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Determining key success factors for adoption of radical architectural innovations in the heavy-duty trucking industry in the Netherlands

a BWM Approach

by

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EXECUTIVE SUMMARY

The past years there has been a major shift in the automotive industry from regular combustion engines that require the use of fossil fuels to more sustainable power trains. Also, innovations as autonomous driving are expected to make transport more sustainable. Especially now, as fuel prices are rising, regulatory pressures and global warming is increasing, the trucking industry is looking to adopt these radical innovations. These disruptive innovations require companies in the heavy-duty trucking industry to transform the current socio-technical system to increase the adoption rate of sustainable transportation possibilities.

This thesis focuses on two main innovations, zero emission HDT power trains and fully autonomous heavy duty trucks. Battery electric (BE) and fuel cell electric (FCE) powered vehicles are considered the best potential zero-emission power trains solutions. Autonomous and connected vehicles are considered the promising future of safe and efficient transport. The scope of this thesis focuses on one main stakeholder: the logistical service providers. For logistical service providers decarbonisation is a chance to modernize and reduce emissions while improving their own operations. These logistical service providers are the decision makers, whether these innovations are adopted or not. What factors determine the adoption of these radical architectural innovations?

The understanding of how innovations disperse and spread across companies is a topic that many companies and researchers are interested in. However, there has not been significant research in the adoption of radical architectural innovations in the heavy duty trucking industry in the Netherlands. The main objective of this thesis is to set up factors that decision makers perceive as important when adopting radical architectural innovations. Where after, by applying the BMW, weights will be assigned to these factors to determine the key success factors of innovation adoption. Therefore, the main research question is as follows:

Which key-success factors determine the adoption of radical architectural innovations in the heavy-duty trucking industry in the Netherlands, according to industry experts?

The following sub-questions are introduced:

- *Which success factors influence radical innovation adoption, according to literature?*
- *What factors do heavy-duty trucking industry experts identify when adopting radical innovations?*
- *What is the importance of these factors according to heavy-duty industry experts?*

This research has found that the key success factors for radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands are 'governmental regulations', 'strategic motives' and 'supplier supporting efforts'. The least important determinants are 'bandwagon effect', 'trialability' and 'end user acceptance'. This research finds 'governmental regulations' to be the most important factor for the implementation of BE- or FCE powertrain HDT and fully autonomous heavy duty trucks. Due to the high purchasing costs and complexity, logistic service providers are dependent on the governmental subsidization and regulations regarding (as indicated by industry experts) maximum weight, allowance on public roads and ethical jurisdiction.

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With a bachelors in Science Business and Innovation, I found the topic of innovation adoption to be incredibly intriguing and a great challenge that I enjoyed all the aspects of.

The learning curve that I went through was immense and I am very thankful for the opportunity the TPM faculty has provided me with. This project marks the end of my academic career and the past 2 years at the Technical University of Delft have inspired me and teached me lessons that I will prosper for the rest of my life.

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1 INTRODUCTION

The concern for global warming has been a worldwide major topic the last decade with air pollution by human made gasses being mainly produced by the transport industry (Abro et al., 2019). Due to the high demand in supplying transportation worldwide, approximately 11 billion liters of gasoline, diesel, heavy fuel oil and jet fuel is used per day (Kalghatgi et al., 2018). This results in the transportation sector being accountable for around 14% of global greenhouse gas emissions (Booker, 2021).

Following the Kyoto Protocol in 1997, the Paris Agreement at COP 21 in 2015 resulted in a stronger commitment from majority of the 197 Parties to "strengthen the global response to the threat of climate change.." (Agreement, 2015). In the EU, countries have set up sustainable transport targets for 2050 aiming to reduce global warming (Commission, 2021). Many carriers choose for road transport as it directly contributes to the global economy and national economies efficiency. However, the emissions have direct negative impact on local health, air pollution and the global greenhouse effect (Teixeira et al., 2021).

Therefore, the past years there has been a major shift in the automotive industry from regular combustion engines that require the use of fossil fuels to more sustainable power trains. Also, innovations as autonomous driving are expected to make transport more sustainable. Especially now, as fuel prices are rising, regulatory pressures and global warming is increasing, the trucking industry is looking to adopt these radical innovations. These disruptive innovations require companies in the heavy-duty trucking industry to transform the current socio-technical system to increase the adoption rate of sustainable transportation possibilities (Amelang, 2021). These obligations make actors in the heavy-duty trucking industry face a new challenge in meeting sustainability standards in their operations and fleets.

Sustainable innovations

This thesis focuses on two main innovations, zero emission HDT power trains and fully autonomous heavy duty trucks. Battery electric (BE) and fuel cell electric (FCE) powered vehicles are considered the best potential solutions (Cunanan et al., 2021). However, when adopting these zero emission trains, the infrastructure and entire logistic freight system will have to adjust. Autonomous and connected vehicles are considered the promising future of safe and efficient transport (Shirvani, 2019). However, the implementation of autonomous trucks are also broader than alone the truck itself. Implications include infrastructure, urban planning, cybersecurity, privacy and insurance (Slowik and Sharpe, 2018). Although autonomous heavy duty trucks are not prohibited on public roads (yet), this disruptive innovations seems to get traction within transport and logistics and is seen as future solution.

The challenge of decarbonizing involves many different stakeholders as drivers (end users), logistical service providers, shippers, original equipment manufacturer's (OEMs), energy companies, regulators and financiers but in this research one main stakeholder is relevant: the logistical service provider. For logistical service providers decarbonisation through using sustainable power trains is a chance to modernize and reduce emissions while improving their own operations. Also, implementing automated heavy-duty trucks will result in less congestion and efficient and sustainable transport. The OEMs are crucial in leading the process of the development of sustainable heavy-duty vehicles and implementing new technologies in their vehicles (Shell, 2021). However, the logistical service providers are the decision makers whether these innovation are adopted or not. What factors determine the adoption of these radical architectural innovations?

This research has found that the key success factors for radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands are 'governmental regulations', 'strategic motives' and 'supplier supporting efforts'. The least important determinants are 'bandwagon effect', 'trialability' and 'end user acceptance'. This research finds 'governmental regulations' to be the most important factor for the implementation of BE- or FCE powertrain HDT and fully autonomous heavy duty trucks. Due to the high purchasing costs and complexity, logistic service providers are dependent on the governmental subsidization and regulations regarding (as indicated by industry experts) maximum weight, allowance on public roads and ethical jurisdiction.

This thesis consists of 6 chapters and is organized as follows. To start with, in chapter 2 a literature reviews is presented. Here, the theories of innovation adoption have been reviewed. Furthermore, current literature regarding innovation adoption in heavy duty trucks or in logistical service providers' organizations have been reviewed. Factors stated by these theories or in these papers are put in a conceptual model, consisting of 25 factors for innovation adoption. Furthermore, the methodology of this research is elaborated on in chapter 3. Exploratory interviews with 5 industry experts were held, to identify relevant factors and create a final model of 20 factors for radical architectural innovation adoption. With this final model of identified factors, a multiple criteria decision-making method has been conducted, the Best-Worst Method (BWM), to assign weights to the factors for adoption in the heavy duty-trucking industry. In chapter 4 the results of this research are be presented. In chapter 5, these results are interpreted, discussed and limitations will be given. Chapter 6 entails the conclusion, and provides direct answers to the sub- and main research questions.

1.1 KNOWLEDGE GAP

In the past few years, there has been quite some research on determining factors for radical innovation adoption in the transport an logistic industry Bae et al. (2022); Talebian and Mishra (2022); Orji et al. (2020); Raj and Sah (2019); Hsu and Yeh (2017).

Multiple innovation theories have been determining which factors individuals or organizations consider when adopting an innovation. The diffusion of innovation theory by Rogers (1962), who set up attributes of an innovation, has been used in many later researches. The Technology Organizational Environmental framework by Tornatzky and Klein (1982), who divides factors under three different elements. The network economics by Katz and Shapiro (1985) and the neo-institutional economics by DiMaggio and Powell (1983). These all have stated generalized factors for innovation adoption.

However, There has not been any research into factors for radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands. Furthermore, there is no research that determines key-success factors by assigning weights to the factors. With this research I hope to build on the theory that the process of adoption is not random, but can be predicted by factors that determine innovation adoption. By using the Best-worst method this thesis will assign weights to the factors for the adoption of radical architectural innovations in an industry for which this has not been done before. Also, in the current literature, there is no further research in effective policy interventions with regards to the actual implementation of autonomous HDT or BE- and FCE HDT.

1.2 RESEARCH OBJECTIVE

This thesis aims to explore the factors that determine radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands. The main objective of this thesis is to set up factors that decision makers consider when adopting radical architectural innovations. Where after, by applying the BMW, weights will be assigned to these factors to determine the key success factors of radical architectural innovation adoption. Therefore, the main research question is as follows:

Which key-success factors determine the adoption of radical architectural innovations in the heavy-duty trucking industry in the Netherlands, according to industry experts?

The following sub-questions are introduced:

- *Which success factors influence radical innovation adoption, according to literature?*
- *What factors do heavy-duty trucking industry experts identify when adopting radical innovations?*
- *What is the importance of these factors according to heavy-duty industry experts?*

2 LITERATURE REVIEW

In this chapter a literature review is provided. The data for this review has been found in (online) libraries and in scientific articles. A paper by Bae et al. (2022) focuses on radical architectural innovation adoption and has been used as a starting point, from which other papers have been reviewed using the 'snowballing' technique. These papers formed the basis of the literature review below. Here, innovation adoption theories and a broad selection of relevant scientific literature, regarding radical architectural innovation adoption within transport and logistics, are looked into. First, in section 2.1, characteristics of innovations will be discussed and the innovations this research focuses on will be categorized. Then, in section 2.2 the theories of innovation adoption will be reviewed and analyzed. After, in section 2.3, current literature regarding the adoption of FCE- and BE powertrain and autonomous heavy duty trucks in logistical service providers' organizations will be reviewed. Factors that are stated in all relevant papers will be added to the conceptual model for this research; factors for the adoption of radical architectural innovations. Furthermore, in section 2.4 the adoption of other innovations in transport and logistics will be analyzed. The factors stated in these papers determining their adoption will also be added to the conceptual model. However, if factors were already stated or overlap with other factors, they were not included. As overlapping factors may negatively influence the outcome of the pairwise comparison in the Best-Worst method, elaborated on in chapter 3.

