case study contains two episodes that express the contingent nature of first-mover advantages and the pattern of development and diffusion. It shows that situations differ much, and this amplifies the problems with prior research mentioned in section 1.4 on scientific relevance. The goal is to find specific aspects and building blocks to validate and increase the quality of a conceptual model. Because comparisons will be drawn, it is imperative that the episodes are chosen carefully so that the researcher can describe comparable results across cases, or describe contrasting results based on a theory (Yin, 2003; Baxter & Jack, 2015). The technology and social aspects that are important to consider, are aimed to be identified and the case will explain the importance of clarifying ambiguities of definitions.

2.4 Interview approach

To answer the fourth and fifth sub question of this thesis, semi-structured interviews will be used. In a semi-structured interview, most questions are defined beforehand but there is room left for respondents to make their own reasoning and to ask follow-up questions. New discoveries can still be found during the interview and the interview is not only used to validate existing knowledge.

For the fourth and fifth question it is important to gather knowledge from managers familiar with the topic. They will be presented with the conceptual model, the pattern of development and diffusion of a technology, and how the first-mover advantages influence the maturity of the innovation. Then they will be asked how the weights of the different first-mover advantages and disadvantages change over the course of the development of a technology. This will be done with different examples which are formulated during the case study. A scenario will be provided for which the interviewees are asked what they would do in that situation. The goal is to gather answers that predict how the information will be used in the future and not what they would have done in hindsight. Also, they will be presented with technology and social aspects that could influence the success caused by a first-mover advantage or disadvantage. Here they will rank the importance of the aspects and potentially add extra aspects.

3. Literature research: a combination of two literatures

Companies that develop products must enter the market at some point in time. Most of the time there are already existing products within this market but if they are the first to develop this product, they have a choice in when to enter. For these companies it is valuable to know which benefits and downsides there are on entering first, second or later. This exactly is what the literature of first-mover advantages is all about. The first part of this chapter will elaborate on the different advantages and disadvantages belonging to entering first, second or late and will use examples to clarify. It becomes clear that much research has been done but some loose ends are still present. Extra attention will be given to symmetry between first-mover advantages and second-mover disadvantages and symmetry between first-mover advantages and first-mover disadvantages.

The development and diffusion of a product can go in several ways which never can be guessed up front. In hindsight it might look obvious but in the process itself it often is hard to tell how exactly it will go. Rogers (1962) introduced the innovation life cycle model which became the mainstream model of pattern of development and diffusion. This model describes an innovation consisting of two parts: a development phase and a diffusion phase. Later, Ortt & Schoormans (2004) introduced his pattern of development and diffusion which also includes an adaptation phase. This pattern will be described more elaborately in the second part of this chapter. It will be stated how the pattern came to exist and the different phases and factors will be described.

3.1 Literature research setup

The first part of the literature review is about first-mover advantages and disadvantages. A start was made with reading the paper of Lieberman and Montgomery (1987), Tellis and Golder (2015) and Suarez et al (2014). These papers include information about first-mover advantages and were used to get an indication on keywords for the search for more literature. Since the concept of first-mover advantage is a heavily studied subject for the past 35 years there exists an abundance of literature about this topic. To find the needle in the haystack to eventually answer the research question posed in the introduction and find knowledge gaps for further research a structured approach had to be used (Jesson, 2011). Not only first-mover advantages and disadvantages had to be explored but also second-mover or higher order market entry orders had to be included. The use of searching through title, abstract and keywords eventually turned out that those higher order numbers do not have to be used in the search of relevant literature.

Keyword selection

The keywords that are used to find research papers are presented in table 4. Scopus was used to search for the relevant papers within the abundance of literature available these days. Scopus is used because it classifies papers by categories and research areas, and search terms can be easily specified in the search browser. When the keywords from table 4 are combined with the operators 'AND' and 'OR,' the keywords are used to search within the title, abstract or keywords so a list of papers comes out. In table 5 the precise search entries are provided and the amount of hits they yielded.

AND	OR
First-mover	First-to-market, early-entrant
Second-mover	Follower, late-entrant, second-to-market
Advantage	
Disadvantage	

Table 4: Keyword selection.

From table 5 it can be seen that not all words from the research questions are used as keywords to find relevant articles, especially weight and context. These words are not used because they either took the amount of hits to zero or only ended up with articles that were duplicates of the other search terms. For this reason, the method slightly deviated from *research questions -> keywords -> search term*.

Search within	Search term	Hits

TITLE-ABS-KEY	First-mover AND second-mover AND advantage	264
TITLE-ABS-KEY	First-mover AND disadvantage	117
TITLE-ABS-KEY	Second-mover AND disadvantage	203

Table 5: Combination of keywords as search entries and the amount of hits.

The specification of the keywords made the need to define extra inclusion or exclusion criteria unnecessary. The number of papers that showed up was high but could be done. Also, the wide variety of literature about this topic made it more useful to scan more papers by reading the abstract to find relevant papers than to filter them out too heavily by inclusion or exclusion criteria. Once the reading of the abstracts started it became clear that between the results of the search queries quite some were duplicates which also resulted in less articles that needed to be considered.

Reading the abstracts was the next step to filter the hits. At first, the abstracts were scanned for papers that involved definitions and elaborations on different first-mover advantages. The aim was to get a good overview of all possible first-mover advantages and how they are argued to be advantages or disadvantages (by also taking into account other characteristics). Also, the abstracts were scanned on the notion of relationships between first-mover advantages and first-mover disadvantages and/or first-mover advantages and second-/late-mover disadvantages. Papers were filtered out if it was clear from the abstract that first-mover advantages played a minor role in the research or only were used to illustrate a different construct. This made clear that no knowledge on first-mover advantages was to be gained from that paper regarding the other papers.

Lastly, the introduction, conclusion and recommendations of papers with abstracts that showed potential were investigated and the ones that provided important knowledge were used in the literature research. Also, references in relevant papers were used to find new papers that did not show up in Scopus. This is a less structured approach because one works from reference to reference, yet it was used to find papers in this literature research. Eventually around thirty articles were read in their entirety. Figure 5 shows the steps that led to the reduction of the number of articles.

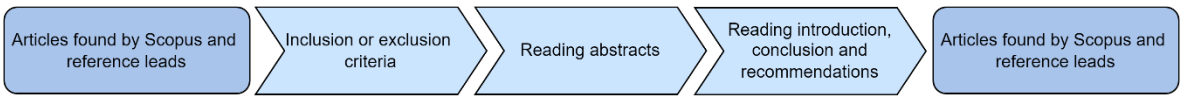

Figure 5: Article reduction process steps.

Literature research pattern of development and diffusion

The literature research on the pattern of development and diffusion literature was done differently than on the first-mover advantage literature. Because most of the literature on the pattern of development and diffusion is produced by Ortt, the approach started by looking at his prior work. Since this resulted in enough information to describe the pattern of development and diffusion no additional extensive search has been performed.

3.2 First-mover advantage literature

Throughout strategic management, economics, and marketing literature many have demonstrated the existence of first-mover advantages and disadvantages or second/late- mover advantages and disadvantages (Montgomery & Lieberman 1988; Suarez and Lanzolla 2005; Birger 2006). The paper of Lieberman and Montgomery (1988) gathers information on multiple sources of the concept of first-mover advantages and raises questions about what has been researched until that time. First-mover advantages refer to the phenomenon where an early entrant of a new market is more likely to gain superior performance in profit, market share or survival rate. Second- or late-mover advantages are achieved when a firm enters in a later stage which enables superior performance over earlier entrants. Some successful first-mover examples are Twitter, eBay, and Uber and successful second-/late-mover examples are Facebook, Myspace, and Amazon (Feng et al., 2020)

First-mover advantages

A company that makes the strategic choice to be a first-mover could experience multiple benefits. The advantages that this company could confer are brand loyalty and technological leadership, pre-emption of scarce assets, and exploitation of buyer switching costs (Montgomery & Lieberman 1988). If a company acts in an industry

characterised by increasing returns, it could acquire advantages of learning and network externalities that may be self-reinforcing over time (Spence, 1981).

Technological leadership

Following the first-mover advantage literature, a company that introduces a technology into a new market (first-mover) could acquire a reputation as a technology leader in that market. This could help the company better its market share, brand-loyalty, and image, possibly long after new entrants entered the market. The existence of the company in the market enables it to shape customer needs about price, design, and other aspects. Combined with patents or copyrights on customers' preferred features, being first can increase difficulty for followers to imitate the product and grants the possibility for sustained monopoly rents (Schilling, 2022). If product features are to be imitated more easily a first-mover still can build brand loyalty within a customer base to increase sustained revenue.

As an example, we look at Uber. Uber is a mobility as a service provider (Uber, 2022) and entered (and partly created) the shared (mobile) ride-hailing market. Nowadays people even talk about taking an Uber instead of a cab and talk about their Uber driver instead of their taxi driver. By entering the market early and growing fast, they gained market share quickly, built brand loyalty and shaped customer needs which resulted in them still being the biggest in their market.

Pre-emption of scarce assets

The pre-emption of scarce assets enables companies to pre-emptively capture scarce resources such as key locations, relationships with suppliers, relationships with distributors, patents, government permits or permits (Schilling, 2020). This allows early movers to get in the position to pre-empt the limited opportunities available in diverse aspects of the market. First-movers could also make investments in plant and equipment to deter entry by others (Dixit, 1980), and can pre-empt key dimensions in the geographic and product characteristics space (Lieberman and Montgomery, 1988). This advantage could influence market opportunities especially when focused on exploiting the competitive vacuum of the market. It is useful to distinguish between competition effects, which involve rivalry among firms, and market factors, which reflect the market or consumer. Because without competition, market factors can still be a valuable source of early mover advantages (Cho et al., 1998)

An example of the pre-emption of input factors acquired by controlling geographic locations rich in natural resources is given by Pentland et al. (1955). They state that the concentration of high-grade nickel in a single geographic area made it possible for the first company in the region to gain almost all the supply. Because of the pre-emption of these scarce assets, it has controlled a solid proportion of the world's supply of the product (Ranjan, 2018).

Exploiting buyer and switching costs

Exploiting buyer and switching costs is the third main first-mover advantage posed by Lieberman & Montgomery (1987). This advantage is gained when customers buy a product and face costs if they switch to another good. The first-mover's market share can be enhanced by new transaction costs, product, and technology adaptation, learning and contractual obligations (Lieberman & Montgomery, 1987). A famous example of switching costs is the QWERTY typewriter keyboard. The QWERTY keyboard was designed so people could not type fast enough because otherwise two keys would get stuck if used rapidly after each other. Key jams were a big problem in the 1800s because the typist could not easily recognize the jammed keys when using the typewriter. The keyboard layout was designed so commonly used letters were widely spread over the keyboard. Once the issue of key jams was solved, many typists were used to the QWERTY keyboard layout and the switching costs to a different layout were too high even though other layouts were proven to be quicker (Schilling, 2020).

Buyer switching costs that can also be exploited are the buyer's choice under uncertainty which results in brand loyalty. A buyer has imperfect information regarding product quality. For this reason, a buyer may choose to stick to the familiar brand of which they already know the quality and performance of. Brand loyalty of this sort is especially strong for low-cost convenience goods where benefits of finding a superior brand are almost never worth the effort of searching (Porter, 1976).

First-mover disadvantages

Apart from the advantages a pioneer could enjoy, Lieberman and Montgomery also mention first-mover disadvantages, arguments for not entering a market too early. Tellis and Golder (1993) found in their historical

studies of fifty product categories that early entrants have a high failure rate and that only pioneers occupy ten percent of the main market share. Their studies of approximately five hundred brands in fifty product categories found that roughly 47 percent of first-movers fail. Early leaders (second-movers), those who enter later but acquire market leadership during the early growth phase of the product life cycle, have much greater long-term success and enter an average of 13 years after pioneers according to their research. It occurs that players are observed to be first-movers but often the market has misperceived who the pioneer was. People would argue that Amazon is the first online bookstore but if one would know Charles Stack Online Bookstore it influences the discussion (Feng, 2019).

Below the first-mover disadvantages mentioned by Liebermann and Montgomery (1988) will be described. They are categorised into four main categories, namely free-rider effects, resolution of technological uncertainty or market uncertainty, shifts in technology or customer needs, and incumbent inertia.

Free-rider effects

Free-rider effects can best be described as the advantage later entrants gain because of the work already done by first-movers such as R&D, infrastructure development, and educating buyers. The high investment costs of pioneers increase the risk of less return on investments which must be done less by followers. Later entrants do not have to invest in exploratory research, and they can ascertain how a product was created. Before a technology has been successfully developed a company not only had to bear the cost of that technology but also technological paths that did not make it to the market. A new product in a new market often lacks production methods and complementary products which will have to be developed to be able to meet demand and full utilisation of features. New product development failure rate can be as high as 95 percent, which makes it an expensive and risky strategic decision (Schilling, 2020). According to Manfield et al. (1981) imitation costs about 65% of the cost of innovation development. A commonly used example for free-rider effects is Matsushita free-riding on the VCR developed by Sony (Schnaars, 1986).

Resolution of technology or market uncertainty

The resolution of technology or market uncertainty is a disadvantage because although pioneers can steer the direction of the technology's development, the expenses are high. The observation of market development by late entrants can work advantageous because user needs are more defined, and the follower's product can be better aligned with the new knowledge. By reducing unit cost or introducing a better product it expected for a follower to gain market share. If the pioneer does not acquire the best market fit or market uncertainty still is prominent it will experience a disadvantage. A later entrant can increase its brand positioning because of increased learnings about customers needs from the first-mover's product (Kerin et al, 1992).

An example from the Swedish mobile phone market can be used to show the principle of technology uncertainty. After Ericsson (the first-mover) was not able to establish the most attractive market position, Nokia entered the market. After seeing that Ericsson focused their efforts mainly on innovation, Nokia learned and focussed more on design which resulted in becoming market leader (Green et al., 2004).

Incumbent inertia

The incumbent inertia is a first-mover disadvantage because it obliges the pioneer to gain returns on investments even though better products might be out in the market at some point or it is costly to change current production methods into newer products. Cannibalisation of their own product line could be a genuine problem as well as having to invest heavily in new products and knowledge. The history of semiconductors has seen many competence-destroying technological changes (Tushman & Anderson, 1986). Newer entrants see the possibility to be more flexible and adaptive to enter a market and exploit incumbent weaknesses (Lieberman & Montgomery, 1988). A firm may be locked-in to a specific set of fixed assets, knowledge, or other heavily invested resources. Also, organisational inflexibility can occur because of development of organisational routines and standards, internal political dynamics, and development of stable exchange relations with other organisations (Hannan & Freeman, 1984).

Cho et al. (1998) gives an example of incumbent inertia on Toshiba's C-MOS technology involving the production of 1M DRAM. Since NEC's success, N-MOS had become the industry standard, being considered the most appropriate technology for mass production because of its simple manufacturing process and low costs. C-MOS technology was more complex and costly but had the advantage of consuming less energy. In 1985, Toshiba announced massive investment in the mass production of C-MOS 1M DRAM and introduced sample chips within less than a year. The energy-saving feature of Toshiba C-MOS 1M DRAM was well received by consumers and the product

was a hit in the world market. Competitors soon decided to adopt C-MOS technology and Toshiba became the industry leader in the DRAM area**.** The technological leapfrogging strategy of Toshiba made excellent use of NEC's incumbent inertia.

List of advantages and disadvantages

To get a clear overview of the above-mentioned advantages and disadvantages, they are listed in tables 6 and 7. A raw list of first-mover advantages and disadvantages can be found in appendix B. In the end it became clear that Liebermann & Montgomery (1988) and Schilling (2020) provided the clearest definitions. Liebermann & Montgomery (1988) and Schilling's (2020) definitions are used as starting points and where additional information is appropriate, it is complemented.

Technological leadership		
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*Schilling, 2020*
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*Liebermann & Montgomery, 1988*
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	*Liebermann & Montgomery, 1998*
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*Liebermann & Montgomery, 1998*
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*Liebermann & Montgomery, 1998*
Exploiting buyer and switching costs		

Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*Liebermann & Montgomery, 1998*
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	*Liebermann & Montgomery, 1998; Schilling, 2020*

Table 6: First-mover advantages (based on Montgomery & Lieberman 1988; Schilling, 2020).

Free-rider effects		
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*Liebermann & Montgomery, 1988; Schilling, 2020*
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	*Liebermann & Montgomery, 1988; Schilling, 2020*
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*Liebermann & Montgomery, 1988*
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*Schilling, 2020*
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*Liebermann & Montgomery, 1998*
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*Liebermann & Montgomery, 1988*
Incumbent inertia		

Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*Liebermann & Montgomery, 1988*
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*Liebermann & Montgomery, 1998*
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*Liebermann & Montgomery, 1988*

Table 7: First-mover disadvantages (based on Montgomery & Lieberman 1988; Schilling, 2020).

Lieberman and Montgomery incited many researchers to explore this new field of innovation management theories. The first-mover advantages and disadvantages, introduced above, have been a researched topic for the past 35 years and have been extended to second-mover and late-entrant advantages and disadvantages. Most of the time, second-mover advantages are used in the same breath as first-mover disadvantages, but can this always be assumed? Below a discussion is presented if second/late-mover advantages are first-mover disadvantages and vice versa. The symmetry mentioned means the assumption is (partly) made.

Second/late-mover (dis)advantages

Lieberman & Montgomery (1988) describe that some first-mover advantages are disadvantages for later entrants (symmetry can be found), such as pre-emption of scarce assets, switching costs and patents because it uses finite resources. This is not the case for the learning curve. In the 1970s it was believed that cost reduction by the learning curve model led to a considerable advantage because the profitable competition was difficult for followers. However, inter-firm diffusion of technology which diminishes first-mover advantage is emphasised in studies in the 1980s (Lieberman & Montgomery, 1988). Inter-firm diffusion includes among others workforce mobility, research publication, informal technical communication and reverse engineering. The symmetry between first-mover advantages and disadvantages is limited.

M. B. Lieberman and Montgomery (2013) added to their own research that first-mover advantages and follower advantages can exist simultaneously. Advantages to early movers often do exist, but are by no means inevitable, in many contexts for performance measures such as market profit, survival and risk. They state that it is important to know that no entry order effects on performance are permanent but instead diminish over time and can be overcome by competitors.

M.B. Lieberman (2016) addresses late-movers that are quick to adopt the dominant design may benefit from product standardisation without bearing the costs of experimentation and technology switching which first-movers face. A first-mover needs to be able to carry over its technology from a niche market to the mass market once a dominant design that attracts the mass consumers is established.

Tellis and Golder (1996) argue that five factors drive superior performance for early leaders: vision of the mass market, managerial persistence, financial commitment, relentless innovation, and asset leverage. Similarly, the inability or neglect to implement these factors lead to the failure of early leaders. Especially in newly emerging categories the mind-set fires the success of the first four factors. They argue these five factors are more important for enduring long-term leadership than pioneering. A first strike may be desirable, but careful preparation for attack, counterattack, penetration, and consolidation are critical for success. Here a clear symmetry between the advantage and disadvantage can be seen since the lack in an advantage leads to a disadvantage.

Cho et al. (1998) already point out the symmetry between first-mover advantages and latecomer disadvantages so an advantage for first-movers is a disadvantage for late-entrants. They provide instructions for latecomers how to deal with these disadvantages (which are the first-mover advantages mentioned by M.B. Lieberman and Montgomery (1988, 1998)) and how to exploit the late-entrant advantages. They counter the first-mover advantages with focusing, thin margin or loss bearing and volume building. This means that initial entry should be targeted at one or more specific product segments as penetration points, latecomers should be prepared to

withstand hardship or even losses until their operation passes the break-even point and reach a scale economy in the shortest time possible, respectively.

Usero and Fernández (2009) describe in their paper 'First come, first served: How market and non-market actions influence pioneer market share.' that they do not find market actions that are able to significantly erode pioneer advantage. They mention the first-mover advantage described by M.B. Lieberman and Montgomery (1988, 1998) cannot be eroded significantly even when followers are more innovative. A clear sign of first-mover advantage and follower disadvantage symmetry can be seen. Being first has advantages even when it is easy to copy or improve the competitive actions. Their case only supports that non-market measures like legal actions help reduce pioneer market share advantage.

Within the Taiwanese semiconductor industry, a different case is mentioned in the work from He et al. (2013). This paper argues that late-entrants display better performance than followers and first-movers. Mainly because late-entrants can reduce costs by imitating previous entered firms' innovation, avoiding mistakes, and gaining human resources through poaching talented employees from competitors. Normally pre-emption of scarce assets is mentioned as a first-mover advantage but only deceleration in technological development seems to happen. These results contradict earlier mentioned literature.

In research from Querbes-Revier and Frenken (2013, 2016) they address the advantage late-movers enjoy in technology industries where new functionalities are discovered over time, a process known as exaptation. The more exaptation events take place after market introduction and the higher the complexity of the technology the more likely it will be that late movers take over the leadership of first-movers. When more interdependencies between underlying components are present in a technology, a key lesson to hold is that first-movers face more difficulties to provide new functionalities. Although this contradicts the takeaways from papers above (the paper from Usero and Fernández (2009)) about whether pioneers or followers' benefit, it explains symmetry between a second/late-mover advantage and first-mover disadvantage. The higher the complexity of a product the less likely the first-mover advantage can be sustained overall which will eventually turn into a late-entrant advantage. Evolving user needs and the incumbent inertia of a pioneer firm contradict.

Gómez et al. (2013) describe that the balance goes in favour of evidence that supports the benefits of the order of entry. This does not mean initial success does automatically influence the achievement of permanent competitive advantage. After reviewing multiple papers, they conclude that for industrial consumer goods in mature industries, a negative relationship between order of market entry and market share exists. For frequently-purchased consumer goods in mature industries, the relative market share of entrants after the first-mover equals one divided by the square root of order entry. Lastly, in mature industrial and consumer goods markets early entrants see advantage in market share declining over time. This however does not directly result in a symmetry between first-mover advantages, disadvantages or second/late-mover (dis)advantages. This is more in line with earlier discussed papers' views on first-mover advantages (M.B. Lieberman & Montgomery, 1988, 1998; Cho et al, 1998; Usero and Fernández, 2009).

Suarez et al. (2014) describe the lack of a theoretical framework capable of discriminating between different cohorts of entrants. The lack of definition discussed more often (M.B. Lieberman and Montgomery, 1988, 1998, 2013) is important if symmetry between concepts must be seen. Suarez et al. (2014) introduce the dominant category to head into the direction of solving this issue.

From a behavioural perspective market share of pioneers is eroded when it becomes a compromise alternative (Montaguti & Zammit, 2017). A pioneer product can become an intermediate or an extreme, the latter being more favourable (Montaguti & Zammit, 2017). So, a pioneer firm should also be looking at the position their product ends up after competitors enter the market. Apart from that, it is described that late-entrants enjoy a cost advantage related to the stage of life cycle, can differentiate by positioning themselves as superior and have a greater chance surpassing the first entrant when opting for differentiating along alignable rather than non-alignable attributes. Montaguti & Zammit (2017) explain the late entrant-advantages which can be flipped to first-mover disadvantages.

Lastly, the paper 'First-mover advantages and innovation success: a contingency approach' from Chavez and Chen (2021) is used to gather first-mover literature. They argue that large firms' greater resources available to market and development increase the likelihood of innovation success, thus being a first-mover advantage. The first-mover advantages high market orientation increases the likelihood of innovation, higher brand equity reduces customers' perceived risk in accepting innovation, entry barriers having an inverted-U-shaped relationship with the likelihood of success, high market competitiveness protects existing innovation and increases the likelihood of success of incumbent firms and market maturity has an inverted-U-shaped relationship with the likelihood of innovation success are addressed for firms not specifically being large (large firms can also benefit from these advantages). They also explain the first-mover disadvantages of larger firms having greater internal resistance and the more aggressive push against marketing of innovation that decreases the likelihood of innovation success. The

not large firm centred first-mover disadvantages they describe are high replacement costs and simpler quality measurement increasing the innovation success of later entrants (so which are late-entrant advantages). Lastly, late entrant disadvantages high market competitiveness requires more resources, higher product contingency increases switching costs and higher search costs reduce the likelihood of an innovation's success from late-entrants are mentioned. Interesting to see is that in this paper they do not explicitly mention that a first-mover advantage is a disadvantage for late-entrants vice-versa, denying the symmetry. This contradicts with the findings from Cho et al. (1998) where this is done.

Paper	Assumption is made
Lieberman & Montgomery, 1988	Partly
Lieberman & Montgomery, 2013	No
Lieberman & Montgomery, 2016	No
Tellis and Golder, 1996	Yes
Cho et al., 1998	Yes
Usero and Fernández, 2009	Yes
He et al., 2013	No
Querbes-Revier and Frenken, 2013 & 2016	Yes
Gómez et al., 2013	No
Suarez et al., 2014	No
Montaguti & Zammit, 2017	Yes
Chavez and Chen, 2021	No

Table 8: Assumptions on symmetry between first-mover advantages and second/late-mover disadvantages.

At first one can see that no paper dives directly into the relationship between first-mover advantages and second/late-mover disadvantages or first-mover disadvantages and second/late-mover advantages. Table 8 presents an overview of if papers (implicitly) assume this relation. Some papers describe a certain advantage for a first-mover and afterwards explain if and how this is a disadvantage for a second- or late-mover, papers describe a similar advantage but in a different context, so an advantage turns out to be a disadvantage in that case, and others implicitly assume the relationship between first-mover advantages and second/late-mover disadvantages. Inevitably, order is important when one looks at first-mover advantages literature, however the dynamic characteristic of the concept is somewhat neglected between first-mover advantages and second-/late-mover disadvantages. The full list of advantages is assumed to flip from advantage to disadvantage at one point in time or between two companies entering a market. This is a risky simplification which partly causes why researchers have difficulties agreeing and cases differ. When this assumption is reconsidered some advantages turn quickly into disadvantages, but others take time. For example, for customer needs, after the introduction of a product the needs do not become substantially clearer immediately. This process takes time, and, in most cases, followers will not benefit from more knowledge on customer needs for quite some time. However, the pre-emption of scarce geographically locations could immediately become follower disadvantages. If specific locations are favourable, and the particular location is occupied by an early entrant this poses an immediate disadvantage for a follower.