2.1 TYPES OF INNOVATION

Technological innovations can be categorized into different types. Innovations can not only be defined 'radical' or 'incremental', but can be categorized into four dimensions: 'radical vs. incremental', 'product vs. process', 'competence enhancing vs. competence destroying' and 'architectural vs. component' innovations (**?**). The type of innovation characterizes the underlying knowledge and impact it can have on an industry's competitors and customers (**?**). The scope of this thesis focuses on radical architectural innovations.

When looking at the adoption of BE- and FCE- power train in autonomous heavy duty trucks, these two innovations can also be categorized into dimensions. When regarding the heavy duty truck and its processes as a whole system, both of these innovations are characterized as architectural innovations: they directly address the power train or operations of the heavy-duty truck, but indirectly also influence the infrastructure and entire logistic freight system. In addition, due to the paradigmatic shift in technology from the internal combustion engine to electric propulsion via battery- and hydrogen fuel cell technologies, these innovations are categorized as radical (Pohl and Elmquist, 2010). For autonomous trucks, due to the accompanying digitization of the transport system, this innovation is categorized as architectural (Anderhofstadt and Spinler, 2020). Together with the newness and risk of adopting these innovations, both BE- and FCE powertrain adoption as autonomous heavy duty trucks are typified as radical and architectural innovations. This, due to their disruptive manner in the entire heavy duty transport system (Pohl and Elmquist, 2010; Van den Hoed, 2007).

Radical vs. incremental

As stated here above, one of the typologies to distinguish an innovation is the dimension of radical versus incremental innovation. According to Ettlie et al. (1984) this dimension characterizes whether the innovation is clear, low risk and whether it represents a departure from the existing practice. Cusumano et al. (1998) state that radical innovations have a certain degree of *newness* and *differentness* in comparison to the current practice. These degrees also depend on whom this innovation addresses, as an innovation can be new to the whole world, an industry or solely an business unit. Radical innovations should be new to the whole world and in particular significantly different from products and processes in the existing landscape (Schilling, 2002). Henderson and Clark (1990) state that through radical innovations, new applications, markets and industries may arise.

Incremental innovations are the complete opposite, which are not new or exceptional and often involve a minor change from existing practices. An example of incremental innovation is for instance in developing phones, where new technology increases battery efficiency or a larger screen size: these innovations are not disruptive. According to Henderson and Clark (1990), with incremental innovations the existing technology is further enforced with minor changes in the technology content of the entire product or process. (Leonard et al., 1997) agree and state that incremental innovations aim to improve existing products, processes and services. As a high degree of risk of an innovation is often defined as radical, companies that adopt these innovations in an early stage are considered first movers and have significant risk when adopting these innovations. This also implies that over time, the radicalness of an innovation may change. A once radical innovation may be the standard in the future.

Architectural vs. component

Products and processes can be described as systems of components. These components substantially, are a system of even finer components. For example, a Macbook laptop is made of components; a screen, a touch pad, a CPU etc. But, this CPU in turn is made up of registers, an internal clock and logistic gates. Here, we see that components are a system of finer component and can be decomposed until it solely consists of basic elements. An innovation can therefore entail change in single components or to the overall system of components, which is called the architecture, or both (**?**). A component innovation thus does not change the overall configuration of the system, whereby an architectural innovation does. An architectural innovation may change the overall design, and therefore also change the way components interact with each other (**?**). This is in line with Henderson and Clark (1990) who state that in occurrence of an architectural innovation, the existing technology is further exploited which enables changes in the product or process architecture.

2.2 THEORIES OF INNOVATION ADOPTION

Within the innovation management literature, there are significant different studies on the diffusion and adoption op innovations. The process of innovation adoption results in a new product, process or practice being used in an adopting organization. There are two main approaches in studying innovation adoption: the factor- and process approach (Hameed et al., 2012). The process approach examines the experienced behaviour of an organization when an innovation is adopted over time, while the factor approach identifies characteristics of innovations that may influence the diffusion and adaption over time (Hameed et al., 2012). In this thesis, the factors approach will determine whether an organization in the logistic freight industry adopts an innovation. Below, four different scholar visions regarding innovation adoption are further elaborated on.

2.2.1 Diffusion of innovation (DOI)

The Diffusion of Innovation theory was historically first presented by sociologist Gabriel Tarde in 1903. He created and plotted the original S-shaped diffusion curve (Kaminski, 2011). After, Ryan and Gross (1943) introduced four different categories of adopters that have been the basis of many future studies, popularized by Everett Rogers. Simply put, the diffusion of innovation refers to the adoption of new products, concepts, a philosophy, et cetera, by individuals or organizations (Kaminski, 2011). Rogers (1962) was one of the first scholars that studied this process of diffusion and adoption of innovations and was mainly focused technological innovations. He studied the gap between the origin of an innovation and the time of adoption, which sometimes can be a lengthy period. His goal was to discover how individuals or organizations can speed up the rate of the diffusion of an innovation to become widely adopted faster. His definition of diffusion is the process by which an innovation is communicated through certain channels over time amount the members of a social system, until a saturation point is achieved (Rogers, 1962). Rogers (1962) distinguished five main categories of adaptors: innovators, early adopters, early majority, late majority, laggards. The sixth category can be seen as the non-adopters, this is the group that has no- or less positive perceptions of the new technology (Marak et al., 2019). These categories of adopters all have their own characteristics in terms of acceptance and influence of the adoption process (Kaminski, 2011). The most noticeable aspect of diffusion theory is how substantially the innovation decisions of the majority of social system members depend on those of the other system members, which can also be derived from the S-curve in figure 2.1 below.

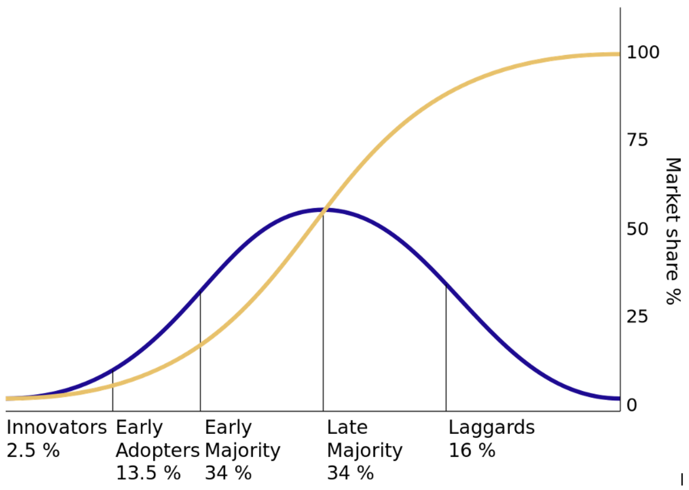

Figure 2.1: Adoption curve (Rogers, 1962)

This s-shaped diffusion curve suggests that only a small fraction of all potential adopters are actually using the innovation during its early stages of adoption. The adoption rate grows continually until it reaches a maximum at the point of inflection, when it is defined as the percentage of new users in a particular time period relative to all possible adopters (of the cumulative number of adopters) (Rogers, 1962). After this, it gradually declines and the diffusion curve saturates at an asymptote, determined by the total number of possible adopters (Orr, 2003).

"A technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" - Rogers (1962).

Rogers (1962) states that technology and innovation are synonyms, and that the technology is composed of an hardware and software aspect. The hardware aspect consist of the physical and material objects, and the software aspect is the informative base for this object. Often, we think mainly of the hardware aspect of innovations, but there are multiple examples where the software aspect of an technology is more dominant. This distinction has to be clear to understand the focus of the diffusion. Rogers (1962) states that with the origin of a technological innovation, it on one hand creates uncertainty in the minds of potential adopters, as on the other hand reduces uncertainty in other potential adopters minds in solving their problems or dilemmas. A problem when looking at the adoption and diffusion of an innovation is setting boundaries around that innovation. It is difficult to determine when an innovation stops and another arises.

Rogers (1962) has set up 5 characteristics of innovations that, as perceived by potential adaptors, to explain the rate of adoption:

1. Relative advantage: this is the degree that the new innovation is perceived as better than the current practice. This advantage is often be expressed in economic terms, but social-prestige factors, convenience and satisfaction are also important. It doesn't matter whether the innovation has an absolute advantage or not, if the potential adaptor perceived an innovation has relative advantage over the existing design, the more rapid it will be adopted (O'Callaghan et al., 1992).

2. Compatibility: is the degree of which an new innovation is in line with existing values, past experiences and fits the needs of the potential adopters. An example by Rogers (1962) gives an example of birth control in countries where their beliefs discourages them from using birth control, this will decrease adoption significantly. Hoerup (2001) states if an innovation is compatible with the needs of an individual, the uncertainty will decrease and the adoption rate will increase.

3. Complexity: is the degree whether an innovation is difficult to understand to potential adopters. This is negatively correlated with the rate of adoption. Therefore, the complexity of an innovation is an important barrier in adoption (Sahin, 2006).

4. Trialability: is the degree of which the innovation is able to be 'tried out'. This decreases the uncertainty and risk of potential adaptors and increases the rate of adoption (Rogers, 1962).

5. Observability: is the degree to which the results of an innovation are observable to others. When adaptors can see that an innovation has good results, their uncertainty decreases and are likely to adopt that innovation faster (Rogers, 1962).

Rogers (1962) stated that if an innovation has these characteristics, and these are perceived by individuals in organizations, the innovation rate will increase. He stated that the adoption of an innovation is dependent on the process that an innovation is introduced an used. Several studies have used the attributes of the innovation diffusion theory to explain the adoption of various innovations. A paper by Asare et al. (2016) researches B2B technology adoption in customer driven supply chains using these factors. They state that relative advantage, compatibility, trialability and observability are positive associated with an organization's intention to adopt an innovation and complexity is negatively associated. In another paper by Dobrovnik et al. (2018) the potential blockchain applications in logistics were identified using these factors. The attributes of Rogers (1962) were used to identify possible use cases of blockchain, and they confirm that the framework can be used as guideline for academics conducting research within innovation adoption. Although there are multiple papers that review the whole innovation diffusion theory (Jeyaraj et al., 2006; Van Oorschot et al., 2018; Lundblad, 2003; Sahin, 2006), their scope is quite limited, and not focused on the attributes.

However, a paper by Grover (1993) has looked into the attributes of customer-based inter-organizational systems to explain adoption. He found that only compatibility and complexity were strong predictors of innovation adoption, not relative advantage. In contrast, a paper by Kapoor et al. (2014) does review these attributes by conducting a meta-analysis on existing literature (230 relevant articles) to describe the 5 attributes by Rogers (1962) and their correlation with innovation adoption. In his paper he analyzes these 5 attributes by their antecedents and descendants and concludes that the relative advantage, compatibility and complexity were statistically significant and associated with the adoption of innovations. On the other hand, the factors observability and trialability were statistically insignificant and less associated with the adoption of innovations. This is in line with research by Tornatzky and Klein (1982) who stated that relative advantage, complexity and compatibility are the only factors that are consistently related to innovation adoption. Also a paper by Russell and Hoag (2004) studied innovation adoption by applying the attributes of Rogers' on two IT innovation cases. For both of the cases, relative advantage, compatibility and complexity were predictors of users' adoption. Based on these assumptions, later studies choose to eliminate the other factors in their research.

A paper by Orr (2003) reviews and criticizes the theory of Rogers (1962). He states that the major obstacle of the innovation-decision is uncertainty, as most people are on average risk-averse. Also Moore and Benbasat (1991) argued that the innovation diffusion theory by Rogers (1962) was more focused on the quality and innovation characteristics, than the adopters perceived characteristics of innovation. Therefore, they have modified the theory by adding more factors. Firstly, the image of an innovation was added, which can be seen distinctively and measured separately from relative advantage. Image refers to the ability an innovation can enhance the social status in a social system. Secondly, the observability is divided in (1) result demonstrability and (2) visibility. The result demonstrability focuses on the results and communicability of using innovation, while visibility focuses on the easy of enabling social learning through observation (Yuen et al., 2021). Lastly, Moore and Benbasat (1991) add the voluntariness factor, which refers to the adopter's perception on how freely they can adopt the innovation. Despite more researchers tried to modify or improve the attributes of Rogers (1962), the framework still remains the basis of most researchers as they have been proven to have a strong correlation with the innovation adoption decision making. Therefore eight factors will be added to the conceptual model.

Technological Organizational Environmental (TOE)

The diffusion of innovation theory has been extensively used in studies analyzing the adoption of innovations. It has been used as single framework, but also in conjunction with other theories. A framework that has been combined in many researches for adoption is the the Technological Organisational and Environmental (TOE) framework by Louis G. Tornatzky (1990) (Oliveira et al., 2014; Ramdani et al., 2009; Wang et al., 2010; Gutierrez et al., 2015; Bae et al., 2022). This framework describes how the context of an organization influences the firms' adoption of an innovation. It consists of three different elements: technological context, organizational context and environmental context. The technological context includes all features of technologies that are relevant in the adoption context for a firm, these may be technologies that the firm already uses or new technologies. The technologies a firm already uses set a limit on the scope and how fast the firm may undertake technological transitioning (Louis G. Tornatzky, 1990). The organizational context describes the features and assets of the company, such as personnel linkages, internal communication channels and firm size (Baker, 2012). The industry's structure, the existence or absence of support infrastructure, and the regulatory landscape make up the environmental context. When the framework is combined with the diffusion of innovation theory, the factors of (Rogers, 1962) align with the technological context element of Louis G. Tornatzky (1990). According to Baker (2012), the TOE framework is consistent with the Diffusion of Innovation theory.

2.2.2 Network economics

According to Katz and Shapiro (1985) the adoption of an innovation is determined by the markets mechanisms behind the industy where adoption takes place. According to them, these mechanisms are not able to be influenced by firms. Katz and Shapiro (1985) have developed an oligopoly model that shows that consumers are willing to adopt an innovation faster when it is compatible with other products or processes in the current landscape. Due to so-called network externalities, the benefit of an individual user grows when more users make use of that certain technology Katz and Shapiro (1985). To illustrate, the consumption externalities of purchasers of a telephone are dependent on the number of other users to interact with, if many people make use of the telephone network, the value of purchasing a telephone increases. Another example in line with the subject of this thesis is in the market of battery electric vehicles (BEVs). When the installed base of electric vehicle users increases, the charging infrastructure will be further developed, which may result in positive network externalities on the users of that innovation.

Farrell and Saloner (1985) add that the eagerness of a firm to adopt or switch to an innovation is dependent on other firms. Firms that early adopt innovation will start the bandwagon, where other firms that (sometime oppose the change) will wait and see whether other firms will adopt first, and will follow after. This phenomenon where early movers influence later movers' decision is the so-called bandwagon effect. The number of users of a technology is defined as the installed base. When an installed base increases, a competitive advantage occurs for the users which affects the outcome whether an innovation is widely adopted or not (Gallagher and Park, 2002). Network externalities mostly play a role in markets with complementary goods, where an increase in the availability of complementary goods result in more people choosing a certain technology (Hill, 1997). When a new good is introduced that is compatible with current products and processes, a market-mediated effect can occur. Here, complementary goods become cheaper and more readily available the greater the extent of the complementary market (Farrell and Saloner, 1985). This market-mediated effect can therefore also be a factor that influences the adoption rate of an innovation.

According to (Hill, 1997) the network effect can also be reversed, meaning that an increase of installed base can have positive effect on the amount of complementary goods. The network economists explain that when one innovation has been adopted, the costs to switch to another format increase which causes user to get locked in a chosen format. When there are high switching costs adopters will remain using the current innovation resulting in not always further adopting, a sometimes, better innovation (Katz and Shapiro, 1985; Hill, 1997; Gallagher and Park, 2002).

2.2.3 Neo-institutional economics

Institutional theories argue that firms are adaptive social constructions that are shaped in reaction to both the internal characteristics and commitments of participants as well as to the influences from the external environment. Within this institutional theory, the new neo-institutionalism by Meyer and Rowan (1977) and DiMaggio and Powell (1983) has emerged. The distinguishing argument by Meyer and Rowan (1977) is that organizations are changed by their institutional environment and gradually become isomorphic with them. The degree of institutional isomorphism promotes the success and survival of organizations (Meyer and Rowan, 1977). This means that an organization is shaped by other organizations in the same environment. When external legitimated formal structures are incorporated, the commitment of both internal participants as external constituents increases since violating them can cause the decrease of a firms legitimacy and social support(DiMaggio and Powell, 1983). Together with institutionalization, the concept of isomorphism are the most important in neo-internationalism. Institutionalization is the process where formal institutions get widely accepted and incorporated (Meyer and Rowan, 1977). This explains how external structures and practices get traction in organizations. DiMaggio and Powell (1983) argue isomorphism results in homogenization. The organizations become more similar over time by adopting similar formal structures and organizational processes (DiMaggio and Powell, 1983). This homogenization has three isomorphic processes.

1. Coercive isomorphism, this is a result of formal and informal pressures of other organization a firm may be dependent on. The pressure exerted on these organizations and decision maker results in incorporating certain institutionalized rules and practices. Also cultural expectations of the society where the organizations function in can influence the adoption of the institutions. Often, smaller firms are dependent on larger organizations, the larger organizations can set pressure to shape these smaller firms (DiMaggio and Powell, 1983).

2. Mimetic isomorphism, this is the process of organizations imitating other organizations in the same environment. They tend to do this to minimize risks in uncertain environments. This process is also done to reduce costs, as the other companies are facing the same dilemma's (DiMaggio and Powell, 1983).

3. Normative isomorphism, this is also the process of imitation. Although, this is done through professionalization of actors within firms, due to similar education, training or professional networks. They tend to copy their professional activities within firms to the point that they're interchangeable.

Thus, the organizational success does not only rely on the efficient coordination and control or productive activities within an organization. The isomorphic processes within organizations result in homogenization. In a paper by (Teo et al., 2003), the neo-institutional theory is also applicable to the influence of organizations on the adoption of technologies. He posits that the decision to adopt may be more influenced by the institutional environment of a firm rather than the rational intra-organizational and technological criteria. Therefore three types of isomorphic pressures by DiMaggio and Powell (1983) are also linked to technology adoption by organizations.

The factors from above theories are presented in table 2.1 below.

Table 2.1: Factors for adoption from theory

Author and year	Theory	Factors
(Rogers, 1962) (Moore and Benbasat, 1991)	Innovation adoption and diffusion	· Relative advantage · Image · Compatibility · Complexity · Trialability · Result demonstrability · Visibility · Voluntariness
(Farrell and Saloner, 1985) (Katz and Shapiro, 1985)	Network economics	· Network externalities · Market-mediated · Installed base · Switching costs · Bandwagon effect
(Meyer and Rowan, 1977) (DiMaggio and Powell, 1983)	Neo-institutional	· Coercive pressures · Mimetic pressures · Normative pressures

2.3 FACTORS FROM PRIOR RESEARCHES

2.3.1 Battery electric- and fuel cell electric powertrain

Until now, there is no extensive literature on determinants of of BE- and FCE powertrain adoption in the HDV industry. Whilst there is research on adoption of EV or alternative fuels in passenger cars (Coffman et al., 2017; Van de Kaa et al., 2017; Yuen et al., 2021), the aspects of business-to-consumer passenger vehicles and business-to-business characteristics of fleet vehicle adoption are structural different. This restricts the interchangeability of these findings (Seitz et al., 2015).

However, a paper found by Bae et al. (2022) explores heavy-duty fleet operator decisions about alternative fuel adoption in California, USA. Aiming to fill the knowledge gap of alternative fuel adoption by heavy duty trucking fleet operators. Based on an existing framework of alternative fuel adoption behavior in organizations, they empirically investigate 20 organizations in California via in-depth qualitative interviews. Leading to a set of practical factors influencing alternative fuel adoption. The reference theories besides the theory by Rogers (1962) is indeed the technology organization environment framework by Louis G. Tornatzky (1990), which includes technological, organizational and external task environment concepts. Besides, the two level framework for organizational innovation adaption by Frambach and Schillewaert (2002), that includes both organizational and individual acceptance within the organization. Therefore the paper by Bae et al. (2022) states that the organizational adoption should be distinguished into both the decision maker level and the individual level (vehicle driver).

The framework presented consists of three main organizational context elements: External environment influences, organization characteristics and perceived technology characteristics and also includes the individual acceptance of the end users (that can influence the decision maker). This acceptance can be described as the attitude of key individuals towards innovation. These factors also have sub-factors that determine how they are influenced: attitude towards innovation, the organizations facilitating efforts (training/education), personal dispositional innovativeness and social usage (Bae et al., 2022). Furthermore, a paper by Anderhofstadt and Spinler (2019) researches factors that determine the adoption of alternative fuel-powered

HDTs in Germany by examining a Delphi study. They state that according to their experts, the truck's available charging/fueling infrastructure (complexity), possibility to enter low-emission zones (government regulations) and current and future costs are key factors for adoption (TCO) (Anderhofstadt and Spinler, 2019). The main factors are presented in the figure 2.2 below.