So, to see if first-mover advantages are symmetrical with second-mover disadvantages a literature review has been performed. The implied symmetry that is discussed is shown in table 9.

First-mover advantage	**Second-mover disadvantage**
Reputation as technology leader	(First-moving gaining a) reputation as technology leader
Shape customer expectations	(First-mover) shapes customer expectations
Learning curve	(First-mover experiencing a) learning curve
R&D and patents	(First-mover having) R&D and patents
Pre-emption of input factors, geographic and product characteristic space and plant and equipment	(First-mover) Pre-empting input factors, geographic and product characteristic space and plant and equipment
Switching costs	Switching costs (of customers)

Buyer choice uncertainty / brand loyalty	Buyer choice uncertainty / (first-mover enjoying) brand loyalty
First-mover disadvantage	**Second-mover advantage**
R&D expenses	Development of R&D
Infrastructure development	More developed infrastructure
Educating buyers	Buyers being more educated
Immature enabling technologies and complements	Less immature enabling technologies and complements
Market and technology resolution expenses	More market and technology resolution
Shifts in technology or customer needs	Seeing shifts in technology or customer needs
Cannibalisation of own product line	-
Lock-in on a specific set of fixed assets, knowledge, or other resources	-
Organisational inflexibility	-

Table 9: Symmetry between first-mover advantages and second-mover disadvantages, and first-mover disadvantages and second-mover advantages.

No paper dives directly into this relationship but some assume it implicitly. It is found that the dynamic nature of first-mover advantages and follower disadvantages is often neglected. Some advantages for first-movers are immediate second-/late-mover disadvantages but others take time or development of certain aspects. For this reason, the conclusion that first-mover advantages are second-/late-mover disadvantages are too simplistic. The complexity of these concepts requires more depth than this simplification allows, which makes it that the conclusion of a first-mover advantage being a second-mover disadvantage cannot be drawn.

Symmetry between advantages and disadvantages

Apart from symmetry between a first-mover advantage and a second-mover disadvantage, and a first-mover disadvantage and a second-mover advantage, there could also be symmetry between a first-mover advantage and a first-mover disadvantage. There could be no symmetry, symmetry as in positive for one side is negative for the other, or symmetry as described by Herzberg's motivation-hygiene theory. In his book The Motivation to Work, Frederick Herzberg (1959) describes that there are certain factors in the workplace that cause job satisfaction and other certain factors (a separate set of factors) that cause dissatisfaction. It is worth looking at if this is also the case for first-mover advantages and disadvantages.

Because of the easy confusion with the symmetry in the last paragraph, the two different advantages and disadvantages that are being compared with each other are made visible in figure 6.

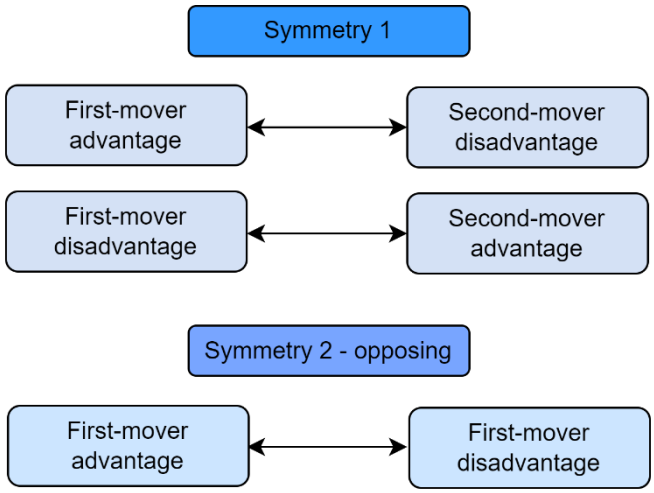

Figure 6: Different advantages being compared for symmetries between first-mover advantages and disadvantages.

The list of first-mover advantages and disadvantages presented earlier displays a couple of interesting advantages and disadvantages when looking into symmetry two. Five symmetries can be spotted from this list. The ones that stand out are shown in table 10 presented below.

First-mover advantage	**First-mover disadvantage**
R&D and patents	R&D expenses
Shape customer expectations	Educating buyers
Pre-emption of input factors, geographic and product characteristic space and plant and equipment	Lock-in on a specific set of fixed assets, knowledge or other resources and organisational inflexibility
Switching costs	Cannibalisation of own product line
Reputation as a technology leader and learning curve	Market resolution expenses

Table 10: Symmetry between first-mover advantage and first-mover disadvantages (symmetry 2).

In the table, advantages gained by pioneering are also listed as costs that pioneers need to bear. This indicates symmetry as a positive for one side and a negative for the other side. There is no indication that Herzberg's motivation-hygiene theory plays a role but an indication of symmetry between first-mover advantages and first-mover disadvantages is there.

Conclusion first-mover advantage literature

The first part of the literature research delivers a clear list of first-mover advantages and disadvantages which can be used as a starting point to bring the discussion further. The dialogue of the deaf mentioned in the first chapter of this thesis seems to not be entirely resolved yet, although a Babylonian confusion of tongues can be bypassed. Explaining your standpoint in favour or against of entering first or second is a lot easier when the advantages and disadvantages are in front of you. The still to be resolved disagreement revolves around the ambiguities on the definition of a first-mover advantage. When is something first, second, or late and when is something an advantage only belonging to that specific order of entry? How to take into account the context and varying industry and technology characteristics? To help answer these questions the next part of the literature research dives into pattern of development and diffusion literature. The pattern of development and diffusion is a zoomed-out perspective on the development and diffusion of a product category. It provides the added value on context (f)actors and shows differences in technology developments.

3.3 The pattern of development and diffusion literature

The development and diffusion of high-tech product categories has been the interest of many people for decades. How this process evolves is interesting from a scientific point of view as well as from a managerial perspective and over time has inspired scientists from multiple disciplines (Ortt, 2009). In his diffusion research, Rogers (2005) notices a lack of attention to the pre-diffusion period. This implies that large-scale diffusion starts directly after market introduction. Along with the well-known S-shaped diffusion curve shown in figure 7 it indicates that a diffusion process is fairly predictable. However, Ortt & Schoormans (2004) show that in practice the diffusion curve invariably starts several years after the first attempt to introduce a version of a product category in the market. This phase before mainstream market diffusion is included in the pattern of development and diffusion and will clarify that prediction of a diffusion process of a technology is quite complex.

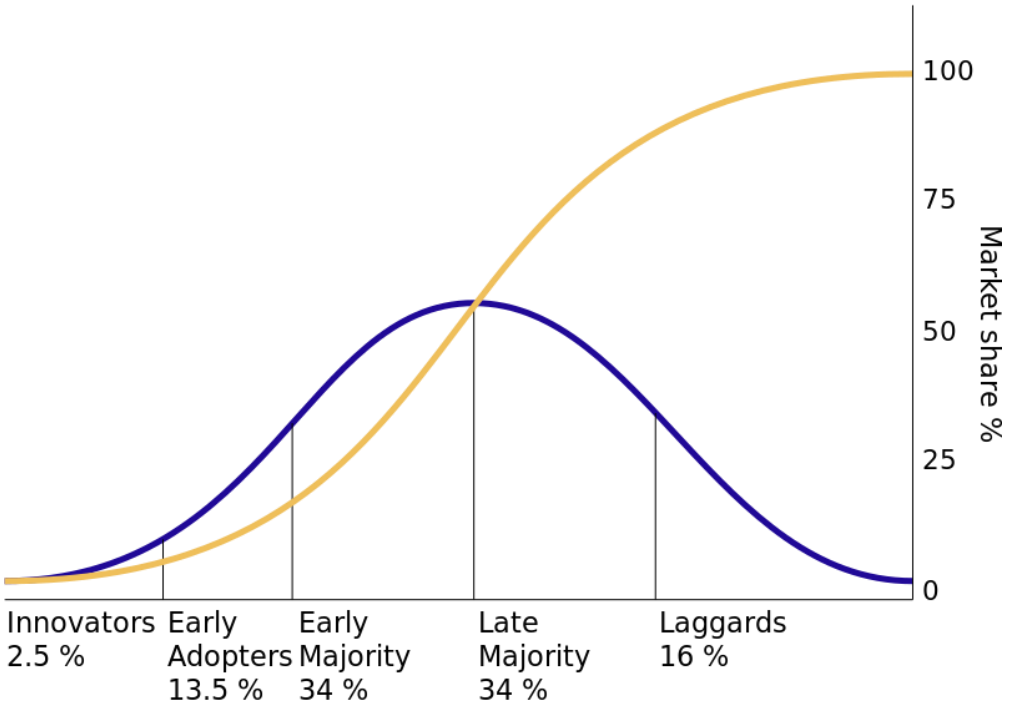

Figure 7: Diffusion of innovations (Rogers, 1962).

Earlier work on patterns of technological innovation and diffusion

The variety of scientific disciplines that studied technological innovation and diffusion have distinguished many distinct types of patterns (Ortt, 2010). Everett Rogers is one of the founding fathers of diffusion theory and distinguishes patterns by describing subsequent adopters of an innovation. With his explanation he primarily goes into depth on diffusion and not so much on development and looks at it from a customer side (demand) instead of producer (supply) or market perspective. An important assumption which needs to be considered is that innovation happens before the diffusion starts, which means that the product does not change after introduction. This perspective is used because a famous example of a diffusion process Rogers uses entails hybrid corn. In this case, the main factors to explain actual diffusion were the customers of farmers which were the demand side of the market. The case set the standards of working for researchers investigating other cases (Rogers, 2005).

A pattern that focuses on distinguishing subsequent types of innovations that emerge in each industry was introduced by Utterback & Abernathy (1975; 1978). In a new industry the focus is mainly on product innovation, but as the industry matures the focus shifts towards process innovation. This often happens when a dominant design, a design that consists of a configuration of components that represents the standard in the market for an extended period because it meets the requirements and needs of a wide range of users (Abernathy and Utterback, 1978), has appeared, after which the production and distribution system changes to enable more diffusion. In contrast with Rogers, here the supply side of the market is the main focus for Abernathy and Utterback, as well as the innovation process instead of the diffusion process. Later Tushman and Rosenkopf (1992) go deeper in on this idea and link it to a technology cycle. This cycle starts with a technological discontinuity caused by scientific progress or an innovative

combination of prior known technologies, followed by a phase of competition, substitution, and technical change. Then a dominant design emerges, after which a period of incremental change takes place where the established dominant design keeps its form.

Similarly, to the technology cycle and dominant design perspective, which involves small innovations that lead to one final significant innovation entering the market, the pattern of development describes a systematic pattern. The pattern of development and diffusion is a systematic pattern where various niche products exist during a pre-diffusion phase (Ortt, 2010) which eventually results in a major product entering the mass market. The pattern helps in deciding a niche strategy based on the technology innovation system and provides learnings about the environment in which new innovations exist before the start of large-scale diffusion.

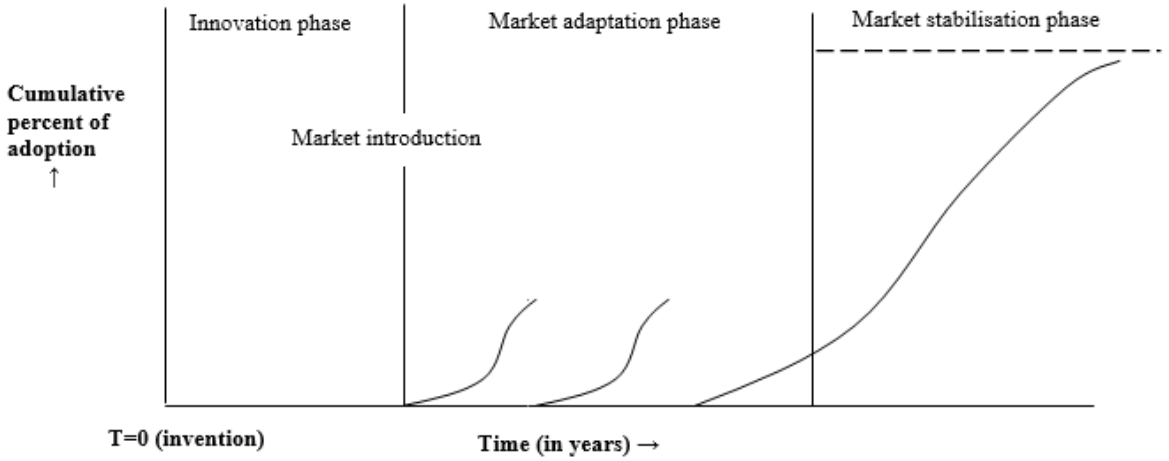

Figure 8: The pattern of development and diffusion (Ortt et al., 2007).

Milestones of the pattern of development and diffusion

Within the pattern of development and diffusion one can distinguish three milestones and three phases. In figure 8 the pattern of development and diffusion can be seen, and the three vertical lines are the three milestones. The first milestone is the invention of a technological principal, the second milestone is the first market introduction, and the last milestone is the start of large-scale diffusion. The first phase is described as the innovation phase, which is followed by the market adaptation phase, and the last phase is the market stabilisation phase. The time between invention and large-scale diffusion is also referred to as the pre-diffusion phase. Below a description will be provided of the different milestones.

Milestone 1: Invention

The first milestone of the pattern of development and diffusion is called the invention. Invention is considered to be the first demonstration of the working principle of a new high-tech product category. At first sight, a new material could be considered as an invention, however, discovery does not mean that the technology is understood and can be reproduced. In the case of aspirin, the discovery happened much earlier than the invention of the process to produce this medicine. Similarly, the material aluminium was discovered in nature long before mankind started to master its process of production. The proficiency in its process of production is the invention (Ortt, 2010). It is important to define invention clearly so the start of the pattern of development and diffusion for that technology is clear. The definition of invention is "*the invention of a new high-tech product category is defined to be the first time that the technical principle of this category is demonstrated and mastered (Ortt, 2010)".*

Within this definition technical principle can still be interpreted in numerous ways. The technical principle can be defined in terms of the physical or chemical processes on which the product category is based and in terms of the functionality that is enabled by the product category (Ortt, 2010). When we look at a VCR's technological principle, we see magnetised particles on a tape which enable the functionality to store video data. Also, several attributes are to be considered to define the new high-tech product category.

Ortt (2010) uses mobile telephony as an example to illustrate the relevance of distinguishing basic product attributes in addition to the technical principle and functionality. A mobile telephone can be defined as a new high-tech product category that requires at least two stations with senders and receivers (attributes) to enable communication (functionality) via radio contact (technical principle). When one considers this the invention of mobile telephony dates to the late 19th century being the work of Marconi and his predecessors. If you look at it as

mobile telephony providing the ability to communicate (functionality) via radio contact (technical principle) with a sender, receiver and switching station to connect them (attributes), the invention could be dated to 1947. That time the Bell labs devised the first switched mobile telecommunication system which often is considered the invention of mobile telephony. This example shows that careful definition is important and when definitions change, the date of the milestone invention may also change.

Milestone 2: Introduction

The second milestone, introduction, has to do with multiple subsequent activities. A product needs to be developed and might be produced on a small scale for testing and pilots. It could be produced for actual use and put in stock, after which it will be sold or transferred over to the users. This could be via selling, but this is not the only possibility (a government institute could develop a new weapon that is used by the military). Eventually the product is used in practice or implemented in the daily practice of users. The definition of the introduction date is *"the introduction date is the date at which the product is available for sales or can be transferred to users (Ortt, 2010)".*

Sometimes it can be hard to distinguish when the introduction happens, especially in the case of military use. In some cases, information about the first pilots or the start of production is publicly known, for other cases information about the first application in practice or first sales is at hand, and there are also cases where this information is kept secret on purpose. The introduction date may change because of information becoming available later in time. This could influence the view on the rate of the development of innovation. When looking back sometimes it looks quite obvious when the introduction happened, but this milestone is strongly susceptible to hindsight bias.

Milestone 3: Large-scale diffusion

The last milestone of the pattern of development and diffusion is called large-scale diffusion. This milestone separates the pre-diffusion phases from the diffusion process which is represented by the well-known S-shaped diffusion curve. Dating this milestone can be difficult because the start of large-scale diffusion and the start of another niche product are remarkably similar. A small-scale attempt to introduce the first products from a high-tech product category could represent the start of the diffusion process or it could be just another niche product. Because of this it is again important to have a clear definition. The definition of this milestone consists of three elements. The three elements are:

- A standard product that can be reproduced multiple times (or standard product modules that can be combined in many ways but are based on the same standard platform).
- A (large-scale) production unit with dedicated production lines (industrial production of a standard product); and
- Diffusion of the product (Ortt, 2010).

The three elements of the definition are all essential to distinguish large-scale diffusion from an earlier introduction of a niche. The existence of a standard product or product modules that is reproduced multiple times is required to set apart experimental batches or made-to-order products from a standard product. A production unit with dedicated production lines is the second element of the definition. As can be seen with the Model T Ford, a standard product in combination with industrial large-scale production is needed to acquire large-scale diffusion. However, a standard product and industrial large-scale production alone will not guarantee large-scale diffusion. The product must sell as well, which is covered in the third element of the definition. The point-contact transistor made of germanium was built by Raytheon in the late 1940s and fulfilled the first two elements: a dedicated production facility and a standard product. Yet, the product did not sell so large-scale diffusion did not start. Only when a better type of transistor, the junction or sandwich transistor, was invented, large-scale production would start (Ortt, 2010).

The phases of the pattern of development and diffusion

The three different milestones of the pattern of development and diffusion distinguish three separate phases: the innovation phase, adaptation phase, and the stabilisation phase. Because of the many times these phases will be mentioned in this thesis an extra description is given.

The innovation phase

The innovation phase runs from the invention to an initial introduction of products based on the technology. The invention is the demonstration of a working principle that often is not yet ready to be manufactured and marketed. In the innovation phase, research takes place to improve the principle and there are often one or more development trajectories designed to make a product based on the principle, which can be sold and applied.

The adaptation phase

The adaptation phase runs from the first introduction to the start of industrial production and large-scale diffusion of products based on the technology. This phase often involves a trial-and-error process in which different product versions are introduced in various market niches. The product, the customer group and application need to be adapted to each other. Adaptation can lead to a standard product. Innovation of products, (production) processes and research into improvement of the technology keep going on as before, during this phase.

The stabilisation phase

The stabilisation phase begins with industrial production and large-scale diffusion. It starts with a standard product that can be manufactured on a large scale and that is applied and sold on a large scale. The product versions and applications have stabilised at this point. Often, the innovation of products, processes, and research to improve the underlying technology will keep going as before.

Different scenarios for the pattern

The pattern is a generic model with a considerable uncertainty in pattern reflected in scenarios, in the fact that the pattern can stop at any moment, the number of iterations, and the length of the phases. The average length of the innovation phase is about 10 years, and a similar length is established for the adaptation phase (Ortt, 2010). It is also possible for a phase to be skipped. There are technologies where both the development and adaptation phase took only a year (for instance in the case of dynamite) and there are technologies where those phases take a century (for instance in the case of the fax). The pattern can stop or be interrupted at every stage. The pattern provides the basis for several scenarios that can occur in practice. Below three scenarios are discussed and in figure 9 the different scenarios can be seen.

- Scenario one is a situation in which the innovation phase takes a considerable time. This means that it takes a long time before a product based on an innovative technology is introduced in the market. This, for example, happened in the case of Aspirin where the innovation phase took 44 years and the adaptation phase only three years.
- Scenario two is a situation in which a product is introduced shortly after the invention but takes a long time until large-scale diffusion starts. Magnetic recording is an example of this pattern because the innovation phase took five years, and the adaptation phase took thirty.
- Scenario three is a case where the innovation phase and adaptation phase are almost skipped entirely. After invention, the new high-tech product almost immediately enters the stabilisation phase. This scenario happened with dynamite, the innovation phase took one year and the adaptation phase not even one (Ortt, 2010).

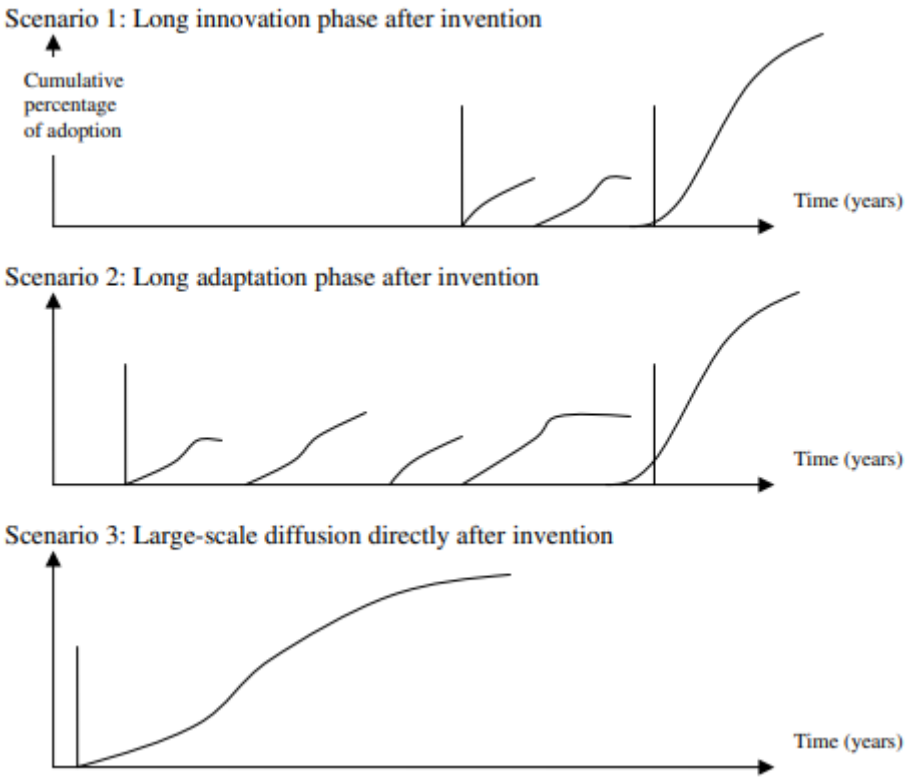

Figure 9: Different scenarios for the pattern of development and diffusion (Ortt, 2010).

Factors of the pattern of development and diffusion

The parts of the pattern of development and diffusion that is described until now provides a description of the process of development and diffusion but does not yet provide an explanation why the pattern occurs in a specific shape. Indicators why the first two phases take more or less time are described as factors. These factors are general and are assumed to be needed for large-scale diffusion of technological breakthroughs. When those factors are in place, they can stimulate development and diffusion, when they are absent or incomplete, they can be a barrier. The total number of factors is fourteen but is split into two categories of seven: core factors and influencing factors. The first seven core factors make up the social, economic, and technological system and the last factors affect the core factors or provide an explanation for the impediment on those core factors. The factors are an expansion of the factors that Rogers uses to explain diffusion in his innovation-diffusion model. Table 11 describes the seven core factors that need to be in place, to enable large-scale diffusion.

Core factors	Description
1 Product performance and quality	A product (with all subsystems including hardware and software components) is required with sufficiently reliable performance and quality (absolutely or compared to other competitive products). Lacking performance or quality can hamper large-scale diffusion.
2 Product price	A product (with all subsystems) is required with a reasonable price (absolutely or compared to other competitive products). The price of a product involves financial and non-financial (e.g., time and effort) investments to acquire and use the product. A prohibitively high price can hamper large-scale diffusion.

3 Production system	A production system that can produce large quantities of products with sufficiently reliable performance and quality (absolutely or compared to competitive products), is required for large-scale diffusion. A lack of production system can hamper large-scale diffusion.
4 Complementary products and services	Complementary products and services for the development, production, distribution, adoption, use, repair, maintenance, and disposal of an innovation are required. Unavailable, incompatible, or too expensive complementary products and services can hamper large-scale diffusion.
5 Network formation and coordination	Required actors and sufficient coordination of their activities to develop, produce, distribute, repair, maintain and dispose of products are required for large-scale diffusion. Coordination can be emergent and implicit (e.g., the market mechanism) or can be formal and explicit (e.g., an industry association). Coordination can involve actual collaboration and a shared vision regarding the innovation and the TIS around it. If types of actors and coordination amongst these actors are needed yet missing, large-scale diffusion can be hampered.
6 Customers	Customer segments are required for large-scale diffusion. Potential customers with a need for the innovation should be identified. To become actual customers, they should be aware of the product, see its benefits relative to other innovations, and have the knowledge, means and willingness to acquire and use it. If actual customers are lacking, large-scale diffusion can be hampered.
7 Innovation-specific institutions	These institutions refer to formal policies, laws and regulations either describing norms and requirements regarding the product, production facilities, and complementary products and services or describing how actors (on the supply and demand side of the market) should deal with the product and system around it. Specific institutions can stimulate or hamper large-scale diffusion.

Table 11: Core factors of the pattern of development and diffusion (Ortt et al., 2013; Ortt & Kamp, 2022).

The core factors make up a complete system surrounding innovative technology. If one or more of those factors are absent or incomplete, or if there is insufficient coordination between the factors, that will impede large-scale diffusion.

The influencing factors can explain why one or more of the core factors are incomplete, absent or do not fit. The influencing factors can explain impediments in the core factors and show changes in those core factors (see Table 12). A single influencing factor can influence multiple core factors. Which influencing factor influences which core factor can vary over multiple cases.

Influencing factors	**Description**
8 Knowledge and awareness of technology	This involves both fundamental and applied technological knowledge. Fundamental knowledge refers to the technological principles involved in components of the TIS, like the product, production and complementary products and services. Applied technological knowledge refers to the knowledge required to develop, produce, repair, maintain, and improve these components. When relevant actors lack knowledge and awareness of technology for their role, this can affect the formation of several TIS building blocks.

9 Knowledge and awareness of application and market	This refers to knowledge of (1) potential applications, (2) knowledge of the market (structure) and the actors involved in these applications. This knowledge is required for all actors including customers to formulate strategies, articulate product requirements and find or target other actors. When actors lack such knowledge required for their role, this can affect the formation of several TIS building blocks.
10 Natural, human, and financial resources	Resources can refer to natural, human, and financial resources. Natural resources refer to raw materials that can be acquired by each organisation separately or by associations of organisations. Human resources refer to individuals with the right knowledge and competences. Increasing human resources may involve education programs, courses, and training on the job. Financial resources can come from various sources. Lack of natural, human, or financial resources can affect the formation of TIS building blocks.
11 Competition	Competition can refer to competition between products based on old and new technologies but may also refer to competition between different product versions with a new technology. Since different product versions often require different production systems and complementary products and services, competition arises between networks of companies. The combined complex patterns of competition may hamper the formation of TIS building blocks.
12 Macro-economic and strategic aspects	Macro-economic aspects refer to the overriding economic situation, such as a recession or economic growth. Strategic aspects refer to interests of countries which are often reflected in generic institutions and government policies. Macro-economic and strategic aspects can influence the formation of TIS building blocks.
13 Socio-cultural aspects	Socio-cultural aspects refer to the norms and values in a particular culture or socio-technical system. These conditions might be less formalised than the laws and rules in the innovation-specific institutions. They include methods and habits, norms, and values ("the way to do things") and may become visible in interest groups or relevant stakeholder groups. Socio-cultural aspects can influence the formation of different TIS building blocks.
14 Accidents and events	Accidents and events may emerge both outside a TIS (e.g., wars, political turmoil, or natural disasters) or from within a TIS (e.g., accidents with products or in production, emergence of new technologies). Accidents and events can influence the formation of several TIS building blocks.

Table 12: Influencing factors of the pattern of development and diffusion (Ortt et al., 2013; Ortt & Kamp, 2022).

To show that the combination of core factors and influencing factors is important, an example can best be used. If the production system would have been missing with the Model T Ford, the cars could not have been sold to many people and if the price would not have been good, few people would be able to afford them. For a production system to be set up, knowledge of technology is needed. Also, in the case of the Model T Ford, there was a sociocultural aspect. Before the Model T was introduced, in big cities like New York and London the power of the main ways of transportation was facilitated by horses. In 1984 the Times of London predicted that within 50 years every street in London would be buried under nine feet of manure (Johnson, 2017). This was named the great manure crisis of 1984. This crisis opened the perfect window of opportunity for the Model T.

The pattern of development and diffusion in practice

The explanation of milestones, phases and factors does not yet show how the pattern of development can be used. The lifecycle of an imaginary product category will be illustrated with a filled-in dashboard of the factors. In

figure 10, one can see the pattern of development and diffusion in an early stage. Above the diffusion curve a traffic light table is shown. This indicates the maturity of the earlier mentioned factors. Many factors are not or not fully developed (indicated by red and orange respectively) so large-scale diffusion is hindered.

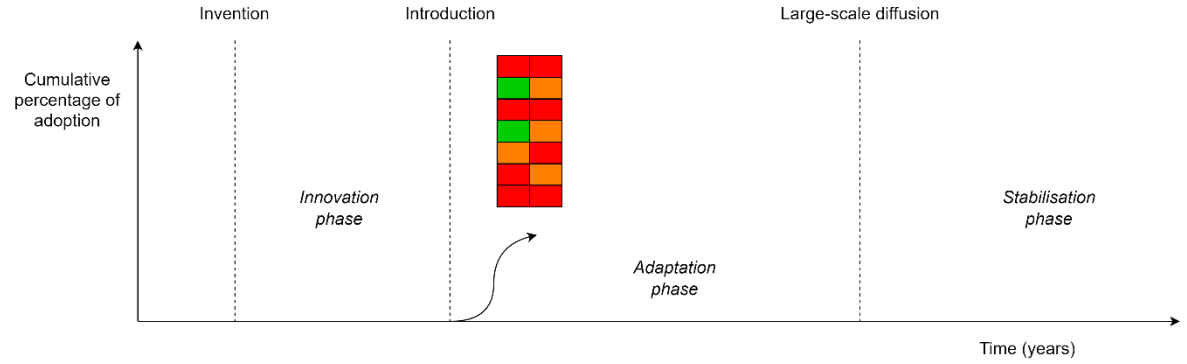

Figure 10: Pattern of development and diffusion with filled-in dashboard - 1

In table 13, it is clearer what is meant by the traffic light representation of the factors. Next to the table a qualitative interpretation of the maturity of the factors should be given. This elaborates on why a factor is mature or not and could provide additional information that is known.

Core factors		**Influencing factors**	
1 Product performance and quality		8 Knowledge and awareness of technology	
2 Product price		9 Knowledge and awareness of applications and market	
3 Production system		10 Natural, human, and financial resources	
4 Complementary products and services		11 Competition	
5 Network formation and coordination		12 Macro-economic and strategic aspects	
6 Customers		13 Socio-cultural aspects	
7 Innovation-specific institutions		14 Accidents and events	

Table 13: Filled-in pattern of development and diffusion dashboard.

In figure 11, a more mature product category is presented. Here more factors are green which indicates less factors hinder large-scale diffusion. This representation is more in line with how one would imagine the development of a product category would go.

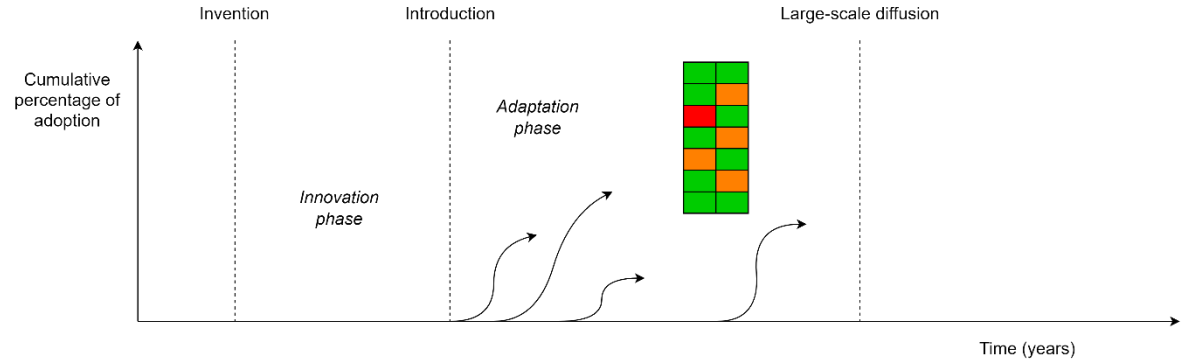

Figure 11: Pattern of development and diffusion with filled-in dashboard - 2

Figure 12 presents the pattern of development and diffusion for a different imaginary product category. Here most of the factors are already pretty mature after the first small diffusion curve. This example shows there is not a minimal necessary amount of product before large-scale diffusion is enabled and the pattern can take many forms.

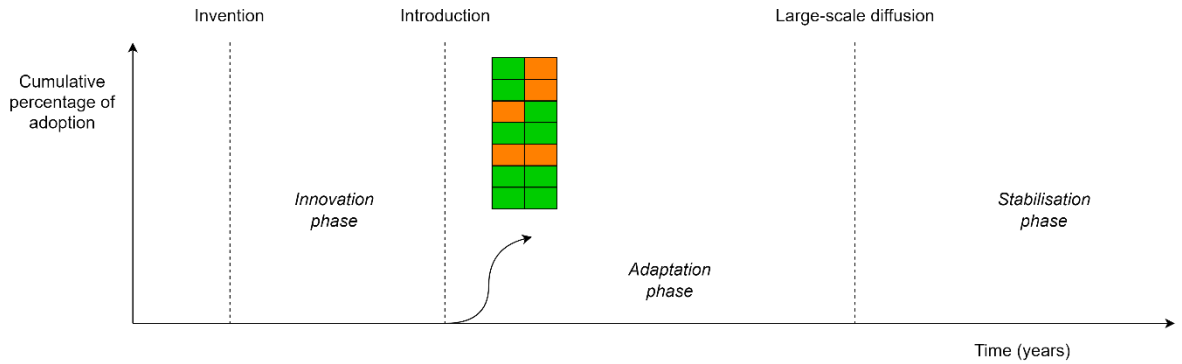

Figure 12: Pattern of development and diffusion with filled-in dashboard - 3

Limitations of the pattern of development and diffusion (a static model)

The pattern of development and diffusion is a static model that represents a situation which is a simplification of reality. This simplification of reality represents a Technology Innovation System (TIS) with the use of core (f)actors and influencing (f)actors. The pattern aims to study introduction strategies by companies for their radically new technological innovations at one particular moment in time during the adaptation phase (Ortt & Kamp, 2022). The static framework requires reconsideration over time to reveal changes in the TIS, thus being limited in understanding the mechanisms of evolution and change in a TIS (Ortt & Kamp, 2022). A dynamic model of an innovation could help investigate dynamics because (dis)advantages shift in value or influence each other or relevant context changes. A static model seems to (partly) ignore complex interactions.

3.4 Combination of first-mover advantages & the pattern of development and diffusion

The combination of first-mover advantages and the pattern of development and diffusion helps to clarify the ambiguities stated earlier in this thesis. At first, the definition of a first-mover will be discussed. Multiple perspectives on a first-mover are possible and one is not particularly better than the other, but it is important to distinguish them.

Defining a first-mover using the pattern of development and diffusion

The literature on first-mover advantages is mostly based on the diffusion theory of Rogers and assumes that a first-mover enters the market just before large-scale diffusion starts. The development of innovation is seen as a project in which different steps are not particularly defined. This results in thinking that everybody always talks about the same entry time while in reality this is not the case. Lieberman & Montgomery (1991), in their paper "To Pioneer Or Follow? Strategy Of Entry Order" already provides some information on possible differences. They say a firm can be a first mover based on being the first firm to (1) produce a new product, (2) use a new process, or (3) enter a new market. And this does not even take into account the specific entry point.

In figure 13 multiple perspectives on first-mover entry points are indicated with red circles. The fourth circle is the commonly used entry time when the diffusion theory of Rogers is taken as a basis. Below the different potential first-mover's entry times are discussed.

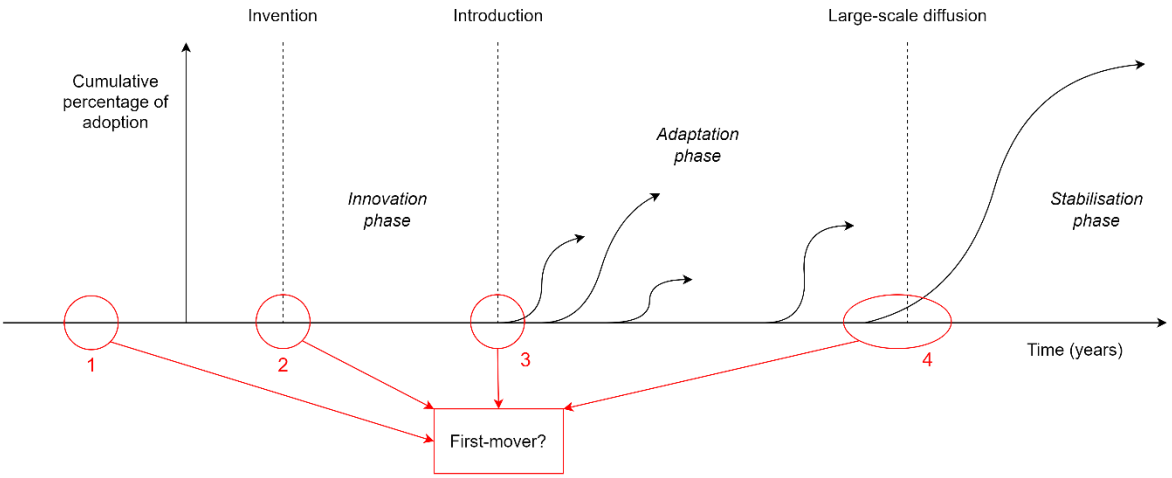

Figure 13: Different perspectives on a first-mover.

The first introduction which could be considered to be a first-mover is the most left circle. This is a period before an invention is invented. At first sight it may be strange to assume that this could be considered a first-mover, however when one wants to take into account the full cost of R&D and cost of managerial decision to try to invent new technological principles in an R&D department, this option seems more viable. For this entry point it becomes clear that also costs belonging to research paths that failed need to be taken into account. R&D costs become a lot more prominent in the consideration of moving first. The potential benefit of for example patenting a specific technological principle, pre-empting a resource, or gaining a reputation as technological leader should outweigh the most for this entry point. This goes hand in hand with no factors of the pattern of development and diffusion having any maturity. This entry point has a lot of risk and almost solemnly is either for research institutions or big companies that can bear the risk.

The second red circle represents a company entering first with announcing the invention of a new technological principle. This could be considered a first-mover because this is the first time a new technological principle is proven to be realistic. In this case a first-mover is the first company to prove a technological principle. It is possible that the technological principle is patented but this is not necessary. The technology could remain open for others to use, or it might be that the invention is made in secret. Looking at the weight of the first-mover (dis)advantages, FM (1) has the R&D costs of paths that do not work, and FM(2) does not have these. R&D costs of applications of the technological principle that were unsuccessful are still included. The factors of the pattern are also similar, but patents could be in place from this point onwards.

The third red circle is when a first-mover is the first to introduce the innovation into the market. Golder & Tellis (1993) in their paper on pioneer advantage describe a first-mover to be *"the first firm to sell in a new product category"* which clearly is the place of the third red circle in figure 13. From this point on the product category starts to develop and a new phase (adaptation phase) within the pattern of development and diffusion starts. From this point on the factors of the pattern of development and diffusion start to mature (slowly or quickly depending on the case). First-mover advantages shaping customer expectations, learning curve, pre-emption of resources, and switching costs, and the symmetric first-mover disadvantages start to play a role. Also, cannibalisation of own product line, lock-in on a specific asset, knowledge or other resource, and organisational inflexibility becomes a risk. We can also see that some first-mover advantages immediately turn into a disadvantage for followers (or vice versa) but others take more time. Switching costs between products of the same product category is an immediate disadvantage for followers but market and technology resolution expenses will not immediately be an advantage for followers. From this point on the competition will increase and factors of the pattern of development and diffusion combined with first-mover (dis)advantages will become more important for strategic decision making.

The fourth red circle indicates a first-mover to be at the start of large-scale diffusion, which is most likely to be assumed when Rogers' diffusion theory model is used. For the public this most of the time is seen as a first-mover because niche products often do not get big attention. This company with this introduction is often seen as "the company that made it possible." An example of this version of the first-mover is Tesla with their electric cars. Before Tesla there were other companies selling electric cars, but Tesla started the large-scale diffusion and now people seem to forget about earlier electric car producers. At this point in the pattern of development and diffusion the factors should in theory be almost fully mature to enable large-scale diffusion. The weights of first-mover (dis)advantages are probably quite different than for FM(3). For example, customer education should be mostly done but the reputation of a technological leader should be harder to grasp. However, Tesla is still observed as a

technological leader. In part for this reason, it is important to research the weights of first-mover (dis)advantages with experts. How exactly the weights are assigned and change over time could be valuable information for strategic decision making.

As can be seen, there are multiple moments in time within the pattern of development and diffusion which could be considered to be first-movers. The most important thing about the different times of entry is not that it is a problem researchers look differently at what the 'real' time of entry for a first-mover is, but that it is clear which one is chosen in that particular study. This way findings and conclusions from different studies can be compared better and knowledge is complementary to each other instead of contradicting and complicating. For example, Wang & Xie (2013) describe they find 589 first-movers within the newspaper industry in New Mexico and Wisconsin based on geography, market entry and exit and mergers of newspapers. Kirjavainen et al. (2020) look at the first-mover of the digital camera industry with the launch of Dycam Model 1, also known as Logitech Fotoman, in 1990 and the first digital single lens reflex camera, Kodak DCS-1, in 1991. In these two examples already, there are two first-movers mentioned.

Now this is clarified an explanation on the use of the pattern of development and diffusion in taking into account first-mover advantages is given to make clear why that is helpful. After that, it is shown what the result of first-mover advantages and disadvantages are on the development and diffusion of an innovation.

Argumentation of combination of literature streams

In the first-mover advantages literature exists a lot of ambiguity. The paragraphs above make clear that the entry time of a first-mover can vary a lot by interpreting the definition differently. This can result in a different outcome, one where first-mover advantages earn more profit, one where it is about even and one where first-mover disadvantages play the key role. What is chosen as the entry time of the first-mover has (as expected) a substantial influence on the outcome. To clarify which potential entry points can be considered to be a first-mover a wider view must be taken. The result of first-mover advantages on the development of an innovation is hard to see when two situations are compared to each other. While first-mover (dis)advantages play a role in the selection of an innovation, the pattern of development and diffusion displays how the innovation changed and how customers reacted towards it. Sometimes, if something is unclear, it is best to zoom out to see context and interpret the difference between situations that previously seemed the same. For example, with a broader view a better estimation can be made on how much of R&D expenses are already done according to the length of the innovation already being in a certain phase. For highly contextual situations it can be helpful to use visualisations, and this is hard to do on the level of analysis of first-mover advantages.

First-mover advantages within the pattern of development and diffusion

In figure 14, the pattern of development and diffusion can be seen. Multiple innovations comprise the complete framework and the figure shows a random innovation which made it to the stabilisation phase.

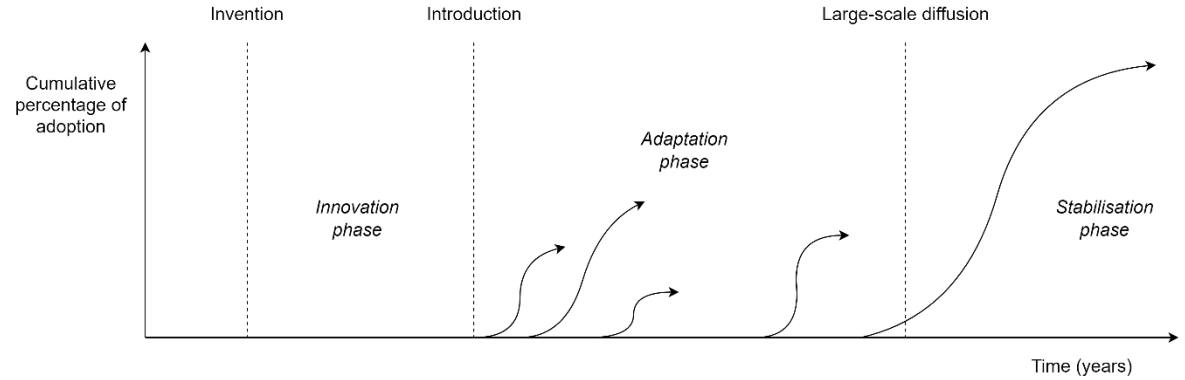

Figure 14: Pattern of development and diffusion of undefined innovation (Ortt, et al., 2007)

The pattern of development and diffusion describes how far a technology is developed and diffused and which factors enable and/or hinder large-scale diffusion (Ortt et al., 2004; 2022). A pattern consists of multiple projects combined and over time a pattern could be drawn. That does not imply that a small diffusion curve from figure 14 is one project. A small diffusion curve can be the result of two different companies selling different product

versions for the same product category. First-mover advantages influence one innovation within the pattern. The first-mover advantages result in progress in time which can be represented within the framework as seen in figure 15.

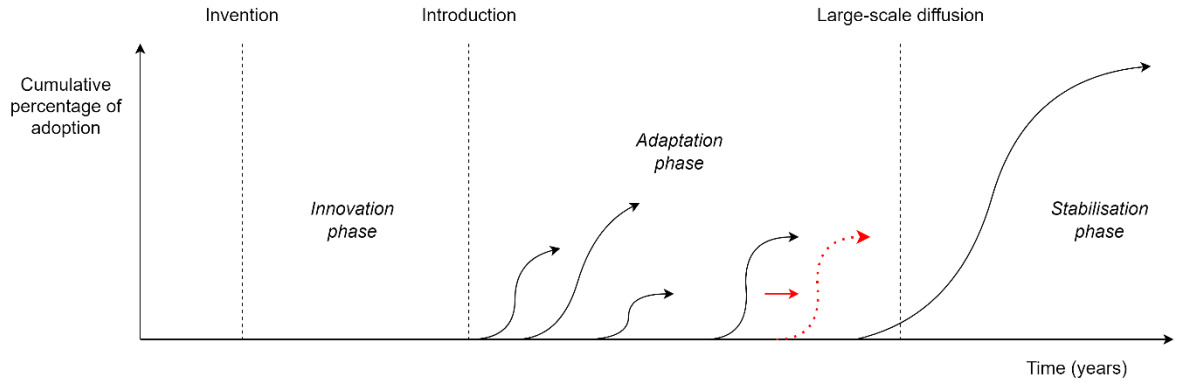

Figure 15: The result of first-mover advantages within the pattern of development and diffusion.

In the figure the first-mover advantages result in a progress in numerous factors of the pattern. Because of the introduction of a new version of the innovation, the status of the overall innovation category develops. The advantages of for example steering customer needs and learning curve progress the factors 6 Customers and 8 Knowledge of technology. The company sets itself a little bit further ahead in the pattern than where the pattern was before the introduction of the improvement on the innovation category. It creates slightly more developed factors for its own innovation. This could also result in the innovation becoming the product that enables large-scale diffusion, which can be seen in figure 16.

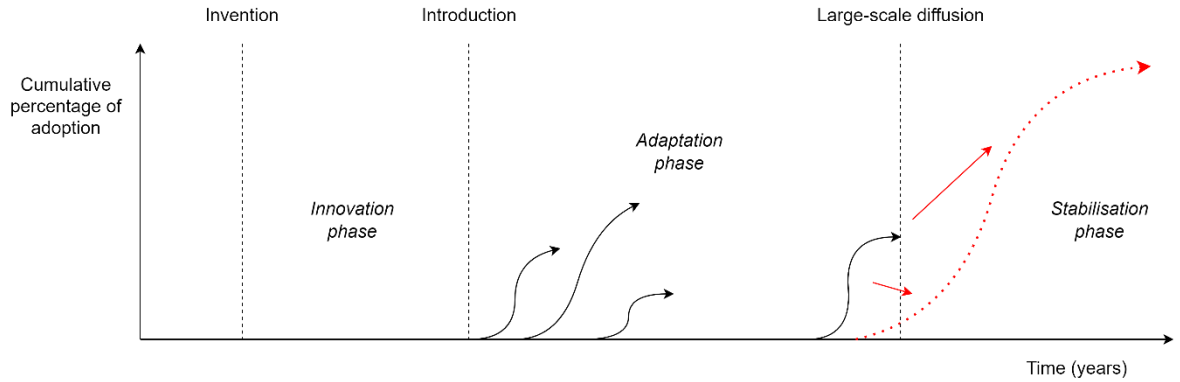

Figure 16: First-mover advantages resulting in large-scale diffusion.

So, first-mover advantages create a development of the factors for the company itself. The created development may be small so the translation to the right within the pattern may be also small but could make the difference in enabling large-scale diffusion.

A clear example of a technology where an advantage influenced the (f)actors of a product category is PV (photovoltaics) solar panels. The first-mover advantage learning curve, where unit production costs fall with cumulative output, significantly influenced the product price to the extent that large-scale diffusion was possible. This effect has been so big that nowadays the LCOE (levelized cost of electricity) of PV solar panels is lower than fossil fuels (IRENA, 2022)

Second-mover advantages within the pattern of development and diffusion

Just like first-mover advantages influence innovations within the pattern of development and diffusion, second/late-mover advantages also have an effect. The effect of second-mover advantages is illustrated in figure 17. It indicates progress in the overall status of the pattern. Companies introducing new iterations of the innovations each time brings more information for the factors of the pattern. The advantages of R&D expenses and further developed

customer needs are the result of other companies introducing their innovations before you which reveals information on the innovation category.

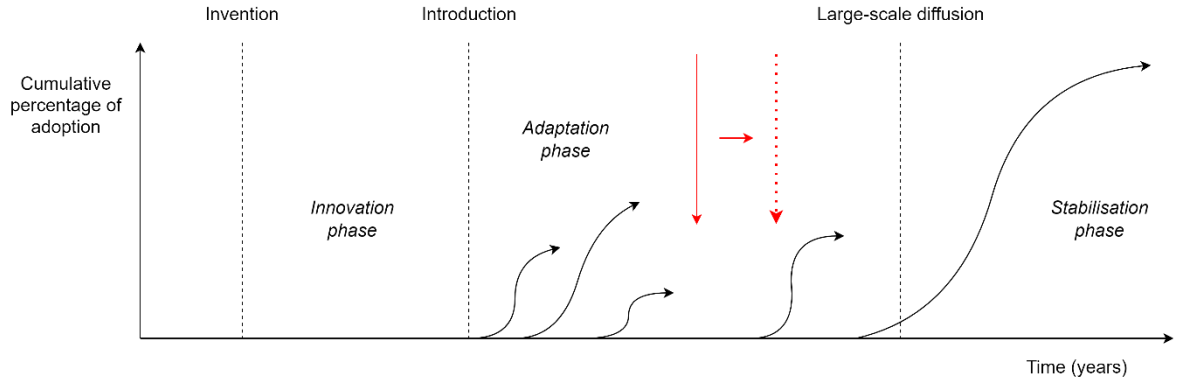

Figure 17: Second/late-mover advantages within the pattern of development and diffusion.