Table 2.2: Factors for adoption by Bae et al. (2022)

Author	Theory	Factors
(Bae et al., 2022)	Innovation adoption and diffusion (Rogers, 1962) Technology-Organization-Environment (Baker, 2012) Technology organization environment framework (Tornatzky and Klein, 1982)	Perceived technology characteristics · Relative advantage · Purchase costs · Perceived compatibility · Perceived complexity · Perceived uncertainty · Total cost of ownership Organizational characteristics · Fleet operational characteristics · Strategic motives · Decision maker acceptance · End user acceptance External environment characteristics · Technology supplier supporting efforts · Government regulations · Social influences

2.3.2 Autonomous heavy duty trucks

There has not been extensive research into the determinants of commercial adoption of autonomous heavy duty trucks. Mostly research has been conducted on business impacts of autonomous trucks (Fritschy and Spinler, 2019; Lingmont and Alexiou, 2020) or perceptions of the organizations towards the technology (Engholm et al., 2020; Pudasaini and Shahandashti, 2020). However, more attention was laid on research for the adoption of autonomous vehicles by consumers (Yuen et al., 2021; Alawadhi et al., 2020; Shabanpour et al., 2018). Nevertheless, while the technology for consumer vehicles and heavy duty trucks seem similar, the drivers for adoption differ significantly (Talebian and Mishra, 2022).

A paper by Talebian and Mishra (2022) aims to unfold the state of adoption of autonomous trucks by the fleet industry. In line with the paper by Bae et al. (2022), they state that the size of the firm and the innovative behaviour of the decision maker influences the adoption rate of autonomous trucks. However, the overall hesitation to trust the autonomous technology is large amongst decision makers due to the safety concerns, liability questions, privacy matters and infrastructure changes. A paper by Anderhofstadt and Spinler (2020) looks at preferences for autonomous heavy-duty trucks in Germany. The developed model is based on two main theories; the technology acceptance model (TAM) by Davis (1987) and the theory of planned behaviour (TPB) by (Ajzen, 1991).The TPB consists of three factors that affect the behavioural human intention of the decision maker, which can be understood as the attitude towards innovation: (i) attitude toward a behaviour, (ii) subjective norms and (iii) perceived behavioural control (Ajzen, 1991). As the adoption of autonomous vehicles can not be based on past experiences, individuals will rely on their social network or influenced by multi mass media.

The TAM model by Davis (1987) focuses on two factors: (i) the perceived usefulness and (ii) perceived ease of use. Both the TAM and TPB include the following relevant variables: performance, expectancy, trust, security, reliability and privacy. From these, especially trust, security and privacy are relevant factors in autonomous vehicle literature (Talebian and Mishra, 2022). These sub factors of Ajzen (1991) and Davis (1987) are incorporated in the main factors 'end user acceptance' and 'decision maker acceptance' by Bae et al. (2022). These are already implemented as factors in the factors stated in the paper by Bae et al. (2022). Therefore, from the prior literature of autonomous truck adoption, no additional factors will be included in the conceptual framework.

2.4 ADOPTION OF OTHER INNOVATIONS

Besides factors for BE-, FCE- or Autonomous Heavy duty trucks, there has also been significant research on factors innovation adoption in transport and logistic sector. To understand the factors determining radical innovation adoption in these logistic service providers, additional papers have been found that provide insights in what factors have determined their adoption in similar organizations. In recent years the 'logistical transformation' is causing logistical service providers to adopt innovations to increase efficiency, reduce costs or enhance communication (Lagorio et al., 2020). From literature that researches the adoption of radical innovations, all factors stated in these papers will be added to the table **??**. Here, the determinants of adoption of radical architectural innovations in the heavy duty trucking industry will be compared with factors of the adoption of other radical innovations in the transport and logistic industry.

2.4.1 Blockchain technology

To start with, a paper by Orji et al. (2020) evaluates the factors that influence the adoption of block chain in the freight logistics industry. This industry is undergoing the process of digitization', where conventional logistic systems transfer to decentralized and digitized systems (Orji et al., 2020). This offers opportunities to create new value in economic, social and business perspectives. The adoption of blockchain technology can be defined as a radical groundbreaking innovation. In addition, blockchain is an architectural innovation as it's implementation leads to reorganisation of business models throughout multiple industries (Beck and Müller-Bloch, 2017). In this research, the factors for adoption are divided into *technological*, *organizational* and *environmental* factors, as in the TOE framework by Louis G. Tornatzky (1990). The most important factors are the availability of specific blockchain tools (uncertainty), infrastructural facility Although, the context of the innovations are different, some definitions of factors are similar. In this case, the infrastructural facility is in line with the complexity factor as it implies the availability of infrastructural facilities. Therefore, no additional factor will be added and highlighted in table 4.1 From the institutional factors, the government policy and support has been mentioned as key factor. Amongst the organizational factors, the training facilities were ranked as most important, as the successful adoption of blockchain technology is dependent on the employees handling this technology.

2.4.2 Drone technology

A paper found by Raj and Sah (2019) analyzes the critical success factors for the adoption of drones as transport system in the logistic sector. This innovation can be defined as radical, as the drone technology is a revolutionising net technology that transforms the current last mile transportation in the logistic sector. However, as it solely changes the way of transport and not the entire system, it can be defined as component level innovation (**?**). According to Raj and Sah (2019) the most important factor that influences the adoption of drones in the logistic industry are 'technological aspects', which are related to the technical barriers, the perception of relative advantage, probability of malfunctioning (uncertainty) and safety of the artificial intelligence programming the drone. Another paper by Sah et al. (2021) states that the most critical barriers to the implementation of drones in the logistics sector are government regulations and threat to privacy and security. Raj and Sah (2019) also agree that government regulations are an important factor when considering commercial application of drones. Furthermore the third most important factor is the skilled workforce, which entails the availability of skilled technical employees who can program the AI and operate the drones. Other factors as infrastructure (complexity), decision maker acceptance, coercive pressures (from the customers) and costs (TCO) have already been included.

2.4.3 Internet of Things

A paper by Hsu and Yeh (2017) researches the factors affecting the adoption of Internet of Things (IoT) in the logistics industry of Taiwan. This IoT enables multiple devices, objects, infrastructures and humans to interconnect. In terms of logistics, the IoT will provide full visibility and transparency within the supply chain. Furthermore, due to the real time data gathered, valuable information can be exploited to create efficient services and valuable insights that can improve the logistic activities (Tran-Dang et al., 2022). Therefore it can be seen as radical architectural innovation, as it disrupts the current industry and affects multiple systems. According to Hsu and Yeh (2017) the factors can be divided into external environment, organisational characteristics, technology characteristics and security. From these, the environmental dimension has the greatest impact on the adoption, whilst within this dimension competitive pressure, government policy and supporting industries are the most important criterion. Moreover, from the other dimensions IT expertise, technology infrastructure and top management support are considered critical in the adoption (Hsu and Yeh, 2017).

3 METHODOLOGY

In this section, the methodology is presented to identify the key success factors of radical architectural innovation adoption in the heavy duty trucking industry. There are two cases this research focuses on: FCE- and BE powertrain adoption in heavy duty trucks fully autonomous heavy duty trucks. Both of these cases have two rounds of interviews. The input for the first interview round is the output of the literature review; the conceptual model of factors for adoption. The input for the second interview round is the output of the exploratory interviews; a list of relevant factors for adoption. The first round consists of in depth interviews to identify relevant factors for adoption. In the second round a multi-criteria decision making model based on the Best-worst method will be conducted to assign weight to the relevant factors. Below, in figure 3.1 the proposed research method is shown in a flow chart.