Second-mover advantages display a further status in time in the framework which had to be paid for by other companies introducing their innovations. As a company you enter later into the market, so more information is at your disposal. The longer you wait, the more information is exposed but keep in mind you never know when waiting time will cost you more than development costs.

Reconsidering an advantage using the pattern of development and diffusion

Being clear about which first-mover a researcher talks about is important when we talk about the advantages or disadvantages of a company experience. The definition by Lieberman & Montgomery (1988) of first-mover advantages is "the ability of pioneering firms to earn positive economic profits" relates to positive profits over another point of entry. So just the potential of earning profits is not enough of a requirement to be talking about first-mover advantages. The profits should be more positive than entering at another point in time. Sometimes waiting/delay cost may outweigh information spill over cost. It might be better to enter because waiting costs are higher than the cost of knowledge that the competitor gains (Rasmusen & Yoon, 2012). Is the advantage for the first-mover also an advantage for the second-mover? Then it is not a first-mover advantage, it is just an advantage. Also, the contingency perspective from Lieberman & Montgomery (2013) is adopted here: being first in market is only a necessary condition for the firm to enjoy first-mover advantages. Whether a pioneer can capitalise on and sustain competitive advantages depends on the fit between the organisational skills and resources of the firm, and the opportunities in the environment.

Entering a market

For the pattern of development and diffusion Ortt clearly defines a new product category. The definition from Ortt (2010) is *"[...]a new combination of a technological principle and a specific functionality (at the time of invention). In other words, in these categories, the technological principle is new, the functionality is new, or both are new."* It is fully new when a new functionality is provided that is not yet enabled by another technology. This definition clarifies when a new product category can be addressed and helps with distinguishing new product categories from existing product categories. This shows why consensus on the definition of a first-mover is important. This definition is needed to know when a mover could be considered first, second or late. Otherwise, difficulties in comparing and building knowledge arise. It also helps to draw perspective on certain first-mover advantages. For example, when we look at the first-mover advantage switching costs. A common view of researchers is that switching costs form a barrier to market entry that protects pioneers and provides them with a competitive advantage over followers. This assumes that people only experience switching costs when they change to a different follower product, rather than when they purchase a pioneering product instead of the product that they usually purchase. However, people who buy a pioneering product may also face switching costs, if the pioneering product is launched in an existing category where consumers are already familiar with equivalent products (Molina-Castillo et al., 2011). So, it is important to be clear about "new" markets when looking at first-mover advantages because otherwise valuable information on certain advantages and disadvantages may be overlooked.

As an example, one can look at the music industry where the compact disc (CD) market evolved while the LP market was still active. The CD was introduced in 1982 and had the ability to store much more data. However, many people were familiar with using LPs to listen to music from and most of them had invested heavily in multiple LPs to listen to their favourite artists. Even though the introduction of the CD in 1982 started a new product category, it cannot be directly concluded that customers of the CD did not experience switching costs. One might argue that the first introducer of CDs experienced more switching costs than followers. Here it becomes clear that the adaptation phase of one product category often overlaps with the stabilisation phase of another product category. Figure 18 shows CD's pattern of development and diffusion overlapping with LPs pattern of development and diffusion. In this figure it also becomes clearer why an adaptation phase can be so various in form. In most situations it is influenced by other older product categories.

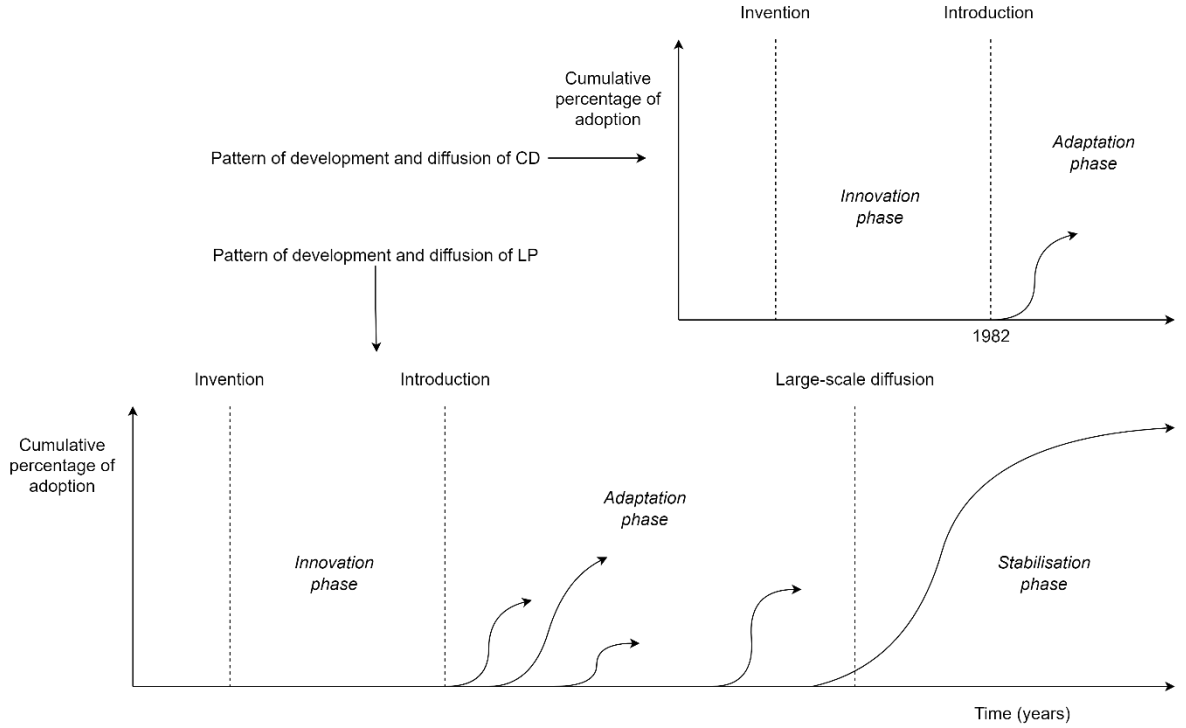

Figure 18: Overlapping patterns of development and diffusion of CD and LP.

3.5 Literature research conclusion

The literature research was performed to give an overview of the two literature streams that are combined within this thesis, and to help answer the first two sub questions. A list of first-mover advantages and disadvantages is provided in this chapter, and it is concluded that symmetry between first-mover advantages and second-mover disadvantages cannot be assumed but that there is symmetry between first-mover advantages and first-mover disadvantages. This can be helpful later in this thesis when the weights of aspects and changes of first-mover advantages over time come to the attention.

The usefulness of the combination between the first-mover advantages and the pattern of development and diffusion has been discussed. It shows what effect first-mover advantages have on the development and diffusion of a product category and it became clear how the definition of a first-mover can differ so much. The zoomed-out view illustrates which points of entry can be argued to be of a first-mover and how this influences the generalisability of various research. It also showed the ambiguities around having an advantage and entering a market. A first-mover advantage should solemnly be called a "first" -mover advantage when the advantage is gained by entering first and not be just an advantage. Unclarities about entering a market and the simplification of switching costs while switching between different product categories have been addressed.

A first shot to answer the first two sub questions has been done. The ambiguities regarding "what is a first-mover?" has been shown and a list of first-mover advantages and disadvantages has been provided. The remaining three sub questions will be answered by the chapters on the conceptual model, case study and interviews.

4. Conceptual model: entering a market

For the conceptual model, two forms will be used: a model and a flowchart. A model illustrates the relationship between the concepts, and the flowchart shows which steps need to be taken when the concepts are used to explore market entry. To use a cooking analogy, the flowchart is the recipe which includes the steps that need to be taken, and the model describes how all the ingredients complement each other in the dish.

4.1 The model

The model is used to illustrate relationships between parts of a certain situation. For this thesis, a model is used to describe what variables play a role when choosing to enter a market or not. The aim of this model is to show a comprehensive view of parts that could be taken into consideration, and to make clear that some research took into account other and/or more aspects in assessing first-mover advantages. Figure 19 presents the model that will be used in this thesis. The model is made from scratch, but inspiration and parts are influenced by the literature described in the literature review.

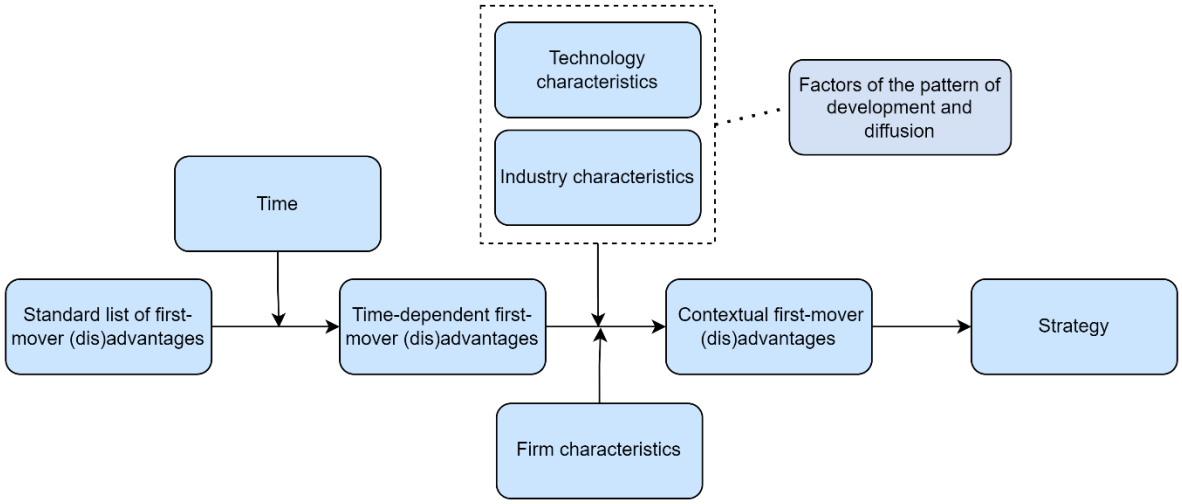

Figure 19: Model to take into account first-mover (dis)advantages in entering a market.

The model consists of eight building blocks: standard list of first-mover (dis)advantages, time, time-dependent first-mover (dis)advantages, industry characteristics, technology characteristics, firm characteristics, contextual first-mover (dis)advantages, and strategy. The building blocks describe the aspects that need to be taken into account when deciding whether to enter a market or not with the help of first-mover (dis)advantages. It only focuses on market entry and leaves other strategies out of consideration. A brief description of the building blocks is given below.

Standard list of first-mover (dis)advantages

The list from table 6 and 7 is taken as a starting point and weights can be applied according to the situation. Within this model the list of advantages and disadvantages is assumed to be a standard list in which different weights can be applied depending on the order and/or time of entry. This could be first but that is not necessarily needed. It should be noted that this building block consists of general information and is not specific for any organisation, individual or situation.

Time

The building block time in the model consists of three parts: the relative time when a company wants to enter (represented in hours, months, a date, etc.), the order (first, second, etc.), and the entry point with the accompanying phase (innovation, adaptation or stabilisation). Within this building block it becomes clear that the pattern of development is used as a normalised timeline. All three aspects can influence the weight of certain first-

mover (dis)advantages. For example, if the order is second but the time within the development is extremely near the first entrant, it is likely an insignificant change in customer needs will be known. However, if the order is second but there has been a significant amount of time between the first entrant and now, there is a higher chance of customer needs being more changed or developed. Similarly, if switching costs play a big role, the order might play a bigger role than expired time. The last aspect of time that is important is the place and phase within the pattern of development and diffusion. Within the innovation phase other first-mover (dis)advantages play a significant role than in the stabilisation phase. The assumption is that depending on the relative time, the order, and phase of the pattern, weights can be applied to the standard list of first-mover (dis)advantages. Later, values can be applied to the (dis)advantages to acquire a score (score = weights x value).

Time-dependent first-mover (dis)advantages

The building block time-dependent first-mover (dis)advantages entail the first-mover (dis)advantages that are at place at that moment. From the standard list that we started with, we now have a list where the time, order and place are progressed. This means that the weights of the first-mover (dis)advantages are now known. The (dis)advantages with weights close to zero are not present and others with big weights are very much present. The time-dependent first-mover (dis)advantages are the standard list of first-mover (dis)advantages enriched with weights that make clear which and how heavy certain (dis)advantages play a role at that moment. The first part of the equation *score = weights x value* is now acquired.

Industry characteristics & technology characteristics

The building block industry characteristics describe how the industry of the product category behaves. This includes economic activity, growth rate and available resources within that industry. The goal of this building block is to provide information on a wide scope. Technology characteristics provide information on the technology field of the product category within the industry. It follows a clear step-down approach from industry, to technology, to product category to produce relevant information. When the Industry and Technology characteristics have to be analysed, one soon experiences difficulties because of the wide variety of parts. To make this analysis easier to grasp and perform the factors of the pattern of development and diffusion are used. The seven core factors of the pattern of development and diffusion make up a complete system surrounding the innovative technology. The seven influencing factors give an indication of the dynamics of the system.

Firm characteristics

The building block firm characteristics consists of three main parts: resources, operational capabilities, and dynamic capabilities. Financial resources have been especially important in research done on first-mover advantages because good financial resources leave the opportunity to choose for early entry of a market when earnings are expected to take some time. A choice can be made to risk financial losses at the beginning to potentially gain brand loyalty or the status of a technological leader.

Operational capabilities entail the capabilities the company possesses now and uses to perform its standard practices. It includes organisational standards and routines, internal political dynamics, and relations with other organisations.

Dynamic capabilities are the firm's ability to integrate, build, and reconfigure internal and external resources/competences to address and shape rapidly changing business environments (Teece et al., 1997). Dynamic capabilities of a firm are (1) identification and assessment of an opportunity (sensing), (2) mobilisation of resources to address an opportunity and to capture value from doing so (seizing), and (3) continued renewal (transforming). These capabilities are required to sustain itself as markets and technologies change (Teece, 2010).

The three parts of firm characteristics combined give a good impression of the capabilities of the firm and how well it is fit to adapt to the environment. The Potential first-mover (dis)advantages and the Firm characteristics now can complement each other into contextual first-mover (dis)advantages.

Contextual first-mover (dis)advantages

The information of the industry and technology characteristics that can be described with the help of the factors of the pattern of development and diffusion, and the place in time, order and relative time one exists has been investigated. It is possible to produce the list of first-mover (dis)advantages at that moment in time. The first-mover

advantages and disadvantages assessed in combination with the firm characteristics help to make the decision to enter a market or not. An estimation of how the weights will change and how that relates to the industry characteristics, technology characteristics and firm characteristics poses the opportunity to evaluate the choice to enter the market or not. This way the first-mover advantages and disadvantages can be taken into account in a more holistic way. Adding weights to the (dis)advantages and showing how weights shift over time, allows the decision maker to not see the (dis)advantages as a static point of information, but as something dynamic. A static model can use factors and weights and derives one score. A dynamic model shows how weights shift over time and hence describe a change in the overall score. That score should hint towards a more or less viable timing of entry. The assumption is that the advantages and disadvantages' weights over time and that for the context a value can be found. This would lead to a score (score = weights x value) which would direct towards a more or less favourable point of entry. Later in this thesis, the case study will dive into the values of first-mover advantages and disadvantages and the interviews investigate weights.

Strategy

The strategy that is assessed in this model is the strategy of entering a market. Other strategies could also be considered but that is out of the scope for this thesis. The final building block of the model results in yes or a no. A yes meaning entering the market now, a no meaning not entering the market at that moment, thus waiting.

4.2 The flowchart

Figure 19 displays the relationship between the building blocks but does not show in which order they should be assessed. For this a flowchart is used which is presented in figure 20 (A bigger version can be seen in appendix C). The flowchart shows a step-by-step approach to take into account first-mover (dis)advantages when entering a market. Underneath the flowchart of the actions, there is a lane which describes the thought process. When one is assessing market characteristics, competition and thus the order of entry, its own firm characteristics, the first-mover (dis)advantages and how they relate to the current situation, and eventually if market entry at that point is desirable, it is not a start to finish process in one go. The analyses that are performed and the thinking steps that one takes influence the view on the initial strategy the user had in mind when started. That results in a continuous process of analysing and evaluating the current position. This is shown by the 'Thoughts' lane from figure 20.

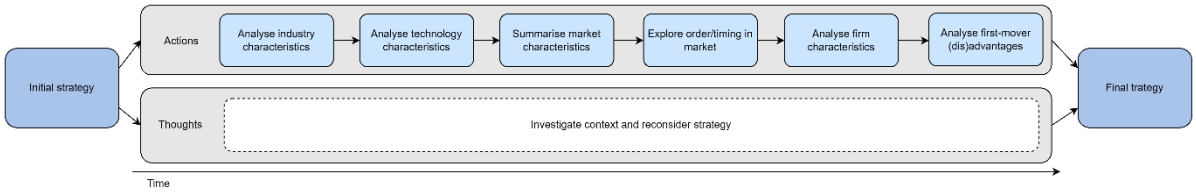

Figure 20: Flowchart to take into account first-mover (dis)advantages in entering a market.

The first three building blocks, analyse industry characteristics, analyse technology characteristics and summarise market characteristics comprise the steps to make an overview of the market that a company considers entering. These steps can be taken without any information of the company itself and are highlighted in figure 21. Because of the difficulty of analysing industry characteristics and technology characteristics, the factors of the pattern of development and diffusion are used. This provides guidance to produce the needed aspects and enables some level of generalisability if performed on multiple product categories. The first seven factors make up the complete system surrounding the innovative technology and the last seven factors give an indication of the dynamics of the system. More on this can be found earlier in this thesis in sections 3.3 and 4.1.

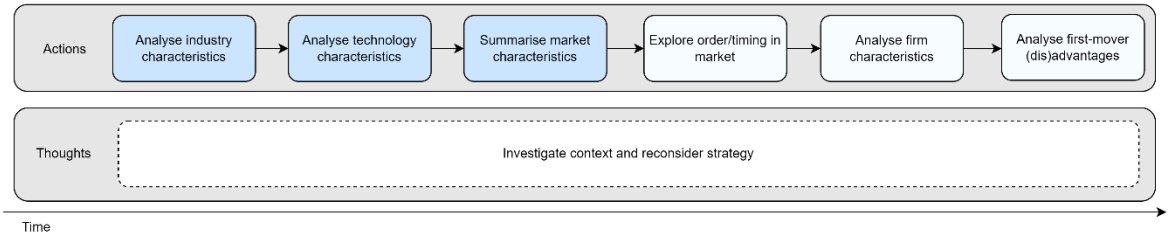

Figure 21: The market level of analysis.

After the market is analysed and displayed in the fourteen factors it is time to explore the order and timing in the market, the firm's characteristics, and what the combination of the two provides with the first-mover (dis)advantages. These are highlighted in figure 22. By exploring the order and timing in the market one should grab table 6 and 7 as a starting point. The order and timing in the market should indicate how to weigh the advantages and disadvantages. One should not take into account for example financial resources into the analysis. It should be a status quo representation. After that, the firm characteristics can be analysed. The combination of the analysis of the first-mover advantages and disadvantages should tell if that situation is beneficial for that company, and the outcome of the combination should be put into the market situation. Because of the symmetry discussed in section 3.2 between first-mover advantages and disadvantages a smooth flow from advantage to disadvantage, and vice versa, should follow from different entry points. The hypothesised symmetry potentially makes it possible to estimate how advantages will develop (and potentially become disadvantages or vice versa) and this can be used to strengthen the argumentation of the strategy. The estimation on the development of the rating of first-mover advantages and disadvantages can help to see if waiting/delay cost may outweigh information spill over cost. It might be better to enter because waiting costs are higher than the cost of knowledge that the competitor gains (Rasmusen & Yoon, 2012). The relation between multiple points in time and the first-mover (dis)advantages and the hypothesised symmetry will be evaluated during the interviews of chapter 6.

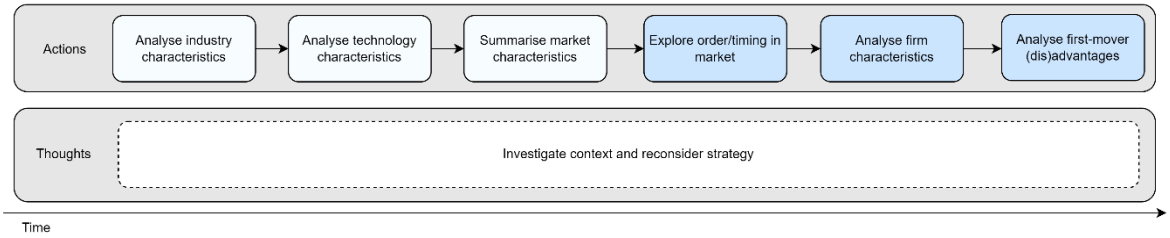

Figure 22: The organisational level of analysis.

These steps describe the analytical part of the flowchart, but with complex decision making it often is the case that intuition also plays an important role. The decision to enter the market or wait, taking into consideration the many variables, is a decision of such complexity that analytical reasoning alone is not enough. Analyses to assess industry, technology and firm characteristics simplify aspects of reality which helps to come up with useful information. However, a feel for the situation can enhance the decision making.

Thoughts lane

Next to the analyses that are performed within the actions of the flowchart, there is a continuous process of rethinking the strategy. Donald Schön in his book 'The Reflective practitioner' describes the following *"competent practitioners usually know more than they can say. They exhibit a kind of knowing-in-practice, most of which is tacit."* He describes that there is more than technical rationality within the process of problem solving which helps us to realise that only a list of analyses is not enough. *"Once we put aside the model of Technical Rationality which leads us to think of intelligent practice as an application of knowledge to instrumental decisions, there is nothing strange about the idea that a kind of knowing is inherent in intelligent action… it does not stretch common sense very much to say that the know-how is in the action – that a tight-rope walker's know-how, for example, lies in and is revealed by, the way he takes his trip across the wire… There is nothing in common sense to make us say that the know-how consists in rules or plans which we entertain in the mind prior to action"* (Schon, 1984). To make a well-thought decision, the analyses are important but tacit knowledge cannot be missing and analytical thinking has to be combined with intuition. The thought as a whole is a combination of the process around the analyses from the person or team performing the

analyses. The analyses in combination with the tacit knowledge and the thought processes around the analyses eventually provide the information to choose to adopt or adjust a market entry strategy.

Order of operations

The order of operations is not strict. Within the flowchart the steps follow a "zoom-in-order" which means that the unit of analyses declines in size (an industry is bigger than a technology within that industry, etc.). However, one can use a different order. It is possible that the final stage confirms or denies the strategy to enter the market, however, this could already be at an earlier stage. For example, if the market characteristics portrait in the factors of the pattern of development and diffusion clearly direct in an undesirable market for the company, the conclusion to not enter the market can be drawn. Eventually the initial strategy can be adapted because new insights are gained, or the initial strategy is kept as it was from the beginning. In that case the analysis validates the initial strategic choice.

4.3 Ambiguities from the literature

Like mentioned in section 3.4, the first-mover literature contains many contradicting results. Figure 19 shows what this research argues should be taken into consideration when taking into account first-mover advantages. Previous research shows contradicting results because aspects of this model often are forgotten. Some researchers take into account firm characteristics and others do not, some take into account financial resources but not the dynamic capabilities, and some assume first-mover advantages are immediate second-mover disadvantages and first-mover disadvantages are immediate second-mover advantages. The model and flowchart illustrate the relationship between the building blocks and the order in which they should be assessed. For example, a company with great dynamic capabilities in combination with a fast-developing industry could take into account first-mover (dis)advantages differently than a rigid company in a mature industry of where development slowed down. This seems obvious but if parts are forgotten or deliberately not mentioned, the results are hard to compare between studies.

4.4 Conclusion conceptual model chapter

In this chapter a model is made to portray the influencing factors on first-mover (dis)advantages and what can influence a company's strategy. The flowchart described in this chapter explains steps that can be taken to take into account first-mover (dis)advantages if one wants to enter a market. The latter is a more pragmatic figure and aims to help improve decision-making. The eventual model has some complexity but can still be understood fairly quickly. The flowchart displays actions and thoughts, which aims to display that the compilation of a strategy goes back and forth between practically performing analyses and thinking and evaluating the situation at stake.

In the following chapter the usefulness of these two figures must be tested, and if needed adjustments need to be made or sidenotes need to be formulated. Now the model and flowchart are ready for use, they can help to show the difference in perceived success from other research. The case study on the electric car from chapter five will try to display this.

5. Case study: market entry of the electric car

In this chapter of this thesis a case study will be done. A case study allows the researcher to explore individuals or organisations, simply through complex interventions, relationships, communities, or programs (Yin, 2002) and supports the deconstruction and the subsequent reconstruction of various phenomena (Baxter & Jack, 2015). The case studies will help to answer two sub research questions. Those are *"What are technology and social aspects that are important to consider when assessing the first-mover advantages and disadvantages?"* and *"How do first-mover advantages change over time?"* The aim is to find out more about the different first-movers presented in section 3.4, how the context differs, how the first-mover (dis)advantages differ and how that affects the perceived success. Within the case study, the model and flowchart from chapter 4 will be used and validated. First the setup of the case study will be shown, after which the case study, on electric cars, is performed.

5.1 Case study setup

In this chapter the case study setup is discussed. The case study will be done on the electric car. This technology is chosen because an internet search indicated that sufficient information is to be found, the history of the electric car knows many new entrants, and the technology is in the stabilisation phase. The electric car will be used to help find aspects that influence first-mover (dis)advantages, and how the first-mover (dis)advantages change over time. The case studies will also function as a basis for the interviews of chapter six. More elaboration on this will be provided later in that chapter.

For the case study on electric cars, a setup can be seen in figure 23. The setup provides the research questions, case study questions, case study objectives, the instrument, procedure, and general rules. This will form a basis for the case study and shows what is aimed to find.

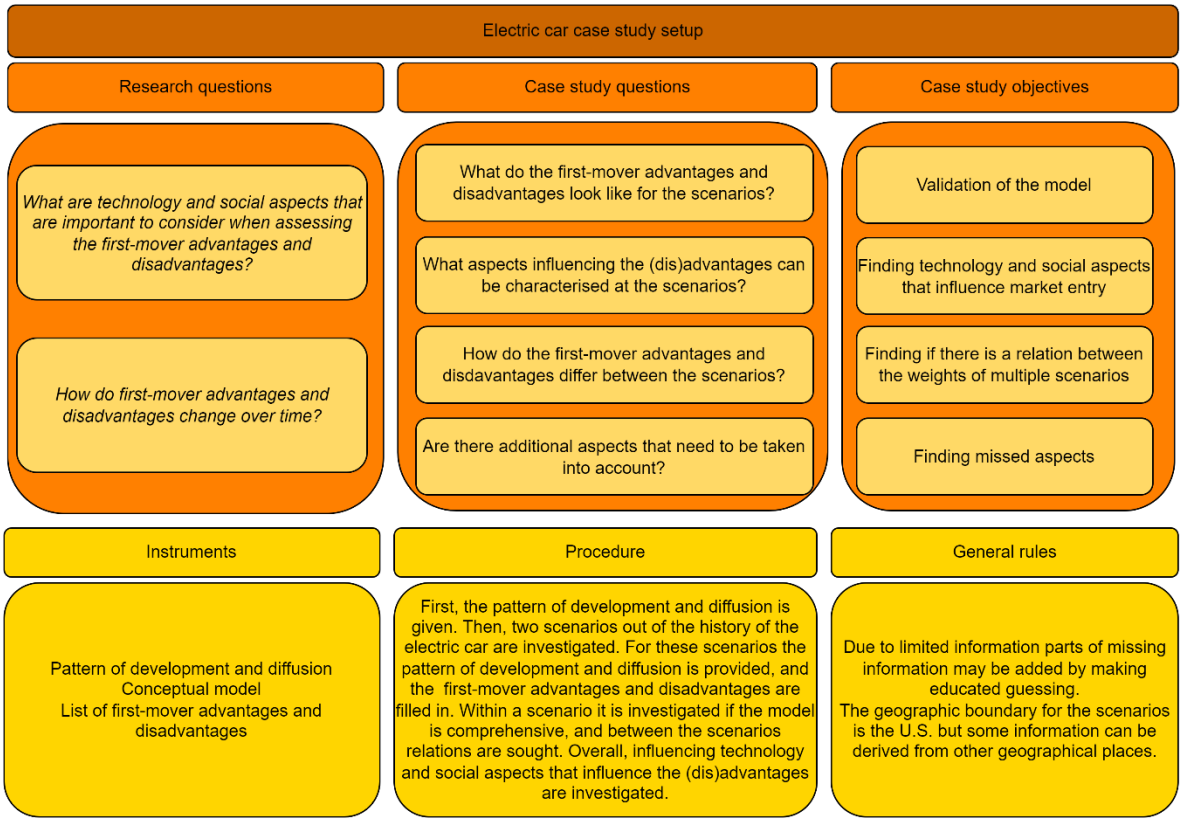

Figure 23: Electric car case study setup.

The information for the case study is gathered by searching the internet and using Google's search engine. The development of electric cars has been studied by a variety of scholars and much information is available on multiple companies, but still some assumptions will have to be made.

5.2 The case study

The case study on electric cars will start with the development of the electric car until now. This will provide an overview of events and show the long history of the electric car. The history of the electric car provides the information to use the model to answer the questions from the electric car case study setup from figure 23.

Pattern of development and diffusion of the electric car

In figure 24, the pattern of development and diffusion of the electric car until 2022 is displayed. The information to produce this pattern is provided in the section 'Electric car development until now' given below.

Two observations can be made fairly quickly. The first observation is that the time from invention until large-scale diffusion is significantly long, around 180 years. Ortt (2010) describes that the average innovation phase takes around 10 years with a variation of 13.5 years and the average adaptation phase takes around 7 years with 8 years of variation. Obviously, the innovation and adaptation phase of the electric car took a lot longer. Throughout history hindering and stimulating factors came up, disappeared and came back again. These days it seems obvious that the electric car will stay but only time will tell.

The second innovation is that over the period of 115 years (the adaptation phase) there have been many entrants. Even after failure often occurred, the electric car was introduced again. After the golden age of 1900-1910 the electric car was over, but nowadays it looks like it will win the race of the ICE and steam engine. So, remarkably throughout history, with the knowledge of many failures, there have been multiple incentives to enter the market again. This presumes that the context and first-mover (dis)advantages shifted positively and negatively over time, which will be investigated in the next section.

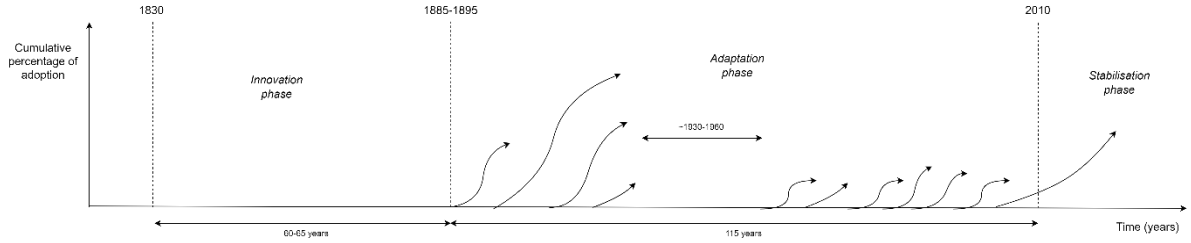

Figure 24: Pattern of development and diffusion of the electric car.

Electric car development

In 1820, a Danish physicist and chemist named Hans Christian Ørsted performed an experiment where the first discovery of electromagnetism was observed. This was the first-time electricity was seen as a possibility for great mechanical activity (Dunsheath, 1976) and few short years after the invention early attempts at building electric-propelled cars appeared (Guarnieri, 2012). In 1827, a Slovak-Hungarian priest built the first crude, but viable, electric motor and implemented it a year after in a tiny car. In Groningen, the Netherlands, a small electric car was built by professor Sibrandus Stratingh in 1835 and somewhere between 1832 and 1839 the Scottish man Robert Anderson is reported to have made an electric carriage (Guarnieri, 2012). After these first rudimental versions the development started. Multiple four- or three-wheeled carriages were invented, yet, unsuitable for practical exploitation. The vehicles were able to run ahead of the development of the internal combustion engine (ICE) driven vehicle but were not able to achieve any sort of success. Only when multiple improvements over a time of 20 years on electromechanical generators, DC electric motors and rechargeable batteries were found, electric vehicles could get a boost.

The main developments were going on in the United Kingdom, France-Belgium, and the United States. In the UK, the advancements of electric cars started after Robert Davidson built the, considered to be, first electric road vehicle in 1873. However, industrial exploitation of this vehicle was still not suitable because of the use of disposable iron/zinc batteries. In France, already in 1881, an electric tricycle was presented by Gustave Trouvé, after which a few years later, versions of electric cars, horse carriages replaced by electric motors, were invented. Thomas Parker was first in the UK to build a more successful electric car equipped with rechargeable batteries in 1884. Parker had a reputation as a pioneer of electrical propulsion; he electrified the London Underground in 1890 and installed overhead tramways in Liverpool and Birmingham (Guarnieri, 2012). 4 years later, Ward Radcliffe built an electric car powered with twenty-eight cells that could drive around 13 km/h and four years after that, Immisch & Company of London built a four-passenger dogcart. In 1889 the London Electric Cab Company set up a taxi service with quickly

exchangeable batteries. France enjoyed the first commercially successful car to carry six passengers at 16 km/h, made by Paul Pouchain. The first successful US four wheeled electric car, which could carry six passengers at 22 km/h, was built by William Morrison in 1890, for which he also applied for a patent. The World's Columbian Exposition from 1893 in Chicago made way for the expansion of the electric car for the following 20 years. Partly because of Edison's DC commercial electric network which spread through the 1880s because it enabled infrastructure for rechargeable batteries. Pedro Salom and Henry G. Morris adapted technology from battery-electric street cars and boats and got a patent in 1894 (Wilson, 2018). They introduced the first commercially viable EV effort, named the Electrobat. The next two years they improved the vehicle and later also built a few cabs to compete with horse-drawn cabs. They ended up selling that to Issac L. Rice who founded the Electric Vehicle Company. The electric car market rose, and many companies were founded in the USA near the end of the 19th century. Some of the companies that entered the market were Pope Manufacturing Co, Anthony Electric Baker, Detroit, Studebaker, Columbia, Anderson, and Edison.

Episode 1: The first market introduction

The period around the introduction of the Electrobat into the market defines the first market introduction and the start of the adaptation phase of the pattern of development and diffusion of the electric car. The Electrobat seems to be the first commercially viable model, although it could be that others were earlier or entered at a similar time. The most important part is that somewhere around 1885 and 1895 the first episode of electric cars started. The pattern of development and diffusion of the electric car can be seen in figure 25.

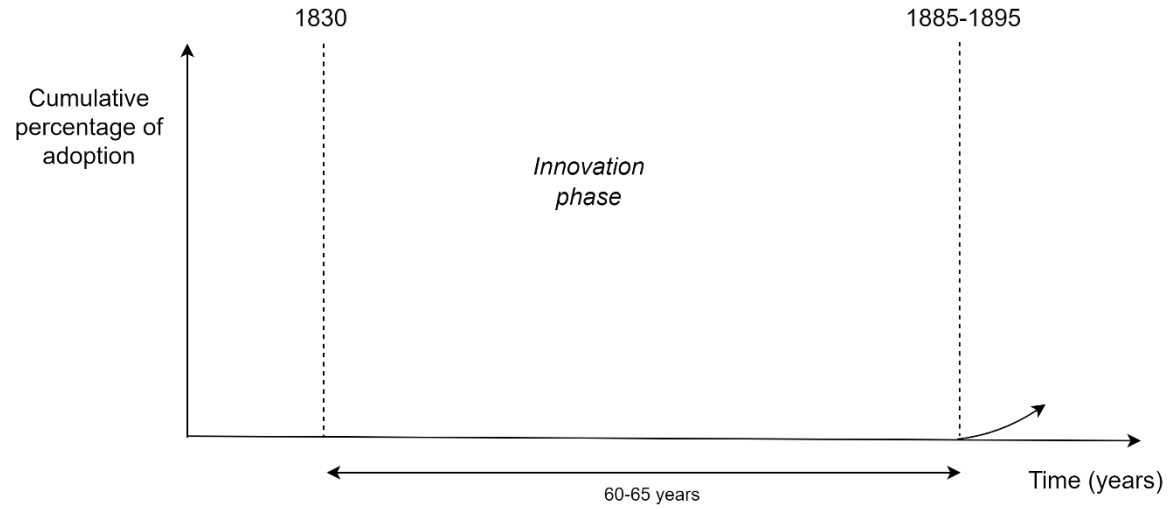

Figure 25: Pattern of development and diffusion of the electric car until 1895.

The curve starts in 1895 and displays the first product version of the electric car. After the first market introduction and around this time multiple companies entered the market and development rose. Now, the focus will be on the first-mover advantages and disadvantages from the model from figure 26.

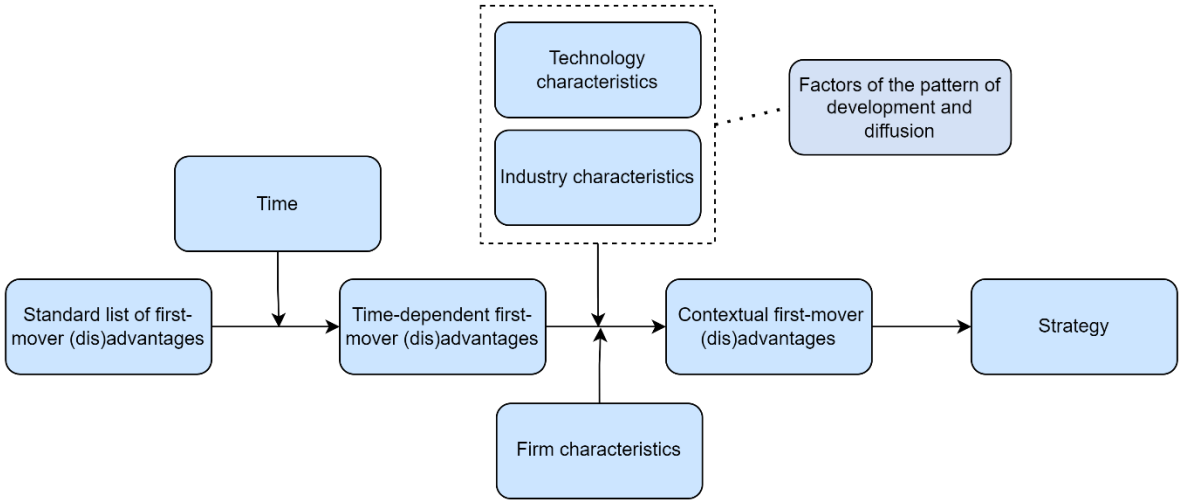

Figure 26: Model to take into account first-mover (dis)advantages in entering a market.

A description of the values of the first-mover advantages and disadvantages will be filled in in tables 14 and 15. A one in the most right column means the advantage or disadvantage is present.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Episode 1**	
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*Multiple designs were introduced around 1895 to prove they had the best electric car. For example, the college dropped the owner of Riker Electric Motor Company pursuing the light electric car. Also, the Electric Vehicle Company clearly aimed for the reputation as a technology leader (Mom, 2004).*	1
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*Important. At that time, it wasn't clear for what purpose electric cars were most suitable and by shaping these expectations favourably a company could benefit (Mom, 2004).*	1
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*Little to no knowledge can be found on this advantage. In this time economies of scale were less developed (Ford was one of the first to introduce this).*	0
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*Important. Pedro Salom and Henry G. Morris adapted technology from battery-electric street cars and boats and got a patent in 1894 (Wilson, 2018). This is an example of the importance of early patents in that era.*	1

Pre-emption of scarce assets			
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	*Somewhat important. The resources to produce batteries have always been important to electric cars. There was no specific shortage that time, but an early entry could benefit.*	1
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*"…the power station of the Edison Electric Illuminating Company, at a distance of a few hundred metres. The station was equipped to process 150 battery boxes (1.5 per car at a planned fleet size of 100) and so was "manipulated by a minimum of manual labour.""(Mom, 2004). This quote indicates the importance of location in geographic space.*	1
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*Plants and equipment were important, but there are no signs that specially for the electric car this was extra important.*	0
Exploiting buyer and switching costs			
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*In that time, the electric car was easy to operate (especially in comparison with the combustion engine) so switching costs belonging to learning (as with the QWERTY-keyboard) were not at play.*	0
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	*During this time, big names like Edison also competed in the electric car market. Since there was no big name within this market yet, there seems to be the possibility to enjoy a first-mover advantage.*	1
		Total	6

Table 14: First-mover advantages in 1895 (main sources Mom, 2004, Wilson, 2018, Westbrook, 2001 & Guarnieri, 2012).

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Episode 1**	

R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*The early days of the electric car saw many versions, so R&D costs were high. The main difference was in the type of battery and charge system which had to be discovered by early movers.*	1
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	No specific difficulties for early movers are found in the literature.	0
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*Important. To show the capabilities of electric cars, several events were organised.*	1
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*Important. In 1895, in total 4000 kWh was installed as central-station batteries in the U.S, which had to go up (it hundredfold in 1904) (Mom, 2004).*	1
Resolution of technological or market uncertainty			
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*Very important. It was unsure what the main vehicle in the future would be and how the technology would develop. Uncertainty about battery development and other propulsion systems.*	1
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*Very important. During the first-market introduction of the electric car the customer needs were not clear. Many efforts were done to steer the needs which brought education costs.*	1
Incumbent inertia			
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*Very important when one looks at companies that also develop gasoline cars. Not so important if one looks at a new generation of the electric car made by the same brand.*	1

Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*Very important. Some companies are fully committed to electric cars, for example, the Electric Vehicle Company. Other car manufacturers, for example Edison, were less committed to one form of propulsion.*	1
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*In 1985, companies in the wider sense were less flexible. There are no signs to be found that indicate that this was more at place in the electric car market. However, the fast-developing market does indicate organisational inflexibility being a real disadvantage for an early mover.*	1
		Total	8

Table 15: First-mover disadvantages in 1895 (main sources Mom, 2004, Wilson, 2018, Westbrook, 2001 & Guarnieri, 2012).

Continuing of the development of the electric car

In 1898, a French electric car made by Jeantaud Duc broke the land speed record with 63.13 km/h and in 1899 (after a series of records had been broken) the Jamais Contente electric car broke the record with 105.88 km/h (first time above 100 km/h) (Abt, 1998). The wealthy class of French people were intrigued by electric cars and France was the largest automobile maker in the world until surpassed in 1904 by the US. The German market first saw an electric car made by Ferdinand Porsche in 1899 (whose son would find today's Porsche company after WOII (Wilson 2018)). The Germans were more interested in the internal combustion engine which resulted in them not participating much in the early development of electric cars.

From 1900-1910 the electric car market had reached the peak of its success. At that time, the American car market was divided over steam, electricity, and gasoline, having a market share of 40%, 38% and 22% respectively. Each of them had its own up- and downsides which for electric cars were them being silent, odourless, reliable, straightforward operation and easy start, but expensive, slow and despite the introduction of exchangeable battery services around 1910 still had low range.

Episode 2: The golden age of the electric car

This episode provides a more in-depth view of the 1910 situation. In figure 28 the pattern of development and diffusion until 1910 is provided. One sees an increase in progress and the upward aiming arrow indicates a growth in adoption. In table 13 and 14 the first-mover advantages and disadvantages will be qualitatively analysed. Afterwards the 1910 situation can be observed and conclusions regarding the 1895 situation can be derived.

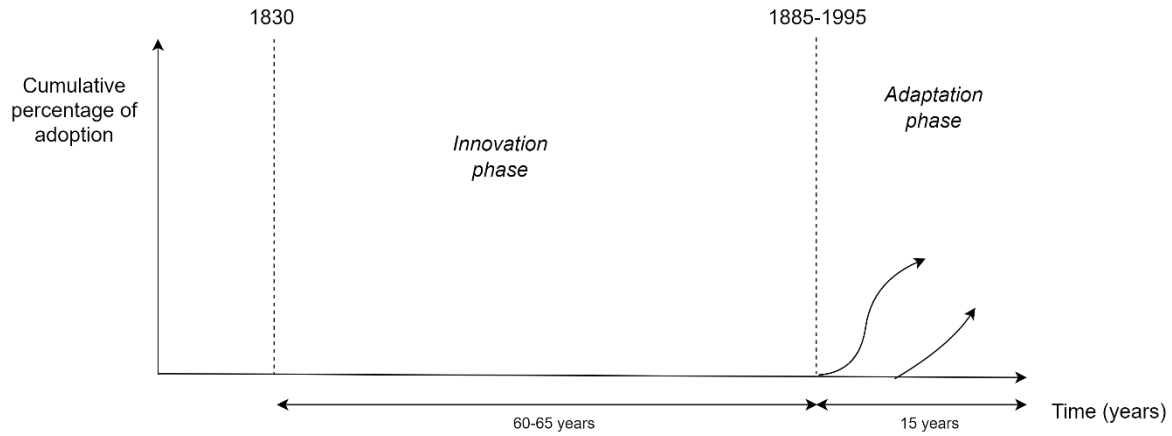

Figure 27: The pattern of development and diffusion for the electric car until 1910.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Episode 2**	
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*At this point multiple companies have entered the market and multiple versions of the electric car in the market. The opportunity to grasp the reputation as a technology leader is not present anymore.*	0
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*Customer expectations of the electric car are already pretty much shaped. Still events to showcase electric car capabilities are organised but the main view of electric vehicles is established. It is seen as a car for women and not adventurous.*	0
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*Still, economies of scale were less developed. The assembly line is about to be invented but is not yet.*	0
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*Patents are still of value. Since no de facto standard has emerged and development is ongoing, inventions can reap a competitive advantage.*	1
Pre-emption of scarce assets			
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the	*While the development of the electric was going rapidly, the opportunity for pre-emption of*	0

	market because of superior information.	*input factors did not seem to be present at this time.*	
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*This advantage is like the 1895 situation. Being located near power electric power stations was an advantage but there are no indications the pre-emption of it seems available.*	1
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*No specific knowledge to be found on this subject.*	0
Exploiting buyer and switching costs			
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*Similarly, to 1895, there was little initial transaction or investment that the buyer made in adapting to the seller's product.*	0
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	*The opportunity to gain brand loyalty was still at place. Wealthy entrepreneurs (Henry Ford and Thomas Edison) tried to establish loyalty with names within the electric car market.*	1
		Total	3

Table 16: First-mover advantages in 1910 (main sources Mom, 2004, Wilson, 2018, Westbrook, 2001 & Guarnieri, 2012).

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Episode 2**	
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*The development was fully going on so R&D expenses belonging to early market entries were not at place anymore. Technological developments had been established of which some spill over seems to have happened. However, this does not mean that development costs have disappeared in full.*	0

Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	*Due to the increased availability of models, the supply of batteries and electric motors seems to have increased in the past fifteen years.*	0
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*"Education was not only necessary to convince the butcher and the grocer; the lower ranks at the central stations—precisely the domain of potential users—had to be addressed, as they appeared a virtually unassailable bulwark of opposition against electric propulsion" (Mom, 2004). Still much work on education of buyers had to be done.*	1
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*Enabling technologies were more developed by this time. More battery technology was available and for example, tire technologies made big steps which was especially beneficial for electric cars (Mom, 2004).*	0
Resolution of technological or market uncertainty			
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*The electric car market seemed to head more towards the taxi/cab services.*	0
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*Prices for electric cars were significantly higher than gasoline cars which resulted in electric cars being for high-society and rich people. This made the target audience more and customer needs become clearer.*	0
Incumbent inertia			
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*This factor is evaluated similarly as in 1895.*	1
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*Still very relevant. The crumbling down of the Electric Vehicle Company in 1907 indicates that a lock-in on a specific set of fixed assets, knowledge, or other*	1

		resources was an important disadvantage.	
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*This factor is evaluated similarly as in 1895.*	1
		Total	4

Table 17: First-mover disadvantages in 1910 (main sources Mom, 2004, Wilson, 2018, Westbrook, 2001 & Guarnieri, 2012).

Additional context

One of the standard themes of automotive historiography is that women at this early stage were preeminent electric-car drivers, but apart from the education of buyers this is difficult to express in the advantages and disadvantages. It is a clear socio-cultural aspect from the (f)actors of the pattern of development and diffusion. Mom (2004) repeatedly describes the technical competences (and maybe even superiority) of the electric car but states that the public did not accept this. The adventurous image of the combustion engine, taming the wild engine, had people interested from the beginning even though the electric car had more suitable technological factors. Eventually the assembly line and electric starter for combustion engines implemented with the Ford model T radicalised the mobility market.

Continuing of the development of the electric car

The main target group around that time were wealthy city customers (because of paved urban streets) that could afford the luxury. In 1912, electric car production peaked. At that time, the Ford Model T could be purchased for 650 dollars which was substantially less than 1750 to 3000 dollars for an electric car. Over time, the price of the Ford Model T fell even more which resulted in 360 dollars per vehicle in 1916. Funny enough Henry Ford's wife, Clara Ford, drove a Detroit Electrics electric car because she found her husband's product dirty and noisy. Around the same time, the implementation of the invention of the electric starter motor for the ICE vehicle (Abt, 1998) made ICE much more reliable and comfortable. Eventually this resulted in electric cars disappearing after around 1920. The electric car industry got a small injection during WOI because of rising gasoline prices, but during the 1920s Detroit Electric's "new" cars mostly were built on bodies of earlier unsold units. From 1907 to 1939 it built more than 35000 vehicles.

So, by 1935 almost all electric cars had disappeared. Despite some small efforts, the electric car market 1935 to 1960 was dead, but because of problems caused by emissions from the ICE, developments started after this time. In 1964 the first Battronic electric truck was delivered to the Pomotac Edison Company which was capable of driving 25 mph for a range of sixty-two miles with a 2500 pounds payload. The Battronic Truck Company was a joint venture by Boyertown Auto Body Works, Smith Delivery Vehicles, Ltd. And the Electric Battery Company. In 1967, Arizona Public Service made the first cross country trip in an electric car to illustrate electric car capabilities. The trip took more than two weeks and had thirty-seven stops for fast charging of the lead cobalt batteries. From 1973 to 1983 it produced 173 utility vans in collaboration with General Electric, mainly for use in the utility industry and to demonstrate battery-powered vehicles' capabilities. Another company, Jet Industries in Texas, focused on converting towards electric cars. They used old chassis from a Ford Escort and Mercury, they planted in 96-volt traction motors, lead-acid batteries and on-board battery chargers using 120-volt alternating current.