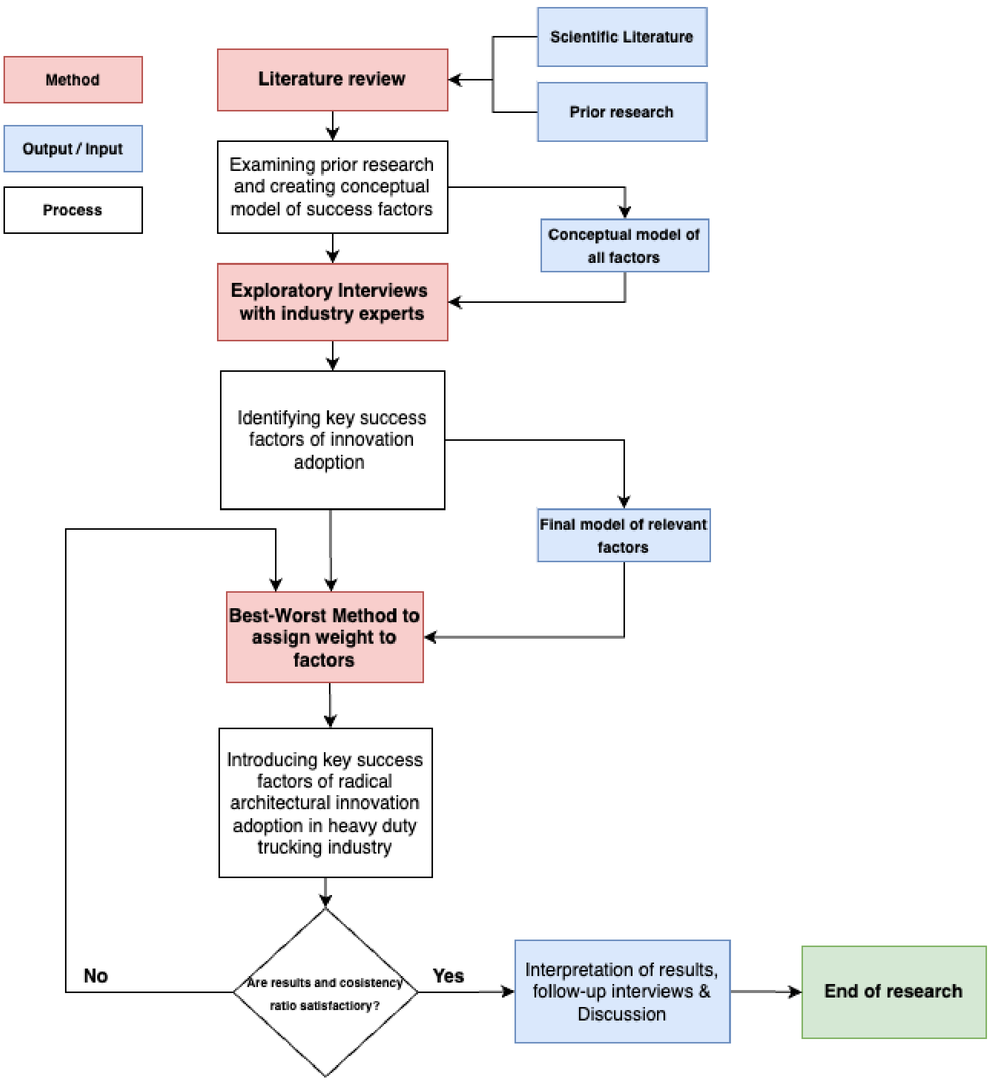

Figure 3.1: Flow chart of research approach

3.1 EXPLORATORY INTERVIEWS WITH INDUSTRY EXPERTS

The first round of interviews is held to identify relevant factors that determine radical architectural innovation adoption in the heavy duty trucking industry. The exploratory interviews are informative interviews to identify which factors of the conceptual model are relevant. The interviews are unstructured, consisting of open questions. The goal of this interview is to discover which factors the experts consider relevant without showing them which factors are in the conceptual model, derived from literature. When an experts states a factor they consider important when adopting an innovation, it is considered relevant. If this factor is not in the conceptual model, it will be added. This research method answers research question two, and provides a final list of relevant factors, which is the input for the second round of interviews.

The scope of this thesis does not focus on the OEM's, but on the logistic service providers with fleets consisting of heavy-duty trucks. This thesis researches which factors they consider as important when adopting radical architectural innovations. In order to have consistent results, the right experts must be identified and selected that can ensure validity of this thesis (Shanteau et al., 2002). Therefore, the experts must have at least 15 years of experience and a managing or direction function within the company. Multiple companies have been approached through LinkedIN, email and cold calling. However, many companies approached only have one or two 'experts', and these did not always have time for interviews. Because both innovations, BE- and FCE powertrain & Autonomous heavy duty trucks, are radical architectural innovations, half of the interviewees will be focusing on either one of these innovations and their determinants for adopting it. Ultimately, three experts have been interviewed with regards to the adoption of FCE- or BE powertrain adoption in heavy duty trucks, and three experts have been interviewed regarding the adoption of fully autonomous heavy duty trucks. The interviewed experts are presented below in table 4.2, although company is not stated to ensure anonymity.

Table 3.1: Experts for exploratory interviews

Expert	Innovation	Function	Experience
E1	BE and FCE	Sustainability manager	± 15 years
E2	BE and FCE	Managing director sales & operations	± 25 years
E3	BE and FCE	Purchasing director	± 20 years
E4	Autonomous	Business Development Manager	± 15 years
E6	Autonomous	Operational director	± 15 years

3.2 BEST-WORST METHOD

The adoption of new innovations with significant alternatives is labeled as a multi-criteria decision-making problem. These type of problems are typified by different alternatives that need to be evaluated with respect to a number of criteria. The BWM is an comparison oriented MCDM method developed by Rezaei (2020) that lets industry experts compare the best criterion to the other, and the worst criteria to the other. This pairwise comparison quantifies the importance of criteria and thus, help prioritize critical key factors while taking adoption decisions. It also helps to understand the adoption scenario for organizations, which can support strategizing (Sharma et al., 2020). When multiple alternatives are considered for adoption, the

BWM can result into the best alternative to be chosen, the alternatives to be ranked or the alternatives to be sorted into classes.

3.2.1 Advantages of BWM

The advantages of the best-worst method by Razaei (2021), and the pairwise comparison, is that it helps to estimate the inconsistencies of the industry experts preferences (Liang et al., 2020). There are multiple MCDM methods that use pairwise comparison. But, the BWM is chosen as it requires less comparisons than other methods, the final weights are highly reliable and comparisons are more consistent than in other methods (Van de Kaa et al., 2017). Also, the BWM makes use of only integer numbers between one and nine, while other methods require matrices with integers and fractional numbers, which makes is more simple than other methods. Making use of this method directly helps answer the main research question.

3.3 BWM STEPS

This BWM consists of five steps that are further explained below by Rezaei (2016).

1. Step 1: The set of decision criteria must be determined. These criteria $(c1, c2, c3, ...cn)$ will determine which of the innovations becomes dominant.
2. Step 2: The most important (best) and least important (worst) criteria must be determined within each categories of factors. These can be decided upon without comparing them with other criteria.
3. Step 3: Determine which factor has the preference over the other by using preference scores from 1 to 9. Whereby, 1 implies equal importance and 9 implies extreme importance. By doing this, a best-to-other vector is created $(A_b = (a_{b_1}, a_{b_2}, ...a_{b_n}))$. Here, a_{b_j} is the preference of the best determinant over determinant j.
4. Step 4: Determine the preference of each criteria in comparison with the worst criteria and rate it by using the scores 1 to 9. By doing this, a Worst-to-Other vector is created: $A_W = (a_{1_W}, a_{2_W}, ..., a_{n_W})$. Here a_{j_W} is the preference determinant j over the worst determinant.
5. Step 5: Calculate the optimal weights $(w_1*, w_2*, ..., w_n*)$. The optimal weight for the criteria is the one where, for each pair of w_B/w_j and w_j/w_W, we have $w_B/w_j = a_{B_j}$ and $w_j/w_W = a_{j_W}$. The formulation to find the solution becomes:

   $$min\ max_j(|w_b - a_b w_j|, |w_j - a_{jw} w_W|)$$

   $$\textstyle\sum_j w_j = 1$$

   $$w_j \geq 0, \text{ for all } j$$

   This can be translated in the linear programming problem below:

   $$min \xi^L$$
   $$|w_B - a_{B_j} w_j| \leq \xi^L, \text{ for all } j$$
   $$|w_j - a_{j_w} w_w| \leq \xi^L, \text{ for all } j$$

$\sum_j w_j = 1$

$w_j \geq 0$, for all j

By solving this equation the optimal weights $(w_1*, w_2*, ..., w_n*)$ and ξn are calculated. It is solved in the BWM solver program in Excel which was used as the optimization program. ξn is the consistency ratio (CR) from Liang et al. (2020). This ratio is used to evaluate the consistency of comparisons made by the experts and the reliability of the weights. The CR is a number between 0 and 1, where 0 is full consistency and 1 is full inconsistency. A lower consistency is sought for, as it implies a higher reliability of results.

3.3.1 Best worst method interviews

For the pairwise comparison of the BWM, a second round of interviews was held. The input for this BWM was the relevant list of factors set up after the first round of exploratory interviews. In the BWM the judgement of an expert can show how valuable or lacking an expert may be in identifying important key success factors. The usefulness and validity of the pairwise comparison in the BWM are greater the finer the sub criteria to compare the alternatives are. When the question is specific it makes it easier for experts to compare and ensure accuracy in their answers (Saaty and Özdemir, 2014). A criteria stated by Shanteau et al. (2002) is that experts should be identified by other experts in that field. Therefore, for this round of interviews, the experts interviewed were either the same experts as in the first round or recommended by them. These experts will be asked to rank the final list of relevant factors according to the best-worst method. This will be done in interviews to resolve one limitation; the experts are now able to elaborate on the questions and ask questions to make sure the method is not misunderstood. The goal is to have as many experts interviewed until the results are consistent. If the saturation level is met, more experts will not change the results significantly. The interviewees for the BWM are presented below in table 3.2. Expert 1, 2 and 3 are the same experts as in the exploratory rounds, experts 7-10 are new experts. These experts were asked to think about the adoption of both BE- and FCE powertrain adoption in heavy duty trucks and fully autonomous heavy duty trucks. With these innovations in mind, they have conducted the pairwise comparisons of factors.

Table 3.2: Experts BWM

Expert	Function	Experience
E1	Sustainability manager	± 20 years
E2	Managing director sales & operations	± 25 years
E3	Purchasing Director	± 30 years
E7	Director	± 20 years
E8	Director	± 25 years
E9	Sustainability manager	± 25 years
E10	Director	± 30 years

4 RESULTS

This chapter will provide the results of the literature review, exploratory interviews and BWM interviews as give answers on all sub-questions. First, in chapter 4.1 the conceptual model derived from literature will be presented. Then, in chapter 4.2 the relevant factors identified by industry experts will be presented. After, in chapter 4.3 the results of the BWM and the key success factors will presented.

4.1 CONCEPTUAL MODEL OF FACTORS FOR ADOPTION

To develop a conceptual framework , consisting of factors for of radical innovation adoption in the heavy duty-trucking industry, the factors found in all relevant literature will be added to the model. These factors are presented in table 2.1 and table 2.2. Factors that overlap with others were removed: mimetic pressures and bandwagon effect overlap. So, mimetic pressures is removed. Also, the total cost of ownership includes the purchasing cost of the vehicle. Therefore, the purchasing cost factor is removed. Furthermore, sub factors that are covered by an main factor were not included too. The conceptual framework is presented in table 4.1 below.

Table 4.1: Conceptual framework: factors for radical innovation adoption

Characteristics of the technology
1. Technological superiority (relative advantage)
2. Compatibility
3. Uncertainty
4. Total cost of ownership (TCO)
5. Trialability
6. Result demonstrability
7. Visibility
8. Voluntariness
9. Complexity
10. Image
11. Safety
Market characteristics
12. Bandwagon effect
13. Network externalities
14. Switching costs
15. Market-mediated
16. Installed base
Organizational characteristics
17. Fleet operational characteristics
18. Strategic motives
19. Decision maker acceptance
20. End user acceptance
External environment characteristics
21. Supplier supporting efforts
22. Government policies
23. Social pressures
24. Coercive pressures
25. Normative pressures

4.2 IDENTIFICATION OF RELEVANT FACTORS

To start with, multiple experts were approached for the exploratory interviews. Where after, 5 interviews with experts were considered as reliable. These interviews were unstructured, consisting of open questions. The goal was to discover which factors the experts consider relevant without being biased, knowing the factors in the conceptual model. The experts and their function are presented in figure 4.2 below. From the 25 factors in the conceptual model, a total of 19 factors appeared to be relevant in the case of radical architectural innovation adoption in the Dutch heavy duty trucking industry. In appendix B.1, for each interviewee, the factors identified in the exploratory interview are highlighted .