Sebring-Vanguard produced over two thousand CitiCars, Elcar Corporation produced the Elcar and Commuter Vehicles the Commuta Car. All driving around 45 mph and ranging sixty miles and considered to be very ugly. At that time, OPEC imposed an oil embargo (in 1973) which quadrupled the per-barrel price to twelve dollars overnight. So, despite the ugly looks of the cars, electric vehicles have a short optimistic perspective. The Sebring-Vanguard and Commuter Vehicles produced 4444 units, making it the largest electric-car producer in America since the end of WWII until 2013 (Wilson, 2018). In 1975, 350 American Motor Company electric delivery jeeps were purchased by the US Postal Service. Recharging cost around ten hours, top speed was 50 mph and range around forty

miles. Unique Mobility Inc built the Unique Mobility Electrek vehicle capable of reaching a maximum speed of 75 mph and a range of seventy-five miles in the late 1970s. Electric Vehicle Associates created the EVcort produced from 1981 to 1994, which also used a stock body of the Ford Escort. It used innovative technology such as regenerative braking and a multistep charging algorithm. It was used for demonstrations and testing programs to show a comparable performance of a practical alternative-fuelled vehicle.

Among other legislative and regulative actions, the 1990 Clean Air Act Amendment, 1992 Energy Policy Act, regulations by the California Air Resources Board (making automakers sell a small percentage of vehicles that made no emissions) and several states issuing the Zero Emissions Vehicle requirements boosted electric car development.

The Partnership of a New Generation of Vehicle between Chrysler, Ford, General Motors (GM) (the "Big Three"), the US Department of Energy and several vehicle conversion companies were active in the development of electric cars. For example, the Chevrolet S-10 was converted by US Electricar and The Geo Metro converted by Solectria Corp. The Geo Metro drove two hundred miles on a single charge during the 1994 American Tour de Sol from New York City to Philadelphia using Ovonic nickel metal hydride batteries. Ford produced the Ford Ecostar in the early 1990s which was considered a R&D model. Ford also put out an electric version of the Ford Ranger pickup, with a range of about sixty-four miles and top speed of 75 mph, later versions improved on this. GM designed an electric car from the ground off which resulted in a car reaching 80 mph with a range of eighty miles equipped with 2600 pounds of lead acid batteries. Around this time, Chrysler, Chevrolet, Dodge, Toyota, Honda, Nissan, and BMW put out similar electric vehicles. Ford sold five hundred electric carrier route vehicles to the US Postal Service which were put in service at 22 post office locations for the main purpose of assessing the current battery technology. After this time, companies started to convert towards hybrid options, the most known being the Toyota Prius. This happened in the period of 2000 to 2011.

Alan Cocconi founded AC Propulsion in 1992, revealing the tzero with 150 kw and lead-acid batteries in 1997. Tesla Motors co-founder Martin Eberhard commissioned a tzero using Lithium-ion batteries that were just becoming commercially available. AC propulsion resisting to put the car into production motivated Eberhard and Marc Tarpenning to found Tesla Motors in 2003 after they went off to pitch the lithium-ion tzero to Silicon Valley venture capitalists. Potential investor Elon Musk approached, who also first tried to involve AC Propulsion, which eventually resulted in Musk investing in Tesla Motors. In 2008 Tesla Motors entered the production of the Roadster, a Lotus Elise equipped with an AC Propulsion tzero The Roadster was the first to put lithium-ion batteries in production and demonstrate a 200-mile driving range. The car was not cheap (around 109000 dollars) but convinced enough people to seriously consider electric cars again. Most other car manufacturers at this time still fulfilled their zero emissions vehicles by taking an already engineered car and converting it to electric power. In 2011, Nissan introduced the Nissan Leaf and brought out a revised version in 2016. It was sold worldwide, able to drive highways and had a one hundred miles range enabling it to become the best-selling electric car in history with total sales becoming more than 300000 in January 2018.

However, we also see many failed products within this time, examples being Coda, Aptera, Venture Vehicles and Better Place. Better Place, founded in 2009, was only able to survive until 2013 despite 850 million dollars of investment. It was a promising company that was backed by Israel and Denmark and partnered with Renault but was not able to succeed with their business plan relying on standardised easily changeable battery packs. Agassi got its ideas sold but burned bridges with existing automakers which is important as a standard needs to be accepted by others to really succeed.

The Tesla Model S, introduced in 2012, which was a big hit. In 2016 Tesla outlasted most of the start-up competition. It outsells the Nissan Leaf most months and it has a great image. In 2017 the Chevrolet Bolt is brought to market that can be purchased below the average for all new-car sales and Tesla brought out its Model 3 which also has a competitive edge on pricing.

5.3 Case study conclusions

For the case study a dive into the history of the electric car is performed. For the two episodes, 1895 and 1910, the pattern of development and diffusion and the first-mover advantages and disadvantages are filled in. This gives an overview of the situation at that time and answers the first case study question from the case study setup. The aspects that play a role in the scenarios are harder to distinguish. Between the two episodes differences can be observed between multiple advantages and disadvantages. For example, the advantages of reputation as technology leader, shaping customer expectations and pre-emption of input factors, and disadvantages R&D expenses, immature enabling technologies and complements and market and technology resolution expenses seem to have been changed.

Furthermore, it becomes clear that evaluating the specific advantages and disadvantages long ago in time is difficult. Even though the two episodes are fifteen years apart and the dissertation from Gijs Mom (2004) provides a

detailed explanation, it is hard to distinguish some advantages and disadvantages. Specifically hard is to investigate influencing factors because this requires a second step in the investigation process. Finding a quote about a certain advantage can be one and might be findable but finding the influencing aspect behind that advantage quickly becomes subjective. The decision to not use data older than 50 years in section 1.2 Scope was relevant. The case study shows a first indication that first-mover advantages and disadvantages change over time and various aspects influence them. Still, the historical case leaves some open endings.

However, the case study does show values for the advantages and disadvantages of two periods in the development of the electric car and shows those values are different for the two cases. The eventual score that is aimed to discover consists of two parts: weights and values. This case study showed that values can be assigned to the advantages and disadvantages at multiple points in time and that those values result in a more or less favourable market entry time. The eventual score (weight x value) should indicate which entry point but without the weights it is hard to make an estimation. Choosing positive 1 for an advantage and negative 1 for a disadvantage (which might be too simple) does not work without weights.

Both episodes contain interesting information that must be taken into account to decide to enter the market. The first scenario describes the start of the electric car market and is filled with opportunity, but it is also accompanied by a lot of uncertainty and more development costs. In the second scenario more information is provided and it can be seen that the market has become more stable, but that competition increased much. The social-cultural aspect of the view on electric cars developed but not in a positive manner. Taking all aspects in consideration from the two scenarios the 1895 scenario looks more favourable. This also has to do with the hindsight bias that is caused by the knowledge of the Ford model T becoming popular soon after 1910 and the many times where 1900 to 1910 has been described as the Golden Age for the electric car by others. By explaining which scenario is most favourable it again comes to mind how important the weights in combination with the values are to come up with a score. For example, the disadvantages education of buyer expectations describes the view of the people on the electric car (considering the electric car to be women's car). Mom (2004) elaborates on all sorts of technicalities from the development of the electric car and also in comparison to competition but ends with the notion of the socio-cultural aspect influencing the final outcome of the technology battle the most.

Luckily, the next chapter on interviews will provide an insight in the weights of the first-mover advantages and disadvantages. The interview scenarios do not complement the case study scenarios fully because for the interviews different points in time are chosen. This is because expert knowledge of the scenarios is needed and for 1895 and 1910 that is not available as for 1995 and 2010. Still, an indication of weights will be given and the other part of the score equation will receive a considerable amount of attention. So, the next chapter will contain interviews on two scenarios, 1995 and 2010. Within these interviews, the weights of the advantages and disadvantages will play the central role. With the help of their managerial and electric car knowledge, this aims to illustrate a more practical analysis of the advantages and disadvantages.

6. Interviews: applying weights to first-mover advantages

The final research methodology that will be performed will be interviews. The interviews will help to answer research question five *"How can the advantages and disadvantages be weighed in a particular situation to come to a decision to enter first or not?"* For these interviews, the case study on the electric car will function as a framework and this provides the necessary information to sketch scenarios that can be evaluated. First, the interview setup will explain which questions are asked, what material is used, what sample size and population are used, and how the interviews will be analysed. After that, the results are presented, and a conclusion is derived.

Use of weights of first-mover (dis)advantages

The interviews aim to find weights for the first-mover advantages and disadvantages to complete the calculation of a score (score = weights x value). Like in many situations, criteria are in conflict. For example, investing in R&D is favourable to develop a better product but that increases R&D sunk cost. Conflicting criteria are typical in evaluating options (entering the market or not) and so they can be seen here. Structuring complex problems well and considering multiple criteria explicitly leads to more informed and better decisions which is tried by applying weights with help of the interviews. Using weights provides information on which advantages and disadvantages are important in that phase and time. This is particularly helpful in a complex and advanced situation where an application is new which is the case for the way this thesis tries to use first-mover advantages and disadvantages. Weights also help strengthen the score calculation. If only values are used the calculation is weak and could vary too much by (dis)advantages that should not play a crucial role at that moment.

Furthermore, it is important to design a safety-vault to make sure the answers are valid. The answers can be too far away from each other or contradict entirely. In multi-criteria decision making a consistency ratio is used to check the reliability of the comparisons. It is out of the scope of this thesis to provide a mathematically argued consistency ratio, but it is important to evaluate the data with this aspect in mind.

6.1 Interview setup

The interviews need a structured approach, which can be achieved best with the help of an interview setup. This interview setup can be seen in figure 30. At the left the research question playing a central role is given. In the middle, one can see the interview questions that were asked, and on the right the objectives are displayed. The interview needs analytical instruments and procedures. They are described below. Lastly, below on the right provides some additional information. The exact interview material is portrayed in appendix A. To be able to give a comprehensive answer to the sub research questions, six main questions for the interviews are formulated with four accompanying objectives.

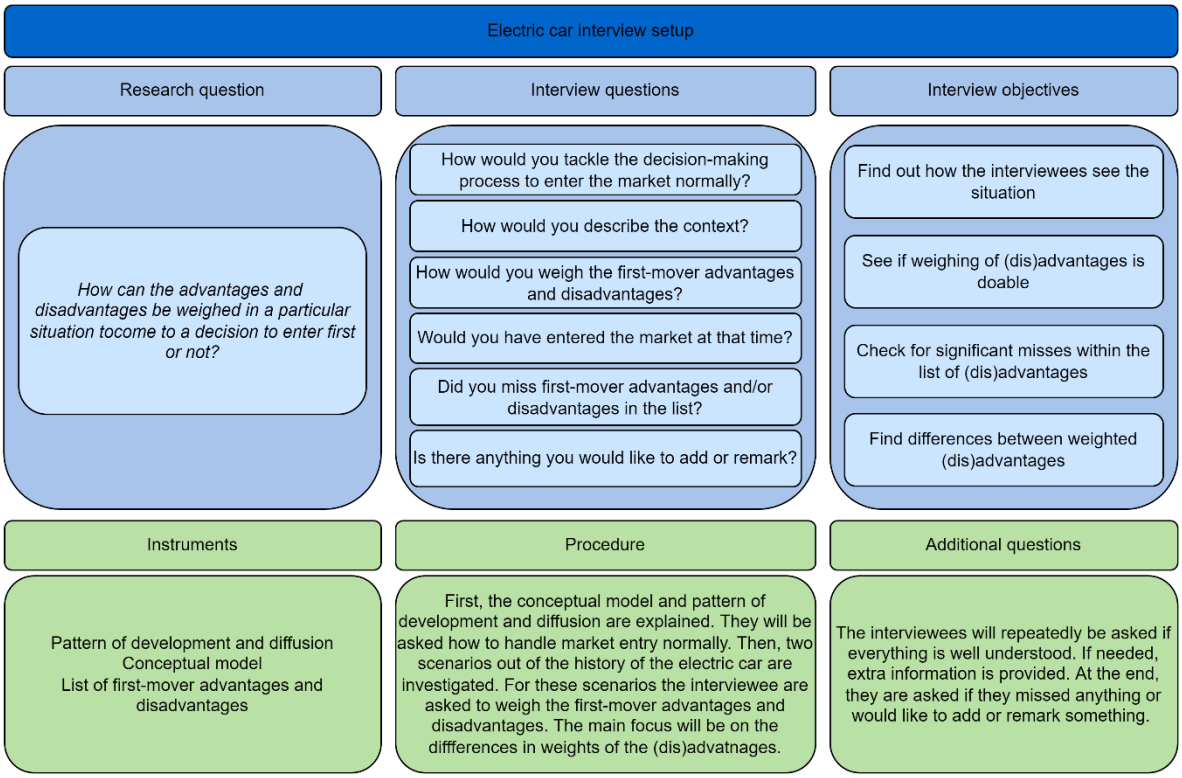

Figure 28: Interview setup.

Next to the interview setup, the sample size and sample population are needed. Below an argumentation on the number of interviewees and their expertise is provided.

Sample size

The right sample size is the sample size that allows the researcher to have the sense of saturation. However, when something is saturated, it is vague and multiple interpretations can give a well-argued answer (Box, 2014). Guest et al (2006) conducted a systematic inductive thematic analysis of 60 in-depth interviews among female sex workers in West Africa. From this interview, they concluded that 70% of the 114 identified themes were found within the first six interviews and 92% within the first twelve interviews. They also found that the most common themes were found early on. After this work, Francis et al (2010), Coenen et al (2012), and Namey, et al (2016) found six interviews for 70% saturation, 5-6 for most themes, thirteen interviews for saturation for an inductive approach and eight for a deductive approach, and eight for 80% saturation, respectively. Summarised by Namey (2019) it is found that 6-12 would be a good amount for the number of qualitative interviews needed to reach saturation. However, for these interviews the questions are very specific. The explorative part is small, and the main focus is on the weights of the first-mover (dis)advantages. To achieve a sense of saturation less interviews are needed for this research. Also, the aim of these interviews is to showcase weights that can be assigned to the advantages and disadvantages but no proof of the exact weights is aimed to achieve. For this it might be better to do a multi-criterion decision making analysis, for example with the use of the best-worst method. Taking this information in consideration around two to three interviews should be enough to showcase that weights can be assigned and different points in time are accompanied by different weights per advantage or disadvantage.

Sample population

Valuable insights about the evaluation of first-mover (dis)advantages can be acquired if the interviewed people have knowledge on the topic. For this interview, the population needs to exist of individuals with knowledge of the challenge of entering a market and/or developing a product. This needs to be within the logistics sector and preferably within the electric automotive industry. Figure 31 presents a Venn diagram with the theoretically perfect interviewees. However, it can be beneficial to have some interviewees who have a relationship with this background but differ slightly to broaden the overall knowledge of the sample population.

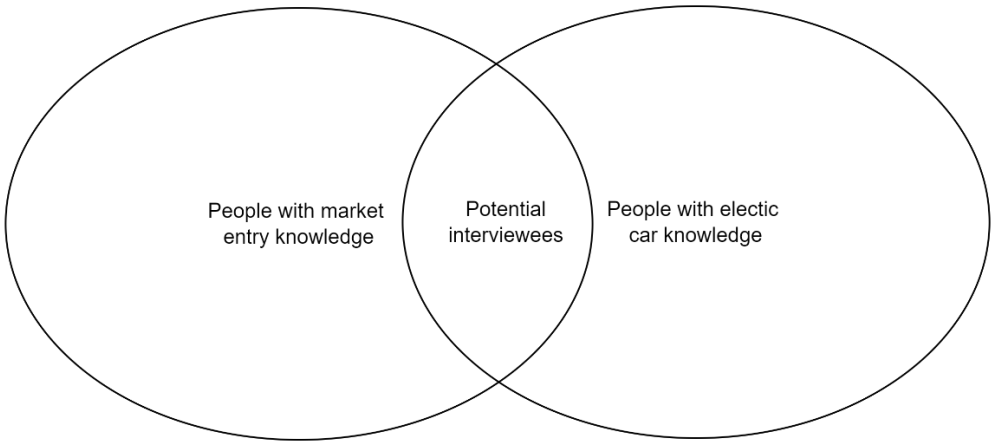

Figure 29: Interviewee domains Venn diagram.

The perspective of this master thesis is from a (big) technology company with an R&D department. So, first automotive manufacturing companies or distributors were contacted. However, most of them responded with disappointing answers or did not respond at all. Eventually, after almost all manufacturers and distributors were contacted the scope for the interview population was slightly widened. Now also academia is included in the sample population. Luckily, the people from table 18 were willing to participate in the interviews. The background and expertise of the interviewees can also be found in this table. The way the interviewees were contacted and how they were provided with information is shown in figure 32.

Background	**Expertise**
Academia	*Professor in Transport Policy at Delft University of Technology.*
Academia and industry	*Lecturer at IvA Business School and owner of a car taxation company. Used to work with Toyota and for Alfa Romeo.*

Table 18: List of respondent details.

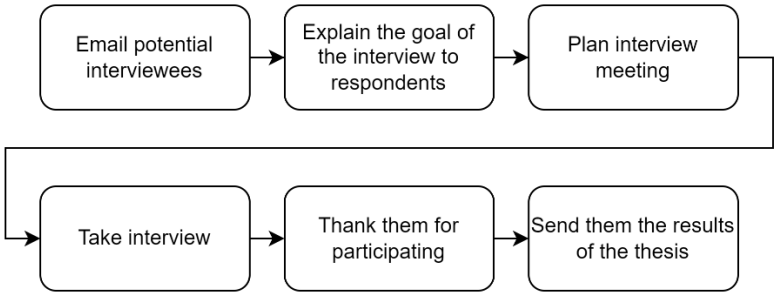

Figure 30: Interviewee contact steps.

The interviews provide valuable information that needs to be analysed in a systematic manner. Which aspects will have the main focus will be described in the paragraph below. After that, the interview results are presented and lastly a conclusion is given.

Method of analysis

The main focus of the interview is investigating how the first-mover (dis)advantages are evaluated in two scenarios within the development of an innovation. Therefore, the method of analysis is comparing how the weights of first-mover (dis)advantages evaluated by one interviewee are different between the scenarios. The combination of differences in evaluation of the context, and weights of first-mover (dis)advantages, resulting in a strategy is most interesting to investigate. The following aspects will have the focus:

- Comparison of the context descriptions within one interview
- Comparison between the first-mover advantages and disadvantages of the two scenarios within one interview
- Comparison of the market entry decisions within one interview

- Comparison between the relation between the two scenarios between the two interviews
- Remarks on the model and/or list of first-mover (dis)advantages
- Other information that stands out

In the next section the results from the interviews are displayed.

6.2 Interview results

This section will present the interview results. The interview started with an elaboration on the thesis subject and what the aim of the interview was. For this the model was shown and the pattern of development and diffusion of the electric car was presented. For both interviews this seemed to go well. After that it was asked how the interviewees normally would have handled a similar market entry decision-making process. The first interviewee elaborated on a strategy to put policy options from the times under question on one axis

Context

Both interviewees were able to give a concise description of the context of the years 1995 and 2010 for the electric car. One interviewee addresses a dissertation on the failure of the electric car, which describes that eventually the image of the electric car (it being for women and not cool) was the most important factor for it failing. Both interviewees describe the 1995 context with upcoming environmental issues having to do with the threat of running out of fossil fuels and pollution. Both describe the Californian regulation on net zero emission cars and hint at lobbyists influencing that. They talk about the EV1 of General Motors and the uncertainty that was all around the regulations of that time. Interviewee one goes more into detail on what markets different automakers traditionally sold their cars to. Both the interviewees describe the 2010 scenario as one where more certainty lived on the electric car being the next new thing. They both emphasise the importance of air pollution regulations and the policy push that came along with it. In both interviews we see a significant difference in the certainty of the situation on electric cars.

Result weights of first-mover advantages and disadvantages

In table 19 and 20 the weights of the first-mover advantages and disadvantages can be seen. Again, it is important to realise that the weights are different from scores (score = weight x value). The first observation that can be made is that some weights differ (which was hoped and predicted). The biggest differences between scenarios for interviewee 1 are factors 'immature enabling technologies and complements' and 'cannibalisation of own product line', which differ 5 points. 'Pre-emption of input factors,' 'switching costs', 'R&D expenses', 'educating buyers', and 'lock-in on a specific set of fixed assets, knowledge, or other resources' differ 3 points. This means that seven (dis)advantages differ significantly between two points in time. The biggest differences between scenarios for interviewee 2 are factors 'shape customer expectations', 'R&D expenses', and 'immature enabling technologies', 7, 6 and 8 points respectively. 'Pre-emptive investment in plant and equipment' and 'infrastructure development' also different substantially. Most important to notice is that between the two scenarios both interviewees can indicate a significant difference in weights of certain factors. Because of a limited number of interviews, no rigorous conclusion can be derived on the actual weights of those (dis)advantages at those moments in time. For this more interviews are necessary.

First-mover advantage	***Interview 1 case 1 - 1995***	***Interview 1 case 2 - 2010***	***Case 2 minus case 1***	***Interview 2 case 1 - 1995***	***Interview 2 case 2 - 2010***	***Case 2 minus case 1***
Reputation as technology leader	7	8	+1	3	2	-1
Shape customer expectations	7	8	+1	10	3	-7
Learning curve	7	8	+1	10	10	0
R&D patents	4	6	+2	10	10	0
Pre-emption of input factors	4	7	+3	10	10	0
Pre-emption of locations in geographic and product characteristics space	2	2	0	6	4	-2
Pre-emptive investment in plant and equipment	2	4	+2	4	1	-3

Switching costs	2	5	+3	1	1	0
Buyer choice under uncertainty/brand loyalty	4	4	0	10	10	0

Table 19: Weights first-mover advantages for the electric car (1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage).

First-mover disadvantage	***Interview 1 case 1 - 1995***	***Interview 1 case 2 - 2010***	***Case 2 minus case 1***	***Interview 2 case 1 - 1995***	***Interview 2 case 2 - 2010***	***Case 2 minus case 1***
R&D expenses	3	6	+3	4	10	+6
Infrastructure development	2	4	+2	4	1	-3
Educating buyers	4	7	+3	8	10	+2
Immature enabling technologies and complements	2	7	+5	2	10	+8
Market and technology resolution expenses	10	9	-1	8	8	0
Shifts in technology or customer needs	6	7	+1	1	1	0
Cannibalisation of own product line	2	7	+5	5	5	0
Lock-in on a specific set of fixed assets, knowledge, or other resources	3	6	+3	4	3	-1
Organisational inflexibility	2-6[1]	6	+0-4	2	1	-1

Table 20: Weights first-mover disadvantages for the electric car (1 = not a significant disadvantage, 10 = very much a disadvantage).

Additionally, a couple other observations about the weights can be made. First, a difference can be seen in the overall number of points assigned as weights. The overall number of weights of interviewee one has increased by 34 while the overall number of weights of interviewee two decreased by 2. This can be seen in the following equations:

$$\sum overall\ change\ in\ weights\ from\ case\ 1\ to\ 2\ interviewee\ 1 = +34$$
$$\sum overall\ change\ in\ weights\ from\ case\ 1\ to\ 2\ interviewee\ 2 = -2$$

This leads to the second observation to be made which is that for interviewee one almost all weights (except market and technology resolution expenses) became bigger, while for the second interviewee the advantages became smaller and the disadvantages bigger. The third observation about the change of advantages and disadvantages between the two cases is that the relative change between interviewees differs. The relative change of the first interviewee almost did not change, while for the second interviewee the advantages and disadvantages came close to each other. This can be seen in the following equations:

$$\sum \frac{weights\ of\ advantages\ case\ 1\ interviewee\ 1}{sum\ of\ overall\ weights\ case\ 1\ interviewee\ 1} = \frac{39}{73} \approx 0.53$$

$$\sum \frac{weights\ of\ advantages\ case\ 2\ interviewee\ 1}{sum\ of\ overall\ weights\ case\ 2\ interviewee\ 1} = \frac{52}{111} \approx 0.47$$

$$\sum \frac{weights\ of\ advantages\ case\ 1\ interviewee\ 2}{sum\ of\ overall\ weights\ case\ 2\ interviewee\ 2} = \frac{64}{102} \approx 0.63$$

$$\sum \frac{weights\ of\ advantages\ case\ 1\ interviewee\ 2}{sum\ of\ overall\ weights\ case\ 2\ interviewee\ 2} = \frac{51}{100} \approx 0.51$$

Interviewee 1 has a 53/47 relation between advantages and disadvantages for the first case and a 47/53 relation for the second case. Interviewee 2 has a 63/37 relation between advantages and disadvantages for the first case and a 51/49 relation for the second case. But what else can be seen from these relations? Both relations have become less

[1] Weight depended on the company. The weight six was used in the formulas.

favourable for the second case which is unexpected if one takes into account that both interviewees would not enter the market in scenario one, and both strongly considered to enter in the second. So, the weights both interviewees assigned to the scenarios imply a less favourable situation for scenario 2 but the eventual decision was favourable for that scenario. And the other way around; for both interviewees the relation between advantages and disadvantages for scenario 1 is more favourable than for scenario 2 but is qualitatively evaluated less favourable.

Market entry decisions

The decision to enter the market was evaluated similarly by both interviewees. Both would not have entered the market in 1995 and would have in 2010. For 1995, both mention the uncertainty of market resolution as a big influencing factor. The future of the automotive market was under pressure by the emission regulation, but it was unsure if the policy would go through and thus, they would not have entered the market. In 2010, they would both consider entering the market and say there was way more certainty on the view of the future. Remarkably, both interviewees' weights of first-mover disadvantage 'Market and technology resolution expenses' are similar for 1995 and 2010. Especially with the findings from the change in relation between advantages and disadvantages between the two cases for both interviewees the market entry decision becomes interesting. It might be that the context, in this case socio-cultural aspects and Innovation- specific institutions from the (f)actors of the pattern of development and diffusion with environmental motives play a big role in the decision making.

Remarks on the model and/or list of first-mover (dis)advantages

Both interviewees were asked if they had remarks on the model and/or list of first-mover (dis)advantages. The interviewee of the first interview started asking how the context was taken into account within the model and this became clear after some more elaboration. The interviewee expressed concerns on the building block 'time', which was not included into the context building blocks 'industry characteristics' and 'technology characteristics'. A remark was made that the building block 'current first-mover (dis)advantages' was expected to be changed in a revision of the model. The second interviewee initially had no remarks but ended with the notion of overlap and co-dependence between certain first-mover advantages and disadvantages. For example, R&D developments influence customer expectations. In the view of this interviewee these factors could not be seen separately. Both interviewees mentioned the differences between companies during weighing the first-mover. For example, cannibalisation of own their product line. Interviewee two mentioned that some companies can sell older models in other parts (less developed) in the world and others not so the answer was dependent on the brand. Interviewee one described a difference in organisational inflexibility between companies, American companies being more conservative in business models than Japanese or German, scoring 5-6, 2-3 and 4 respectively for that disadvantage.

Additional remarks

Both interviewees often compared the disadvantages to a different product category of the same company. For example, one interviewee one explains that R&D expenses are not a big problem for the electric car but is a problem if one invested heavily in R&D for the combustion engine. This aims at cannibalisation of the own product line but outside this product category So cannibalisation of own product line not as cannibalisation for a newer version of the electric car but regarding the cannibalisation of the combustion engine product line. Interviewee two explained this as well but after asking the weight of cannibalisation of their own product line. Here we can see that the assessment of first-mover advantages and disadvantages is often correlated with other products of a company. It can be seen in the argumentation for the weights of the first-mover advantages and disadvantages that context is very much influencing the weights. Geographical boundaries, regulations, perceived market development, and more all play a role during the decision-making process.

6.3 Interview conclusions

The research questions that were aimed to be answered by the interviews were *"How can the advantages and disadvantages be weighed in a particular situation to come to a decision to enter first or not?"* The two interviews weighed the advantages and disadvantages and with the argumentation it now can be seen how they weighed. During the interviews and case study it also became clear that better geographical boundaries and perspectives could have helped to address certain advantages and disadvantages more specifically. For example, the interview episodes could have been limited to the USA or California, where the regulations were introduced. Now a worldwide approach was used which was too broad. Also, the perspective of a specific company could make the answers less ambiguous. This

was the aim at first, to interview experts from companies with an R&D department but they were not willing to cooperate. Eventually a well-known company could have been chosen also for the interviews that were done.

Interestingly the argumentation to enter a market is not fully aligned with the numbers they eventually assign (the relation if values are chosen equal being more favourable in scenario 1 but qualitatively evaluated less). The weights indicate a certain state which can be taken into account for the decision to enter the market or not. Apart from the weights, more knowledge on the model and list of first-mover advantages and disadvantages is gathered. Unfortunately, the weights differ so much that one starts to question the validity of the weights. For this the safety-vault in the section 'Use of weights of first-mover (dis)advantages' earlier in this chapter was mentioned. The significant difference in weights indicates that the method to find them might not work properly. The number of interviews is too low to conclude any of this, but it does cause some concern.

7. Conclusion

This thesis begins with the significance of a well-thought decision and a brief summary of the evolution of the literature on the first-mover advantage. It appears that the literature about entering first, second, or late has been a dialogue of the deaf for around forty years. We use the pattern of development and diffusion to shed new light on the conversation, and we attempt to steer the approach with five questions.

The literature research is used to address the first three sub-questions. The first sub-research question, *"What is a first-mover?"* is answered, and it is made obvious that this subject can be seen from numerous perspectives. A first-mover can be viewed as before the technological principle is invented, when the technological principle is invented, when the product is introduced to the market for the first time, or when large-scale diffusion begins. It may be the case that additional perspectives are used in the literature, but this thesis contends that the most crucial aspect is clarity regarding what is regarded as a first-mover in that particular study.

Second, the literature research addresses the second sub-research question: *"What are the first-, second- and late-mover advantages and disadvantages?"* After extensive desk research, a list of first-mover (dis)advantages is produced. The list may not be exhaustive, but it is compiled to the best of knowledge available. We present nine advantages and nine disadvantages but do not show second- or late-mover (dis)advantages. However, there is symmetry between second-mover (dis)advantages and first-mover (dis)advantages. It is not important that advantages or disadvantages belong to the first, second or any other order but the list can be used in any situation to help provide a status quo. In that sense, the (dis)advantages are first, second and late or none of these. This relates to the more important aspect of the advantages and disadvantages central in the fourth and fifth sub research question *"How do the first-mover advantages and disadvantages change over time?"* and *"How can the advantages and disadvantages be weighed in a particular situation to come to a decision to enter first or not?"* The conceptual model, the case study, and the interviews demonstrate that advantages and disadvantages can be weighed in a specific situation; hence, the weights fluctuate throughout time. However, it is not possible to conclude how exactly the advantages and disadvantages change over time.

The third sub-research question, *"What are technological, and social aspects that are important to consider when assessing the first mover advantages and disadvantages?",* which was intended to be answered by the literature research and case study, became difficult to answer. The highly contextual nature of the advantages and disadvantages became clear multiple times but did not allow to separate technological and social aspects. However, these elements are included as conceptual model building pieces. The prior hypothesis was that these aspects could be separated and their influence on the advantages and disadvantages could be expressed but this is not found within this thesis.

The primary objective of considering first-mover advantages and disadvantages is to make a well-thought decision regarding an effective market entry strategy. This objective's research question is *"How to take into account first-mover advantages and disadvantages in the decision to enter a market?"* In order to achieve this objective, information is provided on the definitions in the old literature, a list of first-mover advantages and disadvantages is compiled, and notions of symmetries are discussed. Additionally, a model and flowchart are designed to display relations and use, and examples and practicalities are investigated. This thesis presents a new perspective on first-mover advantages and disadvantages and reopens the door to using them in strategic decision making. First-mover advantages must be taken into account as mover advantages and evaluated independently of any order. A status quo can be determined, and a tailored strategy can be created. Since the (dis)advantages can be used over the development of a product category, the order is unimportant. Analytical reasoning and intuitive reasoning should be combined to come to well-thought decision.

8. Discussion & future research

This thesis presents new information on first-mover advantages and introduces the combination with the pattern of development and diffusion. The literature research from chapter three combines first-mover advantages with the pattern of development and diffusion, and chapter four presents a model and a flowchart to use first-mover advantages. Then, a case study and interviews are conducted to fill in the model and gather information to strengthen the proposed figures. Each chapter offers learnings; however, this chapter describes three general learnings from this thesis. In addition to the learnings, future research is proposed to investigate the interesting open endings.

Model & flowchart

Chapter four presents a newly designed model and flowchart that describe the decision-making process of entering a market using first-mover advantages and disadvantages. The model describes the relationship between the components that need to be taken into account and the flowchart describes the execution of the process. The model serves as a tool in chapter five and six to quantify the first-mover advantages and disadvantages. By having the model, it is clearer how the decision-making process can be split up. The model explains the context building blocks that are filled in as values during the case study, and the time-dependent first-mover (dis)advantages include weights that are filled in during the interviews. Together, they comprise a score (score = weights multiplied by values). While the model is utilized in chapters five and six, the flowchart is no longer utilized following its debut in chapter four. The fourth chapter discusses the flowchart and its processes, but it is not used in the thesis. This is primarily because it made research briefer, but it would be fascinating to determine the flowchart's utility.

There exists a distinction between the model and the flowchart. The primary distinction between the model and the flowchart is that the model describes solely analytical components, whereas the flowchart describes both analytical and intuitive components (the action and thoughts lane). The thoughts lane shows a continuous re-evaluation of the steps to be completed and introduces an intuitive component. The chapter argues that for some complex problems, analytical thinking is insufficient and intuitive reasoning based on experience and tacit knowledge is a necessary supplement. Although not defined in the model, this component is present in the decision-making process. The model depicts a strictly analytical perspective of the decision-making process, which is not incorrect given that these are the factors that influence a market entry situation. However, the final phase of the model's "strategy" employs an intuitive component. What a decision maker does with the information it has gathered is the thinking lane or intuitive portion of decision making.

It would be interesting to determine the effectiveness of the flowchart described in this thesis for future research. Four different approaches to the decision-making process could be tested as part of study. One group only uses the action lane to conduct analytical evaluations in order to evaluate the market entry opportunity. One group exclusively uses the thoughts lane and attempts to make decisions instinctively. One group utilizes both the action and thought lanes, while the remaining group receives no instructions. This study's research questions could include, *"What information gap exists after analyses to decide to enter a market?," "What is the information gap between intuitive reasoning and analytical reasoning in the decision to enter a market?",* or *"How useful is a step-by-step guide in the decision to enter a market?"*

Finding weights of first-mover advantages and disadvantages

The final two sub-research questions try to develop a score that, if attainable, would be highly helpful in assessing first-mover advantages and disadvantages. A strategy for quantifying the desirability of the order of market entry with weights attributable to a given point in time and values for the unique context and company creates a tangible scenario for a complex decision-making process. Theoretically, it seems extremely promising to break the process into parts in order to determine weights and values independently, and therefore to use distinct characteristics to construct the score. In practice, it is difficult to maintain this separation. During the interviews, the interviewees think to understand the purpose and objective of the interview. However, when the weights are quantified, we see that not just time (the time building block from the model) is considered, but also industry or technology characteristics. Between the two interviewees the answers are significantly different and so, not consistent. The requirement to be able to identify values and weights separately could be too far reached. It appears challenging to separate the two in the suggested environment. This does not mean it is impossible to separate the two but to accurately measure the weights, a different approach is needed. The interviews in this thesis used a structured approach but it did not produce the desired result. Although respondents were asked to provide weights, it looks like they supplied values or the score (score = weights multiplied by values). This conclusion is drawn because from their

answers it can be seen that not only the building block time is taken into consideration. This indicates that it may be preferable to gather the weights of the first-mover advantages and disadvantages through a different way, with the interviews then being used to assign values.

Multi-criteria decision analysis could be a strategy for resolving the challenge of determining weights. A multi-criteria decision analysis helps in structuring difficult problems and is especially effective in advanced and complex situations where the application is new. In this situation, the difficulty lies in assigning weights to first-mover advantages and disadvantages. The best-worst method is a multi-criteria decision analysis that evaluates a set of alternatives using a finite set of criteria (Rezaei, 2015). It is based on a systematic pairwise comparison of the decision criteria. The two sets of pairwise comparisons serve as input for an optimization problem that results in criteria weights (Rezaei, 2015). This method would assign weights to the first-mover (dis)advantages in a certain circumstance, thereby determining which advantages can be utilized in that situation. In this method, weights are accumulated in a structured manner with more reliable results.

Future research could explore the application of a multi-criteria decision analysis to the list of first-mover advantages and disadvantages in a particular situation. To ensure that the appropriate multi-criteria decision analysis is selected, the first research question could be, *"Which multi-criteria decision analysis is optimal for weighting first-mover advantages and disadvantages?"* Depending on the multi-criteria decision analysis the required input should be gathered. In case of the best worst method this would be *"Which criteria (first-mover (dis)advantages) play a role in phase X of the development of technology Y?"* Then, the next question would be, *"What are the weights of the first-mover advantages and disadvantages that belong to phase X of the development of technology Y?*" This thesis would first present information on whether or which multi-criteria decision analysis (or analyses) would be appropriate for determining first-mover advantages and disadvantages (the scientific contribution). Second, it would indicate which (dis)advantages should be prioritized for that technology in that period. This is highly helpful for organizations that are focusing on market entry and development (the managerial contribution).

Pattern of development and diffusion being influenced by first-mover advantages and disadvantages

At the end of the first part of the literature research this thesis provides a list of first-mover advantages and disadvantages. However, this list alone was insufficient to settle the argument on first-mover advantages, which has lasted approximately forty years. Guiding the dialogue of the deaf on being first, second or late to a constructive discussion requires a zoomed-out perspective that helps with the definition of a first-mover advantage. The rest of the literature research elaborates on the pattern of development and diffusion but more importantly on the combination of first-mover advantages and the pattern of development and diffusion. A list of first-mover advantages and disadvantages is helpful, and symmetries between first-mover advantages and disadvantages, and first-mover advantages and second-mover disadvantages help to understand what the relations between the advantages and disadvantages are. Yet, the eventual effect of a first-mover advantage, second-mover advantage, first-mover disadvantage, second-mover disadvantage, or any other order is the most important part of considering them. The pattern of development and diffusion demonstrates that a company's entry into a market can alter the development trajectory of a product category. It makes apparent that the scenario following your or a competitor's entry into the market is different and should be the most advantageous for your organization. So which circumstance is preferable:

1) The scenario in which you entered the market and the pattern of development and diffusion altered because of that. The status after your entry is the theoretically most favourable.

2) The scenario where a competitor entered the market and the pattern of development and diffusion changed accordingly. The status after the entry of your competitor is the theoretically most favourable.

While deciding to enter the market it should be taken into consideration that your entry influences the context. It should be considered before opting to enter the market that your entry would affect the setting. If the scenario is most favourable following your entry, you should enter. If the scenario is most favourable after a competitor enters, you should wait.. Weighing off the two scenarios is what you do with filling in the values for first-mover advantages and disadvantages. Complementary to this, a company should look at how well a situation suits other companies. Situation one can be theoretically most favourable for you but if a competitor can potentially profit even more from this situation (you entering first) a second consideration might be appropriate. Similarly for the second situation.

How much your entry (or the entry of a competitor) influences the development of a product category is hard to define. Here, multiple building blocks play a role. How dynamic the context is and how much your influence is on that context is caused by the industry characteristics, technology characteristics and the firm characteristics. If the context is very static, your entry should be considered as a drop of water on a hot plate. If the context is dynamic the plate might not be so hot after all, or your entry is represented by many drops of water. The amount of influence, and

thus the amount of change in the situation, you cause in relation to the context is important to define. If your entry can alter the scenario enough so market entry for competitors is not profitable anymore, the situation seems optimal.

Future research could dive deeper in the relationship between first-mover advantages and the change of context or development of a product category after market entry. As mentioned, interesting influencing factors are technology, industry and firm characteristics. A study could be done to look closely to where in the development of technology the most influence is caused by market entries. So, instead of which entry point is most favourable the research focuses on which entry point has the most influence on the development of a technology. The main research question of a research could be *"Which point in the development of a technology influences the development of a technology most?"* Another interesting research subject is the difference in usability of first-mover (dis)advantages between big and small companies with the new information presented in this thesis. Above it is argued that a situation differs after market entry but the amount it differs depends (among other things) on firm characteristics (for example the size). Is it even possible for small companies to take this change of context into account or is this useless because of their lack of impact? A research question for this research could be *"How much impact does the market entry of a small company have on the context of a product category?"* or *"What are minimal requirements for a company to have to significantly influence the development of a product category?."* For these questions, the unit of impact or a threshold of significant influence should be found but those could be very interesting to discover. This study would apply the concepts provided in this thesis in a new setting and potentially enrich the literature of first-mover advantages and the pattern of development and diffusion.

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Appendix A: Interview materials

Interview case

For this interview we will look at two moments in the history of the electric car market and look at the decision to enter the market. The electric car has a rich history, but the focus will be on two points. To make the decision to enter a market or not you normally gather information for multiple aspects. The information that plays a role in this decision is displayed in the model from figure 36.

On the left a building block can be seen that consists of first-mover advantages and disadvantages. These are advantages and disadvantages of entering a market early or late, summarised in table 22 and 23. Then the moderating factor time influences that list. Those are the first-mover (dis)advantages at that moment in time. Time within this model consists of three parts: the relative time when a company wants to enter (represented hours, months, etc.), the order (first, second, etc.), and the entry point with the accompanying phase (innovation, adaptation or stabilisation). The right part of that has to do with the market and firm characteristics in relation to the first-mover (dis)advantages.

The accompanying phase means the phase within the pattern of development and diffusion. An example of the pattern of development and diffusion is displayed in figure 37. This is a pattern that displays the development and diffusion of an innovation, which normally starts with the invention of a technological principle, at some point in time a first product will be launched into the market and (if it gets that far) large-scale diffusion will start. An example can be the LP. The technological principle was invented, then some time later the first version was introduced in the market, and after multiple versions were brought to market, the large-scale diffusion started and almost everybody had LPs.

For this interview we will focus on a small part of the model, the circle in figure 38: the standard list and the influence of time.

On the left we see the building block "Standard list of first-mover (dis)advantages." This building block entails a list of first-mover advantages and disadvantages displayed in table 22 and 23. This will be the main interest of the interview. We will now first go through the advantages and disadvantages of tables 22 and 23.

Now first some questions on the information you have seen.
Q: Is it clear and what is your first impression?
Q: Everything clear? – if not, more explanation will be given

Episode 1: 1995

The first period we will look at will be around the year 1995. Among other legislative and regulative actions, the 1990 Clean Air Act Amendment, 1992 Energy Policy Act, regulations by the California Air Resources Board (making automakers sell a small percentage of vehicles that made no emissions) and several states issuing the Zero Emissions Vehicle requirements are in place. The past years have been interesting, and you have the choice to develop your new electric car and enter the market. In figure 34, the pattern of development and diffusion until 1995 can be seen which gives an overview of the long history. We now look at the point in time at the far right.

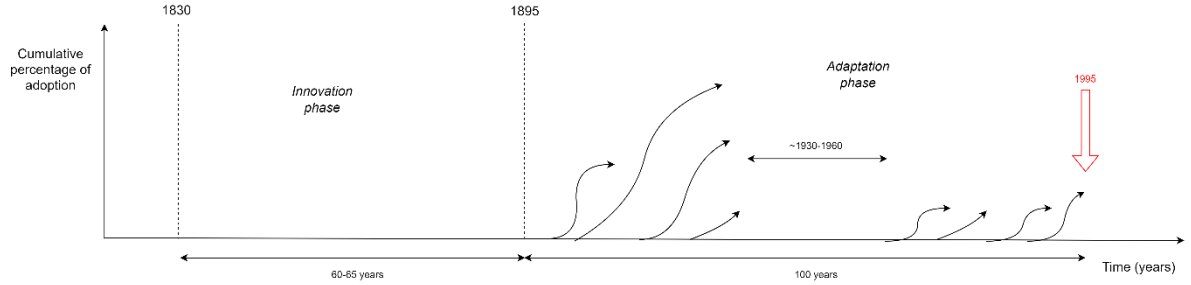

Figure 31: Pattern of development and diffusion of the electric car until 1995.

We are in 1995 and know that some electric cars have been introduced in the market in the past 20 years. These cars are shown in table 21.

Company	*Car*	*Year*
Sebring-Vanguard	Citicars	1974-1977
Elcar Corporation	Elcar	1975
Commuter Vehicles	Commuta Car	1979
American Motor Company	Electric delivery jeeps	1975
Unique Mobility Inc	Unique Mobility Electrek	Late 1970s
Electric Vehicle Associates	EVcort	1981-1994

Table 21: Introduced cars 20 years prior to the episode.

Q: How would you describe the context of this situation?

Q: How would you tackle this decision-making process normally?

Now we will have a second look at the list of first-mover advantages and disadvantages. With the knowledge you have and the model that has been presented,

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 22 and 23.

Q: How would you weigh the first-mover disadvantages at this place in time?
Q: Now that you know the context and weights of first-mover (dis)advantages, would you enter the market?

Episode 2: ~2010

The second period will be the point around 2010. Tesla introduced the Tesla Roadster in 2008, the Mitsubishi i-MiEV was launched in Japan in July 2009 and in Europe in December 2010, the Peugeot iOn in 2010 and the Citroën C-Zero in 2010. In 2009, senior leaders of several large automakers including Nissan and General Motors stated that the Tesla Roadster acted as a catalyst for more efficient vehicles, especially with the introduction of the Lithium-ion battery. In figure 5, the pattern of development and diffusion of the electric car until 2010 can be seen. It can be noted that it is not so different from the pattern of development and diffusion until 1995 because no big changes had been made.

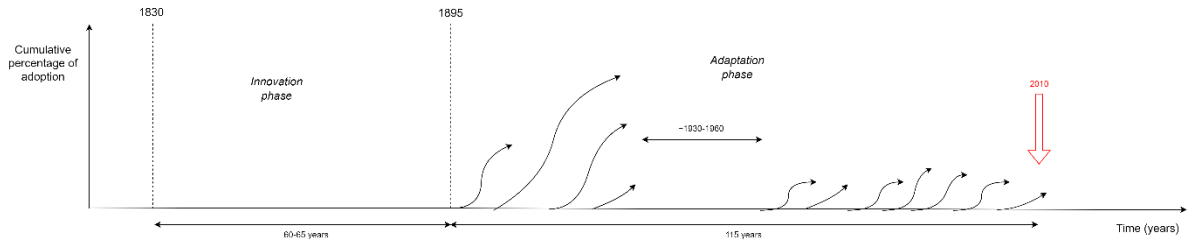

Figure 32: Pattern of development and diffusion of the electric car until 2010.

For this moment, we again will answer the questions

Q: How would you describe the context of this situation?

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 24 and 25.

Q: How would you weigh the first-mover disadvantages at this place in time?
Q: Now that you know the context and weights of first-mover (dis)advantages, would you enter the market?
Q: Now that we've weighed the first-mover (dis)advantages, what do you think of the list of first-mover advantages and disadvantages?

Figures

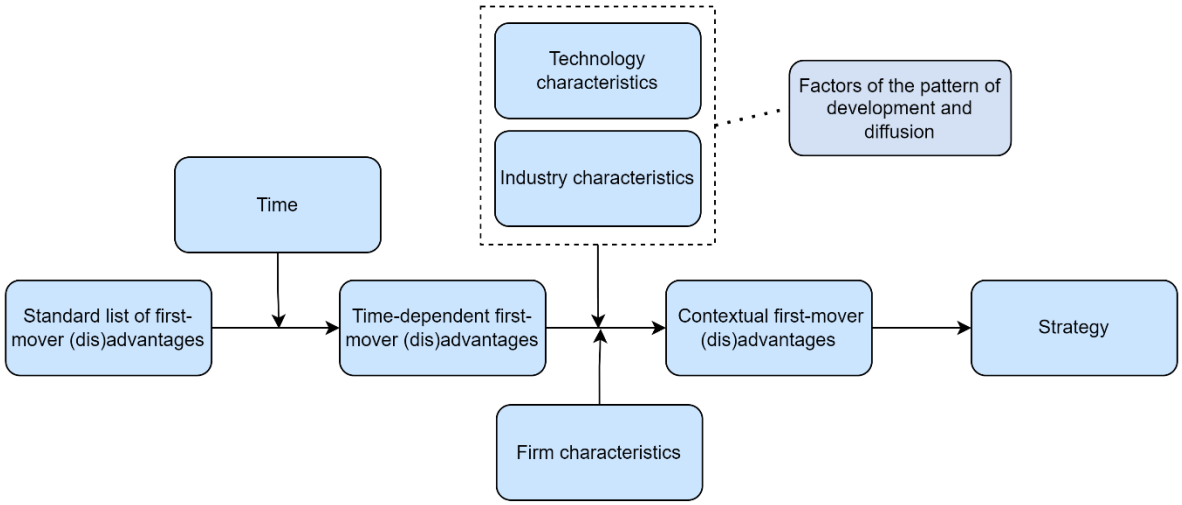

Figure 33: Model to take into account first-mover (dis)advantages in entering a market.

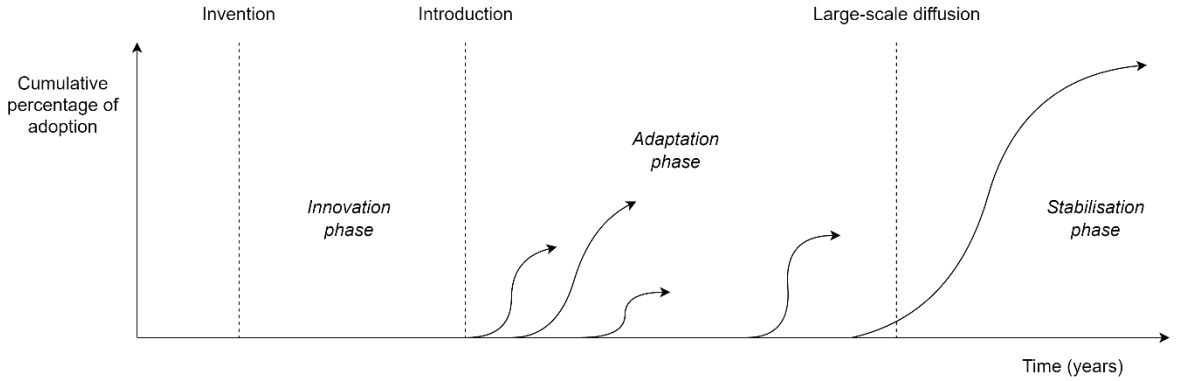

Figure 34: Pattern of development and diffusion of undefined innovation (Ortt, et al., 2007).

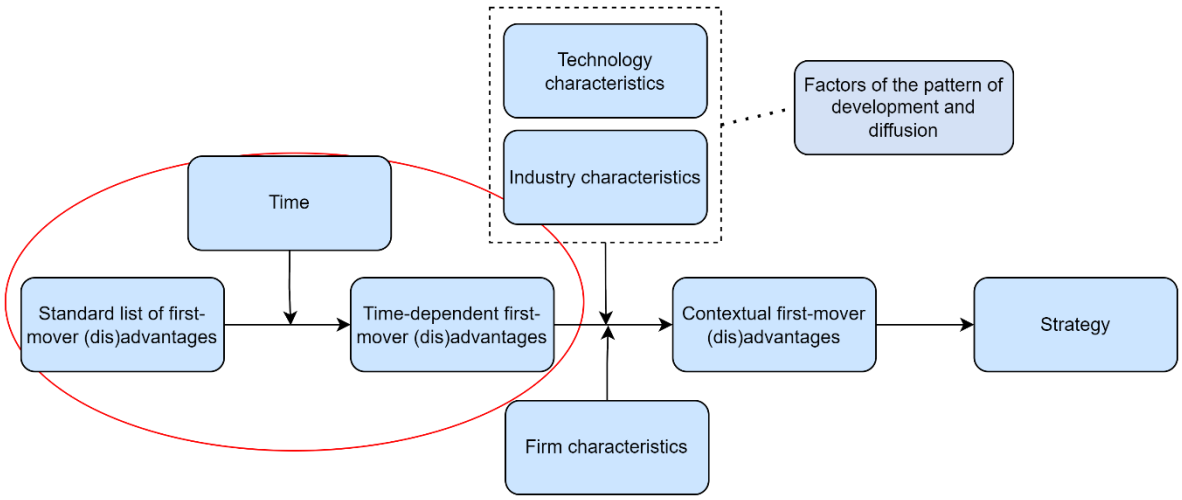

Figure 35: Part of interest for the interviews.