Table 4.2: Experts for exploratory interviews

Expert	Innovation	Function	Experience
I1	BE and FCE	Sustainability manager	± 15 years
I2	BE and FCE	Managing director sales & operations	± 25 years
I3	BE and FCE	Purchasing director	± 20 years
I4	Autonomous	Business Development Manager	± 15 years
I6	Autonomous	Operational director	± 15 years

4.2.1 Characteristics of the technology

From the theme characteristics of the technology, the 'technological superiority', 'compatibility' and 'total cost of ownership' were considered important factors according to all experts. Expert 1 stated that technological superiority makes sense when adopting an innovation; "you'll always look for an innovation with the most potential". For expert 2, the performance of the technology is important too; "a FCE- or BE- powertrain needs to have enough power and must be efficient". He stated that 'compatibility' is very important too, as the truck has to be compatible with their operations, which is transporting goods in and to many different countries.

According to expert 4, the costs are the first thing they look at when considering the adoption of an innovation. Expert 3 also stated that the TCO is a large factor, as the TCO incorporates all costs, as the maintenance costs, which is in line with how complex an innovation is. According to expert 5, the 'result demonstrability' is very important, he stated that it is important to demonstrate new innovations that show results, to determine whether the new technology fits in the operational employability of a company. He was the only expert that stated 'trialability' as an important factor, referring to a trial they're currently conducting on an autonomous heavy duty truck between the terminals and a hub in an XXL business park. He also implied that this 'trialability' is in line with 'result demonstrability' as they use this trial to look at results of the vehicle when operating in the companies activities.

The 'complexity' of the new technologies is perceived as very important, according to expert 1, 3 and 5. Not only the complex infrastructure to recharge or refuel, but also the complexity of the technology itself. Interviewee 5, highlighted the fact that internationally the developments are not always as developed as in the Netherlands. He mentioned that a vehicle can break down in Spain, Italy or France and that it is very important that the technology in not too complex, resulting in it not being solved on site there. If not, this may effect the operational efficiency of the vehicle. The factor 'safety' has been stated by experts 1 and 5. According to them, safety is not even debatable, because if the technology is not safe or perceived as safe, it will never be adopted by them; 'Safety is the priority of every transport company'. The factors identified by experts from the theme characteristics of the technology and their definitions are presented below in table 4.3.

Table 4.3: Identified characteristics of the technology

Characteristics of the technology	Definition
Technological superiority (relative advantage)	The degree to which an innovation is "perceived as being better than the innovation it supersedes" (Rogers, 1962). A higher technological superiority has a positive effect on radical architectural innovation adoption.
Perceived compatibility	The degree to which AFVs are "perceived as consistent with the existing values, past experiences and needs of potential adopters" (O'Callaghan et al., 1992). i.e., The vehicle needs to be functionally suitable in terms of vehicle power, payload and/or driving range. A higher perceived compatibility has a positive effect on radical architectural innovation adoption.
Complexity	The degree to which an innovation can be used and is understandable to potential adopters (Rogers, 1962; Bae et al., 2022). i.e., fleet operation issues associated with inadequate refueling/charging infrastructure. A higher complexity has a negative effect on radical architectural innovation adoption.
Uncertainty	"The degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives" (Rogers, 1962). i.e., vehicle safety concerns and operational risks A higher uncertainty has a negative effect on radical architectural innovation adoption.
Total cost of ownership (TCO)	Monetary evaluation on overall cost of ownership (Bae et al., 2022). I.e., how much does it cost and what it costs to operate. A positive TCO has a positive effect on radical architectural innovation adoption.
Trialability	The degree of which the innovation is able to be 'tried out'. This decreases the uncertainty and risk of potential adaptors and increases the rate of adoption. (Rogers, 1962) A higher trialability has a positive effect on radical architectural innovation adoption.
Result demonstrability	The result demonstrability focuses on the results and communicability of using a product (Jeyaraj et al., 2006). A higher result demonstrability has a positive effect on radical architectural innovation adoption. (Bae et al., 2022)
Safety	The perceived degree of danger of an innovation. A higher perceived safety has a positive effect on radical architectural innovation adoption.

4.2.2 Market characteristics

The market characteristics theme is the team with most factors deducted from the conceptual model. No experts have stated anything about 'switching costs', 'market-mediated', or 'installed base'. According to expert 1, their company is very critical when adopting innovations. They don't look at other companies and what they're doing, but solely focus on the strategy they have. He highlights that other companies might have different standards, or not show the difficulties they encounter to other companies. Therefore, effects as the bandwagon effect are not relevant.

Expert 3 stated that 'network externalities' may affect his adoption, as currently the grid is not capable to charge many trucks at all. He stated that if more companies will adopt battery electric trucks, the government and complementary companies are forced to improve the grid and load balancing, which will create a surplus that may affect his adoption too. The 'bandwagon effect' is only stated by expert 4. The company he works for is smaller, compared to the other interviewed companies, and doesn't have such a large fleet. He stated that if many companies adopt a technology, it must be a good technology and they could follow. However, they still have to focus on their own strategy.

One additional factor has been added to the market characteristics list, namely: 'collaborative marketing'. Experts 1, 2 and 3 have stated that there should be more collaboration between logistic providers in the market, to learn from each others experiences, instead of depending on oneself. Especially expert 2 stated that companies should work more together to enable this transition. He stated that if this market effect occurs, the adoption rate of all companies will increase. However, due to a lack of trust, there is no collaboration between logistic service providers at all. The factors identified by experts from the market characteristics theme and their definitions are presented below in table 4.4.

Table 4.4: Identified market characteristics

Market characteristics	Definition
Bandwagon effect	This is the process of organizations imitating other organizations in the same environment. They tend to do this to minimize risks in uncertain environments (Tornatzky and Klein, 1982). A phenomenon where early movers influence later movers' decision
Network externalities	A change in the benefit, or surplus, that a company derives from an innovation when the number of other companies making use of that innovation increases. (Gallagher and Park, 2002)
Collaborative marketing	When process where two or more organizations work together to define common problems and develop joint solutions, for mutual gain. (Hartley et al., 2013) i.e. through sharing knowledge or past experiences.

4.2.3 Organizational characteristics

From the theme organizational characteristics, all factors were identified by at least one expert during the exploratory interviews. According to expert 1, there is an internal drive for him to innovate. He stated that this drive must align with the company's strategy to be innovative. This is in line with expert 4, who stated that in order to be an innovator or early adopter, the intrinsic drive and acceptance of the decision makers is very important. Therefore, the factor 'decision maker acceptance' is considered relevant. Expert 5 stated that the strategy of a company is very important when adopting autonomous trucks, he stated that the curiosity whether an innovation can help them improve really drives innovation adoption. Also expert 1, 2 and 4 stated that the 'strategic motives' of a company are important when adopting innovations.

Expert 1 laughed when asking about the drivers preferences, he stated that they're not able to let the truck drivers influence the decisions of the whole company. The drivers all have their preferences, but if the drivers all resist driving hydrogen trucks, it will make the adoption difficult. Expert 4 gave an example; when they'd implemented LNG trucks, the drivers resisted to drive these trucks. Expert 2 also agreed that it is very difficult to convince the end users to innovate, but they do think it is important. Expert 3 stated that they organize educational events for these end users to realize the transition is the future. Therefore, according to them, the 'End use acceptance' is a relevant factor when adopting innovations.

According to expert 3, the 'fleet operational characteristics' may affect a company's adoption rate. He stated that their company has more than 1500 trucks, resulting in more than 200 trucks being replaced each year. They order one or two alternative fuel trucks a year and don't consider that very special. However, they can more easily test the capabilities of these vehicles. In contrast, expert 5 works for a smaller company that doesn't order trucks every year. For them, the decision to order a truck with a innovative powertrain or fully autonomous heavy duty truck is more difficult when there is a lot of uncertainty in the market. Therefore, the factor 'fleet organizational characteristics' may affect the innovation adoption rate of a company. The factors identified by experts from the organizational characteristics theme and their definitions are presented below in table 4.5.

Table 4.5: Identified organizational characteristics

Organizational characteristics	Definition
Fleet operational characteristics	The characteristics of the company such as size, vehicle vocation and past experiences (Bae et al., 2022).
Strategic motives	Extrinsic motives that an organization strives for improving their competitive position in the market and industry (Baker, 2012).
End user acceptance	Attitude of vehicle drivers towards using an innovation, which may confirm the compatibility of the technology (Baker, 2012).
Decision maker acceptance	The attitude towards an innovation of a key decision maker can initiate discussions and persuade other decision makers to adopt an innovation (Baker, 2012).

4.2.4 External environment characteristics

From the external environment characteristics, the OEM was a huge topic in the interviews with experts 1, 3 and 4. Expert 4 stated that the transition gets initiated by the OEMs. If they start to fully invest in hydrogen trucks, the rest will follow and the transition will be faster. Now, companies are hesitant in what technology to choose, because the technologies are developing very fast and no one wants to have a bad bargain; "the range of an electric truck might multiply in the coming years for the same purchasing cost". This increases the uncertainty of an innovation. Expert 3 stated that if the OEMs must stop spending their RDI capital in finding ways to make their conventional diesel trucks more sustainable, but solely focus on zero-emission technologies. According to him, this is the only way the technologies will develop faster: the technological characteristics will improve, and logistical providers will start to adopt that innovation. Therefore, the factor 'supplier supporting efforts' has been included as relevant.

Furthermore, the factor 'coercive pressures' has been adjusted to 'pressures from customers' as all experts only highlighted the pressure of the customers as important when adoption radical innovations in the heavy-duty trucking industry. Expert 1 stated that this customer pressure is very important. Currently, transporting with sustainable vehicles is more expensive than conventional diesel transportation. Therefore, he stated that if the customer is not willing to pay more for sustainable transportation, it is difficult for his company to invest in these sustainable solutions. However, if the customer solely wants sustainable transportation, these companies will be pressured to make this sustainable transport available.

Moreover, all experts have expressed that governmental policies are a main factor when adopting radical architectural innovations. Expert 4 for instance, thinks that autonomous vehicle implementation on the public road will not be available the coming 20 years, due to the jurisdiction not being ready. Also, expert 2 stated that governmental regulations may increase the adoption rate: "if the government reduces the taxes or toll for sustainable trucks, the customers would prefer sustainable transport and we will be pressured to innovate". Therefore, 'governmental regulations' is included as relevant factor.