Tables

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 1**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	

Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	

Table 22: First-mover advantages for 1995.

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 1**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	

Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	

Table 23: First-mover disadvantages for 1995.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 2**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will	

	prevail later in the evolution of the market because of superior information.	
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	

Table 24: First-mover advantages for 2010.

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 2**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	

Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	
Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	

Table 25: First-mover disadvantages for 2010.

Raw results interview 1

Interview case

Interviewee information

Professor in Transport Policy at Delft University of Technology, the Netherlands, faculty Technology, Policy and Management. Main interests are in long-term developments in transport, in the areas of accessibility, land-use transport interaction, (evaluation of) large infrastructure projects, the environment, safety, policy analyses and ethics.

The case

Q: Is it clear and what is your first impression?

B: Is it about a new company or an established company that enters a market?
S: It is about a bigger company that wants to enter the market.

B: What is the core of your research? You want to include dynamics over time?

We go into some elaboration on the pattern of development and diffusion.

B: Are characteristics of the technology itself in the model?
S: yes, they are in the building block Technology characteristics

B: And context? Electric cars in NL, Brazil, etc.
S: yes

B: It amazes me that the context and technology characteristics do not affect "current first-mover advantages". I would say that context and innovation characteristics strongly influence first-mover advantages.
S: Yes, but in this model, we implemented an in-between step.

B: For me it is a bit illogical that only time influences the current first-mover advantages. VERY IMPORTANT POINT THAT HE SEEMS TO DISAGREE WITH THE MODEL.

A second elaboration is given but it is decided to go on with the other interview questions.
Q: Everything clear? – if not, more explanation will be given
B: Yes, I think it is clear. If I also agree with everything, that I do not know, but I do understand it.

Episode 1: 1995

B: Gijs Mom wrote his "proefschrift" on the history of the electric car and talks about why the electric car failed. That mainly had to do with image and framing, electric cars were for losers and women. It had nothing to do with the functionalities but only with the image. The electric car won races, but people did not believe it because the electric car was not a "real" car in the eyes of many people.

Q: How would you describe the context of this situation?

In 1992, California announced that in 1998 2% of sales had to be zero emission, zero emission meaning electric. Hydrogen wasn't an option and there were no alternatives. So, in 1998 2% of sales were to be electric cars. But there were opposing parties. The American automotive industry did not like this and tried to go against the regulations. An innovation researcher from Utrecht University described this. The automotive companies did not want to go against the regulations themselves, but daughter companies had to do this. This was successful because the policy eventually was not implemented. So, around 1995 the threat of the policy was at play but on the other side there was uncertainty about if the policy was going to be implemented.

First-mover advantages were mainly a guess if the policy was pushed. It was only in California but was seen as an example for other States. Therefore, I think the context is that important. The super important context variable was how policy would develop.

We already had the Lithium-ion battery, production costs were high, so lithium wasn't default.

Q: How would you tackle this decision-making process normally?

The big difference would be if I'm an American automotive company (or a company that focuses on the American market) or if I'm focusing on a different market. The American automakers traditionally sold many of their cars in their own country. The percentage of exports is way lower than that of Japanese automakers. That means that for American manufacturers it was more important if that policy was pushed. Equal for companies that aim to sell in the US. Will that policy go through? Then we must enter the market. (It was purely a policy push) How big is the possibility the policy goes through, can I come out of it with a fine or can I not sell at all if I'm not selling 2% electric.

I would have drawn multiple policy options on one axis and on the other axis I would have put strategies on the other axis. So, selling electric cars and how. Only the amount of cars sold was important, no km driven. You could

launch a couple of small electric cars as an addition. Could I easily remake ices into electric, you could sell them with a loss to be able to sell normal ice cars.

Now we will have a second look at the list of first-mover advantages and disadvantages. With the knowledge you have and the model that has been presented,

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 2 and 3.

Q: How would you weigh the first-mover disadvantages at this place in time?
Q: Now that you know the context and weights of first-mover (dis)advantages, would you enter the market?

Because the automotive lobby was very strong (also in Germany) I would take into account that the policy would not be implemented. Years went on with a debate so I would probably not enter the market.

Episode 2: ~2010

Q: How would you describe the context of this situation?

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 4 and 5.

Q: How would you weigh the first-mover disadvantages at this place in time?
Q: Now that you know the context and weights of first-mover (dis)advantages, would you enter the market?

Yes, because at this time, there were many indicators that environmental and air pollution became important. So, bringing a car onto the market I don't know but definitely adopt a strategy that could help me with introducing an electric car in the near future.

Q: Now that we've weighed the first-mover (dis)advantages, what do you think of the list of first-mover advantages and disadvantages?
S: Anything to add/change?

I think that you will change the conceptualisation of the model. I don't think that the factor time can be taken apart for every innovation but that it is very much dependent on the context. It cannot be taken apart from the context.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 1**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*7*, Could surely play a role, if you develop an interesting vehicle and can export this to other States, that could be important. If the policy was established, it did not, but you did not know that by then. But with much uncertainty because policy is unknown. However, still it could be important if the policy was not pushed because you could enjoy the reputation.
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*7*, Also important. There were no electric cars and customer expectations, at least not on experience. So, if you could show the possibilities that would be important.

Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*7*, also important. Side note: the combination of components, electric motor and battery development was already quite developed. So, the learning curve was important, not for the single components but it was for the combination. Maybe more experiments with lithium-ion batteries were done.
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*4*, patents are difficult because I don't know how much you need patents on top of battery and motor knowledge, for the combination it is unsure if patents are needed.
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	*4*, accus and electro motors were already developed. It was about low amounts so pre-emption in that moment was not that important. If you would say that from 2% in 1998 it would go up, it could be important but at that moment it was not as important.
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*2*, Locations were not important, automotive manufacturing was quite footloose, a factory could be easily changed from locations.
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*2*, not as important as in 1970, it was quite easy to pick up a factory and set it up in a different place.
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*2*, electromotors and batteries were familiar technologies so switching costs were not high.
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover	*4*, in this period brand loyalty was more important.

	can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 1**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*3*, Not as much R&D costs for producing an electric car but mainly the costs that you've put into developing internal combustion engines that go to waste. Do you also take into account early depreciation expenses of the ice? The market of cars is not growing much because of the introduction of electric cars. At that moment it was not that big because the amounts that had to be sold were not as much. So, you could maybe rebuild the ice into an electric car.
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	*2*, distribution was mainly dealt with via traditional lines.
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*4*, You must educate them about recharging and range, what if a battery does not work. You must tell people what is important, so it plays a role.
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*2*, At that time you could charge your car with a normal electricity socket. In America most people live in spacious homes, and they probably were the first to buy so this would not be that important.
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*10*, Super important, it was unclear if the policy would go

		through. Market uncertainty was the most important question.
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*6*, Technology is also important, if it is obligatory, it would boost the technology, also battery technology.
Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*2, When it was about 2% and the automotive market was growing, it was not that important. So, if you look at 2% and only in California it becomes not important.*
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*3,* At that time it was not that important (later more important when hydrogen motor was introduced but not now)
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*Americans were way more conservative.* *American 5-6, Toyota/Nissan 2-3, VW in between.*

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 2**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	*8*, way more important because people thought that electric cars would enter the market somewhere around here.*
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	*8*, very important.

Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	*8,* very important
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	*6,* probably less important but the interviewee says that he has less knowledge about this factor.
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	*7,* important for battery technology but not known for electric cars
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	*2,* less important because of footloose
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	*4,* volume went up in America, so it became more important
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	*5,* yes because there were discussions about how much to invest in diesel motors.
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	*4,* more policy uncertainty.

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 2**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	*6, are we putting our money on electric or not and way bigger amounts of money*
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	*4, also more important than in 1995*
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	*7,* yes, many test-pilots were done and how did people react
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	*7,* recharging infrastructure became important
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	*9, uncertainty was still very big. World scale? A lot of uncertainty on policy*
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	*7, also more important*
Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	*7, also more important*

Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	*6, people were also thinking that hydrogen would become an important competitor (BMW said that they would introduce a hydrogen motor in 2017 but this could also be window dressing to stop the policies)*
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	*6, fairly important because automotive companies had traditional (old) thought patterns but different between companies.*

*Interviewee mentions that the numbers are relative towards the factors of the same time should not be seen as absolute numbers. So, reputation as technology leader in 1995 which got a 7 is a seven regarding the pre-emption of input factors in 1995 and not 7 regarding the 8 of reputation leader in 2010.

Raw results interview 2

Interviewee information

Teacher at IvA Automotive Business School. Almost 50 years of experience in the automotive market. Has worked for Toyota and Alfa Romeo. Also owns a car taxation company.

The case

Now first some questions on the information you have seen.

Q: Is it clear and what is your first impression?

Politics have an underlying factor. Lobbyists play a big role. That is hard to prove but an important point to take into account.

Q: Everything clear? – if not, more explanation will be given

Yes, I think so. You want a marketing strategy with an analysis that you leave little to chance and feeling so you can take anything into account. For example, that you're too late with resources. Now you see with electric cars that the demand for red copper is high. If you're in stocks, you can invest in copper mines. Currently the demand for Lithium is also high, that price went up by 500%. Electric cars are dependent on specific materials.

Episode 1: 1995

Interviewee points out that he thinks the first introduction of the electric car was around 1885.

Interviewee points out that the EV1 from General Motors also belongs to the list above.

Q: How would you describe the context of this situation?

1) I think environmental requirements, that people were more aware of fossil fuels were diminishing. Not so much the impact or polluting effect but more running out of fossil fuels and being dependent on the Middle East and Russia.
2) More environmentally aware.

Those two were the main reasons why more electric cars had been brought to market. This caused a peak in the development of the electric car but eventually was put down by the automotive industry itself. They didn't want to change because that costs a lot of money. You saw it with the EV1, they retrieved all those.

Now we know that fossil fuels were not running out, but at that moment we didn't know.

It is comparable to the coal story. Around 1900, they thought that we were running out of coal and that coal would be bad for the environment, so alternatives were investigated.

Q: How would you tackle this decision-making process normally?

Brand loyalty and range were the main important factors. People had to trust in your brand and your product. A good product was needed so you didn't acquire a bad name for yourself. No mistakes were allowed. The Toyota Prius had to be the example for electric and hybrid cars. The first models were sold with a loss to gain the trust. Building a strong brand name was important. Also, affordability was important, and that was a problem for the Prius. A big company could bear the losses at the start.

Now we will have a second look at the list of first-mover advantages and disadvantages. With the knowledge you have and the model that has been presented,

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 2 and 3.

Q: How would you weigh the first-mover disadvantages at this place in time?

Q: Now that you know the context and weights of first-mover advantages, would you enter the market?

Very difficult. This is an entrepreneurial question. I think personally that I would not have taken the risk. Only if there was no other possibility. The risk was too big, and it was too unsure how in five years the automotive industry would look. Too unsure. And in hindsight small companies did not make it. The risk could only be borne by big companies. Nobody had a vision on how it would turn out with electric cars. It cost many companies a lot of money and most of them were not profitable.

Episode 2: ~2010

For this moment, we again will answer the questions

Q: How would you describe the context of this situation?

In 2010, it wasn't the question of fossil fuels, we will run out of fossil fuels but the being independent of resources and way more environmental obligations by the government. The government put up high environmental requirements. In 2010 the regulations made more space for electric cars. The government obliged companies to have a green footprint, otherwise you would not be able to do business. If you wanted to build roads, you had to have electric vehicles, if you wanted to be a gardener you had to have an electric leaf blower. You had to have a green footprint. BPM was 0%, road taxes were 0%, so it became a different story. In big cities in Asia the government had to step in. So, the electric car was pushed by the government. You could not live in big cities because of the pollution.

Q: How would you weigh the first-mover advantages at this place in time? Please fill in tables 4 and 5.

Q: How would you weigh the first-mover disadvantages at this place in time?

Q: Now that you know the context and weights of first-mover (dis)advantages, would you enter the market?

In this case I would definitely consider it. A lot more chances than in 1995. In 2010 there was way more certainty that battery electric would be the new thing.

Q: Now that we've weighed the first-mover (dis)advantages, what do you think of the list of first-mover advantages and disadvantages?

In my opinion some of the first-mover advantages and disadvantages overlap and influence each other. For example, R&D developments influence customer expectations. Those things cannot be kept apart.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 1**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	2-3, this is especially important for a high-end technological product. It is difficult to put a good product on the market first.

Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	10, very important. People didn't know yet what the electric car would look like. It was something novice.
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	10. Affordability of the car was a problem. At first no profits were made, and the bet was on the long term. A big company could bear it because they had enough money.
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	10, very important.
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	10, pre-emption of materials is very important. For example, copper mines or companies that made electromotors.
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	5-6, less important. Somewhere in the middle. Every location has pros and cons.
Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	4, most machines are universal. Not very important.
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	1, this was not of any importance.
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	9-10, Very important. If a small brand would have brought it up, it would stick, from a big company it would. Important to put it on the market well so they knew Toyota could make a good hybrid car.

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 1**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	4, development costs of electric engines were lower than combustion engines. Most costs were in the batteries but in 1995 that wasn't really important. There already existed many electric motors. Not much had to be developed.
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	4, not a very important point.
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	8. There was fear of the range. It was quite important to educate how you had to handle an electric car.
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	1-2, in 1995 this wasn't a big problem. The most products were available.
Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	8, it was unsure how the future would develop. The lobby, the competition, it was all unsure and important.
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	1, innovations did not seem to change much in the future. There was speculation on hydrogen technologies, but nobody believed that would become a thing in the upcoming time.
Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	5, It is hard to say without geopolitical nuance. If you can sell your older product line in a different geographical location (say Africa) this is not a problem. If that is not possible, the problem is more significant. *

Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	4, not really a big problem. You had to watch out for the amount of stock you bought but nothing really strange.
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	2, I don't think this was important. Big automotive companies could switch quite quickly.

Technological leadership	(1 = not able to capitalise on this advantage, 10 = very able to capitalise on this advantage)	**Scenario 2**
Reputation as technology leader	A first-mover has the opportunity to place itself in the market as the first to develop a certain technology and establish a technology leader position in the mind of customers.	2, Not important. Bigger companies could run over it easily.
Shape customer expectations	By bringing the first product to market, a company can show what the product should look like. Customers do not have any frame of reference yet so this can still be shaped.	3, not a particular advantage you could reap at that moment as a first-mover.
Learning curve	In the standard learning-curve model, unit production costs fall with cumulative output. This generates a sustainable cost advantage for the early entrant if learning can be kept proprietary and the firm can maintain leadership in market share.	10, very important. With this factor you could get an advantage on the competition.
R&D patents	The first who develops an innovative technology can patent it to protect it. This could result in extraordinary profits.	10, very important. It would cost a lot of money but could be worth it.
Pre-emption of scarce assets		
Pre-emption of input factors	As a first-mover you may be able to purchase assets at prices below that will prevail later in the evolution of the market because of superior information.	10, very important. Batteries that Tesla could buy from Panasonic were not available to other companies.
Pre-emption of locations in geographic and product characteristics space	A first-mover may be able to prevent entry through strategies of spatial pre-emption. Markets that have room for a limited number of profitable firms may be used for this advantage.	4, Not so important. It is not more important than normal, but every company wants a strong geographic and product space.

Pre-emptive investment in plant and equipment	The enlarged capacity of the first-mover serves as a commitment to maintain greater output following entry, with price cuts threatening to make entrants unprofitable.	1, specific plant and equipment were not important.
Exploiting buyer and switching costs		
Switching costs	Switching costs arise from initial transaction costs or investment that the buyer makes in adapting to the seller's product or switching costs can stem from supplier-specific learning by the buyer.	1, not important.
Buyer choice under uncertainty / brand loyalty	Brand loyalty is a positive association of customers towards a company which results in repeat purchase despite competitors' actions to win over the customer (Kopp, 2021). A first-mover can build brand loyalty before the entry of competitors. The first-mover exploits the fact that a buyer may rationally stick with the first brand they encounter that performs the job satisfactorily.	10, very important. If they know you can deliver a quality product, then it's very important.

Free-rider effects	(1 = not a significant disadvantage, 10 = very much a disadvantage)	**Scenario 2**
R&D expenses	The first one to introduce a technology often has most costs of development. Not only the development costs for that product but also development paths that turned out to be unsuccessful (exploratory research).	9-10, at this point very important. Development costs were very high.
Infrastructure development	Innovative technologies most of the time lack suppliers and/or distributors. Later entrants benefit from the earlier demanded infrastructure.	1, not important because you could sell and buy at many places
Educating buyers	Buyers often do not know how they can benefit from innovative technology. Education could for example be done via test pilots, use-cases, etc.	10, very important. Education about range, maintenance and security.
Immature enabling technologies and complements	The success of technologies often relies on complementary products and well-developed production methods. If these enabling technologies do not exist, costs must be made to develop those technologies, or the success chances decline significantly.	10, charging stations were very important. Automotive companies had to help this.

Resolution of technological or market uncertainty		
Market and technology resolution expenses	Late-movers can gain an edge through resolution of market or technological uncertainty	8, yes important. It was still unsure how it would develop.
Shifts in technology or customer needs	Following the line of Schumpeter's (1934) creative destruction, existing products by new firms' innovations. Since innovative technologies often arise when old technologies are still growing, incumbent firms find themselves in a difficult position to correctly perceive the threat.	1, not important. It was known what the customers wanted.
Incumbent inertia		
Cannibalisation of own product line	A first-mover is less likely to innovate than a follower, since its own innovation destroys return on the firm's existing products (Arrow, 1962).	5, similar argumentation as for 1995 .*
Lock-in on a specific set of fixed assets, knowledge, or other resources	A firm with heavy sunk costs in fixed plant or marketing channels that prove sub-optimal may find it rational to "harvest" these investments rather than attempt to transform itself radically.	3, knowledge for many cars was similar. It was not really important that you could lock-in on certain people with only electric car knowledge.
Organisational inflexibility	Organisational inflexibility entails limited adaptive response by first-movers on, the development of organisational routines and standards, internal political dynamics, and the development of stable exchange relations with other organisations (Hannan and Freeman, 1984).	1, not important.

*The interviewee immediately thinks about cannibalisation of a product from a different product category, the internal combustion engine. Cannibalisation of an earlier model of the electric car is eventually answered but the main thing that seems of importance is cannibalisation of different product lines by the electric car. So, the electric car causes cannibalisation of the internal combustion engine product line.

Appendix B: Raw list of first-mover (dis)advantages

First-mover advantage category	Specific advantage	Reference
Technological leadership		Lieberman & Montgomery, 1988
Brand Loyalty and Technological Leadership		Schilling, 2020
Brand Loyalty and Technological Leadership	Reputation as technology leader	Schilling, 2020
Brand Loyalty and Technological Leadership	Brand loyalty	Lieberman & Montgomery, 1988
Brand Loyalty and Technological Leadership	Shape customer needs	Schilling, 2020
Brand Loyalty and Technological Leadership	Learning curve	Lieberman & Montgomery, 1988
Brand Loyalty and Technological Leadership	R&D and patents	Lieberman & Montgomery, 1988
Pre-emption of scarce assets		Lieberman & Montgomery, 1988
Pre-emption of scarce assets		Schilling, 2020
Pre-emption of scarce assets	Pre-emption of input factors	Lieberman & Montgomery, 1988
Pre-emption of scarce assets	Pre-emption of locations in geographic and product characteristics space	Lieberman & Montgomery, 1988
Pre-emption of scarce assets	Pre-emptive investment in plant and equipment	Lieberman & Montgomery, 1988
Switching Costs and Buyer Choice Under Uncertainty		Lieberman & Montgomery, 1988
Exploiting Buyer Switching Costs		Schilling, 2020
Exploiting Buyer Switching Costs	Switching costs	Lieberman & Montgomery, 1988
Exploiting Buyer Switching Costs	Buyer choice under uncertainty	Lieberman & Montgomery, 1988
Reaping increasing returns advantage		Schilling, 2020
Early entrants attract better customer evaluations		Kirjavainen et al., 2020
Barriers of entry	From economies of scale, experience curve effects, proprietary technology, and patent protection	Niu et al., 2012; Robinson and Fornell, 1985; Stringham et al., 2015). From First-mover advantages and innovation success: a contingency approach paper
	Larger firms' greater resources (financial physical and intangible) available to market innovations increase the likelihood of innovation success, generating FMA for large firms	Chavez & Chen, 2021
	Larger firms' greater resources (financial, physical, and intangible) available to develop innovations increase the likelihood of innovation success, generating FMA for large firms when they are pioneers	Chavez & Chen, 2021
	High market orientation increases the likelihood of innovation success, generating FMA for market oriented pioneering firms	Chavez & Chen, 2021
	Higher brand equity reduces customers' perceived risk in accepting its innovations, generating FMA for	Chavez & Chen, 2021

	pioneering firms with brand recognition	
	Entry barriers have an inverted-U-shaped relationship with the likelihood of success of an innovation, and as such with generating FMA for pioneering firms	Chavez & Chen, 2021
	High market competitiveness protects existing innovations and increases the likelihood of innovation success from incumbent firms, generating FMA for incumbent pioneering firms	Chavez & Chen, 2021
	High market competitiveness requires more resources for the success of innovations from later entrants, generating FMA for incumbent pioneering firms	Chavez & Chen, 2021
	Market maturity has an inverted-U-shaped relationship with the likelihood of innovation success and, as such, with generating FMA for pioneers	Chavez & Chen, 2021
	Higher product contingency increases switching costs of innovations within a product category for later entrants, generating FMA for pioneering firms	Chavez & Chen, 2021
	Higher search costs reduce the likelihood of success of innovations from later entrants, generating FMA for pioneering firms	Chavez & Chen, 2021
Market/customers	Switching costs Consumer loyalty	Cho et al., 1998
Market/customers	Switching costs Uncertainty	Cho et al., 1998
Market/customers	Switching costs Transaction costs	Cho et al., 1998
Market/customers	Switching costs Formal contracts	Cho et al., 1998
Competition	Pre-emption Input factors	Cho et al., 1998
Competition	Pre-emption Production capacity	Cho et al., 1998
Competition	Pre-emption Market-side opportunities	Cho et al., 1998
The Firm	Learning by doing Technological leadership	Cho et al., 1998
The Firm	Learning by doing Learning curve effect	Cho et al., 1998
The Firm	Learning by doing Overcoming market complexities	Cho et al., 1998

First-mover disadvantage category	Specific disadvantage	Reference
Free-rider effects		Lieberman & Montgomery, 1988
Free-rider effects	R&D expenses	Lieberman & Montgomery, 1988
Free-rider effects	Infrastructure development	Lieberman & Montgomery, 1988
Free-rider effects	Educating buyers	Lieberman & Montgomery, 1988
	Absence of complementary products	
	Absence of production methods	
Research and Development Expenses		Schilling, 2020
Undeveloped Supply and Distribution Channels		Schilling, 2020
Immature Enabling Technologies and Complements		Schilling, 2020
Uncertainty of Customer Requirements		Schilling, 2020
Resolution of technological uncertainty		Lieberman & Montgomery, 1988
Resolution of technological uncertainty	Market resolution expenses	Lieberman & Montgomery, 1988

Resolution of technological uncertainty	Technological uncertainty resolution expenses	Lieberman & Montgomery, 1988
Shifts in Technology or Customer Needs		Lieberman & Montgomery, 1988
Incumbent inertia		Lieberman & Montgomery, 1988
Incumbent inertia	Cannibalisation of own product line	Lieberman & Montgomery, 1988
Incumbent inertia	Lock-in on a specific set of fixed assets, knowledge, or other resources.	Lieberman & Montgomery, 1988
Incumbent inertia	Organisational inflexibility	Lieberman & Montgomery, 1988
	Larger firms' greater internal resistance to innovation decreases the likelihood of innovation, inhibiting FMA for large firms when they are pioneers	Chavez & Chen, 2021
	Larger firms' more aggressive push against marketing of innovation decreases the likelihood of innovation success, inhibiting FMA for large firms when they are pioneers	Chavez & Chen, 2021
	Higher replacement costs increase the likelihood of success of innovations from later entrants, inhibiting FMA for pioneering firms	Chavez & Chen, 2021
	Simpler quality measurement increases the likelihood of success of innovations from later entrants, inhibiting FMA for pioneering firms	Chavez & Chen, 2021
Market/Consumers	Changes in consumer tastes	Cho et al., 1998
Market/Consumers	Changes in technologies	Cho et al., 1998
Market/Consumers	Free-rider effects Consumer education	Cho et al., 1998
Market/Consumers	Free-rider effects Information spill over	Cho et al., 1998
Market/Consumers	Free-rider effects Skipping trials and errors	Cho et al., 1998
Competition	Incumbent inertia Lock-in of assets/resources	Cho et al., 1998
Competition	Incumbent inertia Organisational inertia	Cho et al., 1998
Competition	Incumbent inertia Technological leapfrogging	Cho et al., 1998
The Firm	Enhanced level of information Resourcefulness	Cho et al., 1998
The Firm	Enhanced level of information Shared experience or assets	Cho et al., 1998

Appendix C: Larger figures