Expert 3 stated that there is a social pressure to be sustainable and innovate. However, expert 5 stated that green washing occurs in many companies due to that. This pressures companies to really be sustainable and have a good story for the clients, "or they will go to another competitor that may lie about what he does and cannot". Therefore, 'social pressure' is also included as relevant factor. Expert 1 and 3 also identify normative pressures to be relevant when adopting new innovations. They both stated that they attend congresses or educational evenings with other decision makers facilitated to inform about this transition. The factors identified by experts from the external environment characteristics theme and their definitions are presented below in table 4.6.

Table 4.6: Identified external environment characteristics

External environment characteristics	Definition
Technology supplier supporting efforts	Vehicle manufacturers / fuel providers can influence the adoption process. For example, by unavailability of vehicles or no opportunities to test a vehicle (Bae et al., 2022).
Governmental policies	Monetary incentives or regulations by the government that can affect the adoption of an innovation (Bae et al., 2022)
Social influences	Direct or indirect social interactions between a member in an organization and others, which influences innovation adoption in organizations, such as via information sharing activities [Rogers, 1962], and social norm (Gallagher and Park, 2002).
Pressures from customers	Result of formal and informal pressures of other organization a firm may be dependent on. The pressure exerted on these organizations and decision maker results in incorporating certain institutionalized rules and practices (Tornatzky and Klein, 1982).
Normative pressures	This is the process of imitation. Although, this is done through professionalization of actors within firms, due to similar education, training, or professional networks (Tornatzky and Klein, 1982).

These factors make the final relevant factor list for radical architectural innovation adoption. This list will be presented to the experts in the best-worst method interviews, which results are presented in the following chapter. In appendix B.1 a table is presented that highlights the relevance of the factors stated by each interviewee.

4.3 IMPORTANCE OF RELEVANT FACTORS

In this section, the results of the BWM are presented. The experts interviewed for the BWM are shown in figure 4.7 below.

Table 4.7: Experts BWM

Expert	Function	Experience
E1	Sustainability manager	± 20 years
E2	Managing director sales & operations	± 25 years
E3	Purchasing Director	± 30 years
E7	Director	± 20 years
E8	Director	± 25 years
E9	Sustainability manager	± 25 years
E10	Director	± 30 years

In these interviews, the experts were asked to rank the relevant factors according to the methodology of the BWM, explained in section 3.3. The BWM excel file has been filled in according to the answers of the experts. In figure 4.1 the weight of the theme's is presented. As can be seen, the 'external environment characteristics' is the theme that has weighed most important and 'market characteristics' has weighed least according to the experts. In appendix B.1 all specific weights are presented for each expert conducting the BWM.

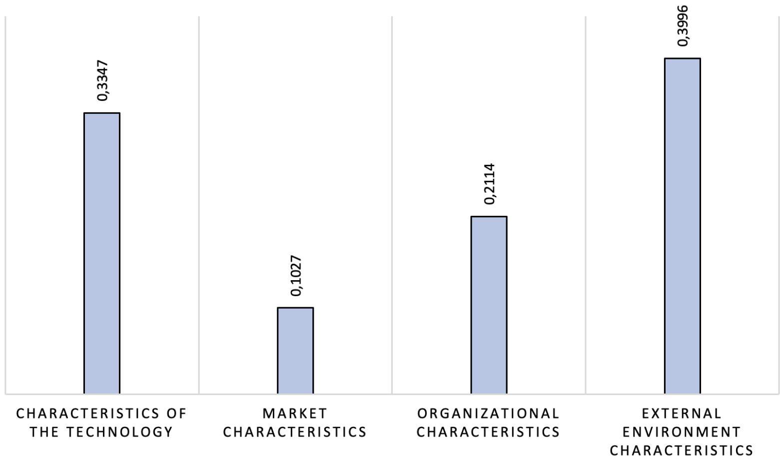

Figure 4.1: Assigned weights of themes by experts

To compute the global weights, the local weight have to be determined first. These are shown in table 4.8 below. Furthermore, the ranking of the factors within each theme is presented. In the characteristics of technology theme, the factor with the highest local weight is 'compatibility' (0,2099) and the factor with the lowest local weight is 'trialability' (0,0308). In the market characteristics theme the factor with the highest local weight is 'network externalities' (0,5075) and the lowest factor is 'bandwagon effect' (0,0833).

In the organizational characteristics theme the factor with the highest local weight is 'strategic motives' (0,5305) and the factor with the lowest local weight is 'end user acceptance' (0,06889). In the last theme, external environment characteristics, the factor 'governmental policies' (0,3448) has the highest local weight, and 'normative pressures' (0,0576) the lowest.

Table 4.8: Average local weight and rank of each factor within theme

Theme	Factors	Local avg weight	Rank in theme
Characteristics of the technology	1. Technological superiority	0,0972	5
	2. Compatibility	0,2099	1
	3. Uncertainty	0,0730	7
	4. Total cost of ownership (TCO)	0,1933	2
	5. Trialability	0,0308	8
	6. Result demonstrability	0,0870	6
	7. Complexity	0,1279	4
	8. Safety	0,1808	3
Market characteristics	9. Bandwagon effect	0,0833	3
	10. Network externalities	0,5075	1
	11. Collaborative marketing	0,4092	2
Organizational characteristics	12. Fleet operational characteristics	0,2295	2
	13. Strategic motives	0,5305	1
	14. Decision maker acceptance	0,1712	3
	15. End user acceptance	0,0689	4
External environment characteristics	16. Supplier supporting efforts	0,2705	2
	17. Government policies	0,3448	1
	18. Social pressures	0,0879	4
	19. Pressures from customers	0,2392	3
	20. Normative pressures	0,0576	5

To end with the ranking of the factors based on the global average weights. These are computed by the local weights of each factor and the weight of the theme that factor belongs to. These result are presented in table 4.9 below. Based on this data, we can conclude that the three most important factors are 'Government policies' (0,138), 'strategic motives' (0,112) and 'supplier supporting efforts' (0,108). The three least important factors are 'end user acceptance' (0,015), 'trialability' (0,010) and 'bandwagon effect' (0,009). In appendix B.1 the weights assigned by the experts are provided that have led to these results.

Table 4.9: Global avarage weights and overall ranking of subfactors

Themes & Sub-factors	Global avg weight	Ranking
Characteristics of the technology		
1. Technological superiority	0,033	14
2. Compatibility	0,070	5
3. Uncertainty	0,024	16
4. Total cost of ownership (TCO)	0,065	6
5. Trialability	0,010	19
6. Result demonstrability	0,029	15
7. Complexity	0,043	10
8. Safety	0,061	7
Market characteristics		
9. Bandwagon effect	0,009	20
10. Network externalities	0,052	8
11. Collaborative marketing	0,042	11
Organizational characteristics		
12. Fleet operational characteristics	0,049	9
13. Strategic motives	0,112	2
14. Decision maker acceptance	0,036	12
15. End user acceptance	0,015	18
External environment characteristics		
16. Supplier supporting efforts	0,108	3
17. Government policies	0,138	1
18. Social pressures	0,035	13
19. Pressures from customers	0,096	4
20. Normative pressures	0,023	17

Consistency ratio

The consistency ratio's of the experts are shown in figure 4.10. For each theme a BWM is conducted, so there are multiple consistency ratio's for every expert. For this ratio, the closer to 0, the higher the level of consistency is. If the consistency ratio is 0,25 it is regarded as inconsistent. The interviewee would not be regarded as experts and his data would have to be removed. However, all consistency ratio's of the experts are within the threshold. Therefore, no expert had to be excluded from the results. From this data, the highest consistency ratio is for the 'market characteristics' theme, with an average of 0,104. The lowest consistency ratio is in the 'characteristics of the technology' theme, with an average of 0,068. From all the experts, expert 1 had the highest consistency, with all consistency ratio's below 0.1.

Table 4.10: Consistency ratio's

	E2	E6	E7	E8	E9	E1	E10	**avg**
Themes	0,061	0,092	0,055	0,106	0,091	0,152	0,097	0,093
Characteristics of the technology	0,080	0,068	0,048	0,073	0,054	0,062	0,092	0,068
Market characteristics	0,042	0,122	0,133	0,160	0,083	0,100	0,109	0,107
Organizational characteristics	0,047	0,081	0,123	0,115	0,089	0,129	0,090	0,096
External environment characteristics	0,039	0,107	0,093	0,091	0,109	0,118	0,061	0,088

Saturation

There were 7 experts interviewed for the BWM, which led to saturation of the results. When deducting experts, the global average weight must not change significantly. In table 4.12 below, the global average weight of 5-, 6- and 7 experts are shown. This research is focused on determining the key success factors for radical architectural innovation adoption. As can be seen in the table, the 5 least important ranked factors don't change in rank. Most importantly, it is important that the top 5 most important ranked factors don't change significantly. Here we see that data saturation is reached. Therefore no more interviews were necessary as the ranking of these factors remained consistent.

Table 4.11: Saturation of data

Themes & Sub-factors	Global avg weight (5 Exp)	Rank	Global avg weight (6 Exp)	Rank	Global avg weight (7 Exp)	Rank
Characteristics of the technology						
1. Technological superiority	0,030	13	0,030	14	0,033	14
2. Compatibility	0,077	5	0,070	5	0,070	5
3. Uncertainty	0,025	16	0,024	16	0,024	16
4. Total cost of ownership (TCO)	0,054	8	0,052	9	0,065	6
5. Trialability	0,011	19	0,010	19	0,010	19
6. Result demonstrability	0,026	15	0,026	15	0,029	15
7. Complexity	0,045	11	0,038	12	0,043	10
8. Safety	0,056	7	0,053	8	0,061	7
Market characteristics						
9. Bandwagon effect	0,009	20	0,009	20	0,009	20
10. Network externalities	0,062	6	0,060	6	0,052	8
11. Collaborative marketing	0,048	10	0,040	11	0,042	11
Organizational characteristics						
12. Fleet operational characteristics	0,054	9	0,055	7	0,049	9
13. Strategic motives	0,115	3	0,119	2	0,112	2
14. Decision maker acceptance	0,034	12	0,042	10	0,036	12
15. End user acceptance	0,015	18	0,016	18	0,015	18
External environment characteristics						
16. Supplier supporting efforts	0,125	2	0,118	3	0,108	3
17. Government policies	0,148	1	0,154	1	0,138	1
18. Social pressures	0,029	14	0,037	13	0,035	13
19. Pressures from customers	0,082	4	0,082	4	0,096	4
20. Normative pressures	0,023	17	0,024	17	0,023	17

Table 4.12: Saturation of data

5 DISCUSSION

In this chapter, the results of this thesis will be discussed. In section 5.1 the results will be interpreted and further elaborated on. Furthermore, in section 5.2 the theoretical contribution of this thesis will be stated. After in section 5.3 the limitations of this research are presented.

5.1 INTERPRETATION OF RESULTS

The theories presented in the literature review identify factors that determine innovation adoption amongst organizations. From the 25 factors in the conceptual model, 19 factors were identified by experts as relevant in the heavy-duty trucking industry. This list of relevant factors have been weighed and ranked according to the BWM. The results indicate that 'government policies', 'strategic motives' and 'supplier supporting efforts' are key-success factors in the adoption of radical architectural innovations in the heavy duty trucking industry. In this chapter, these results will be analyzed.

TOE framework

This thesis could analyze the adoption of innovations according to the TOE framework, which has been used by many researchers to identify factors of innovation adoption in organizations. The papers researching factors of innovation adoption that have been reviewed in the literature review have used this TOE framework. In this thesis, the TOE framework has been combined with the factors of the conventional innovation adoption, diffusion theories and factors stated in prior relevant research. Which have made up the conceptual framework. To make sure an extensive overview of factors is set up and weighed. From the TOE framework, the organizational characteristics have been added (Baker, 2012). According to (Frambach and Schillewaert, 2002) this includes both organizational and individual acceptance within the organization.

The results of this thesis are in line with the TOE framework by (Frambach, 1993) as all factors are identified by at least one expert in the exploratory interviews. From this theory, 'strategic motives' was ranked 2nd important of all factors. According to all experts, the companies strategy strongly determines the rate of adoption. However, the experts have weighed the strategy of the company more important than their own acceptance (12th). According to expert 4 the decision makers strategy must align with the strategy of the company, not the other way around.

However, according to Frambach and Schillewaert (2002), the individual acceptance of the end user is an important factor that affects the decision makers adoption. This research contradicts this. Expert 1 stated: "It is not always possible to let the truck drivers influence all the decisions. They all have their preference for a particular brand or vehicle". Expert 5 stated "I don't think that the end users really influence the rate of adoption by the logistic providers". Due to radical innovations being disruptive, there will always be opponents or to conventional end users. In the decision-making of adoption of radical architectural innovations in the heavy duty trucking industry, the decision maker can not let the end user influence the adoption of a radical innovation as much as Frambach (1993) stated. Therefore, totally in contrast with the TOE framework, the end user acceptance has been ranked 18th of all factors.

Neo-institutional factors

According to the neo-institutional economics, external structures and practices may get traction in organizations. Especially due to the coercive isomorphism, which can be formal or informal pressures of other organizations a firm may depend on (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). They state that the pressure exerted on these organizations and decision maker, results in incorporating certain institutionalized rules and practices. In the papers revived, regarding innovation adoption in logistic service providers, these coercive pressures are described as key determinants affecting the adoption rate of an organization. Also, during the interviews with experts, governmental regulation has been identified by all experts as factor for adoption. Expert 2 stated that governmental regulation in the form of subsidies may affect his company's transition. Expert 3 stated 'An important factor are the government regulations, from 2025 all trucks have to be zero-emission to enter some cities, so we are preparing for that. With other words, without government regulation the transition will never be faster'. He here implies that governmental pressures significantly affect the adoption rate of the company he works for.

The results of the BWM confirm this as the factor 'governmental pressures' has the highest global weight of all 20 factors. From all themes, the external environment characteristics have the highest weight. Perhaps, due to governmental pressures belonging to that theme. However, the factors supplier supporting efforts and pressures from customers are ranked 3 and 4. Thus, the external environment characteristics theme is an important theme when adopting radical architectural innovations in the heavy duty trucking industry. Furthermore, the factor 'supplier supporting efforts' has been ranked 3rd and 'pressured from customers' subsequently 4th. This shows that the external environment significantly affects the adoption of radical innovations in the heavy duty trucking industry. Below, the governmental regulations factor is highlighted.

Governmental regulations

Government regulations has been the highest ranked factor by the experts. This is in line with the paper by Bae et al. (2022), where governmental regulations is also a key success factor in the adoption of alternative fuels for HDV in California. Below a brief overview is given what the experts said about governmental regulations in their interview, focusing on either one of the radical architectural innovations .

Be- and FCE powertrain in HDT
Expert 1 stated that "the purchasing costs of a new vehicle are very high and are partly subsidized by the government. If they wouldn't offer subsidization, it is difficult for us to implement". This is also in line with expert 2 and 3, who also state that governmental subsidization is a very important factor. Expert 2 also added: "Battery electric trucks have a huge heavy battery, we can't transfer the same weight of goods if governments don't allow more weight on the roads. Then this is not interesting for us.". Thus, all experts have stated that due to the high purchasing cost of these vehicles, they are dependent on governmental subsidization and incentives. But also the regulations with regards to maximum weight, loading capacity, road allowance etc. are very important for logistic service providers, as adopting these vehicles now is not efficient for them.

Fully autonomous HDT
Expert 4 stated: "I think fully autonomous driving would not be a possibility in the coming 20 years. Simply because the government regulations are not ready for implementation, and it is far more complex than people think. Think of the jurisdiction on who is responsible for the barge if an accident happens". Expert 5 also stated that "A big problem is that the governmental regulations are always later than the innovation. And the regulations are very specific which can be at the expense of innovations". Here we see that the experts mostly state that the adoption of fully autonomous vehicles is dependent on government regulations. In order to have fully autonomous vehicles on public roads, the regulations on responsibility, ethical dilemma's and access on public roads have to be implemented before anyone of them would even adopt an autonomous truck. Also, due to the high complexity and costs, expert 2 stated that "also the subsidization by the government can lower the threshold for innovation adoption".

Network economics factors

The theory of the network economics state that the adoption of an innovation is determined by the market mechanisms behind the market, which are not able to be influenced by organizations (Katz and Shapiro, 1985). However, when conducting the literature review, the adoption of other innovations in the transport and logistic industry have been reviewed. In these papers, market characteristics have not been stated as factors affecting adoption with regards to the adoption of any of these innovations.

More over, in the exploratory interviews, most experts have stated the relevance of these market mechanisms but stated that they do not significantly affect their adoption of either of these innovations. Expert 1 stated 'Other companies may not have the same standards we have and not show the difficulties they have with the world' which causes them to focus solely on their own strategy. That a company's strategy is a key success factor is also shared by the other experts, as the factor 'strategic motives' is weighed second highest of all factors. Also expert 3 stated that they are willing to learn from other companies about their experiences, but will not follow and adopt faster if another organization already has implemented an innovation. After these interviews, most factors in the market characteristics theme of the conceptual model were removed.

The results of the BWM show that the market characteristics theme has been weighed least of all themes by the experts. When looking at the overall global average weights, the bandwagon effect is weighed 20th, last place. Thus, the experts imply that the bandwagon effect does not significantly affect their adoption of radical innovation in the heavy duty industry. The network externalities however has been ranked 8th most important, this may be due to radical architectural innovations being disruptive to the whole system. This whole system is currently not ready and compatible for the widely adoption of radical innovation. When more organizations adopt a radical innovation, the (often new) compatible good as infrastructure, grid, road balancing etc. will have to be improved. The surplus of the companies who've implemented that innovation will gain and significantly affects the innovation adoption rate.

After the exploratory interviews, the additional factor 'collaborative marketing' was added. Mainly expert 3 stated that currently collaboration between companies do not take place, partly due to trust issues. But, many decision makers think collaboration is a factor that must be considered when adopting innovations. This has been confirmed as the factor has been ranked 11th. Which indeed shows that the experts do weigh collaboration between organizations to fasten the adoption rate of radical innovations.

Diffusion of innovation factors

From the 11 factors in the conceptual model, 8 were identified by experts in the exploratory interviews. The factors voluntariness, visibility and image were not identified by experts. Therefore, the theory by Moore and Benbasat (1991), who added the voluntariness, image and visibility factor is contradicted by this research. However, it does confirm the papers researched with regards to the adoption of other innovations in the transport and logistics industry, discussed in chapter 2.4, who also haven't identified these factors in their research as determinants of adaption. As radical architectural innovations in this industry involve large investments and disruptive changes, voluntariness is not an determinant of innovation adoption. Therefore, visibility and image are not priorities when adopting innovations, but efficiency is.

From theory, the diffusion of innovation theory by Rogers (1962) presented 5 attributes of innovations that determine the adoption of an innovation. If an innovation should have these characteristics, and these are perceived by individuals in organizations, the innovation rate will increase (Rogers, 1962). According to the experts of the exploratory interviews, the TCO and compatibility were most important. Expert 3 stated: "The basis of the decision-making process is the TCO". Expert 2 stated: "Because we drive in so many countries, the trucks must be compatible in all countries". That the experts weigh these factors as important can also be observed in the results of the BWM. The factor compatibility' is weighed 5th and 'total cost of ownership' 6th. However, compatibility has the highest local weight of all characteristics of technology. Which implies that this is the most important attribute, with regards to adopting radical architectural innovation in the heavy duty trucking industry in the Netherlands.

What also stands out, is that the trialability and technological superiority are weighed quite low. Especially technological superiority is weighed lower than expected, according to expert 8 the superiority is not an important, "because the transition has to be made nevertheless". This is in line with the theory by Grover (1993) who stated that the factors complexity and compatibility were more important determinants when adopting innovations. Besides, this research confirms the research of Tornatzky and Klein (1982) and Russell and Hoag (2004) that the determinants of innovation adoption are technological superiority, complexity and compatibility. Although these all have been stated as relevant, these do not all have a high rank.

The results are not in line with the research of Orr (2003) who stated that uncertainty is one of the main obstacles of the innovation decision. This clearly doesn't apply to radical innovation adoptions in the heavy duty trucking industry, as it is ranked 16th. This might be due to the newness of radical innovations, as expert 3 stated: "there is always a uncertainty, but if you want to be a first mover, you'll have to dare to take risks". Also trialability has no high score, according to expert 2 and 7, they think trialability is not important because if they order the trucks from the OEM's they assume the trucks are 'tried out' already. They will not have to do this again.

5.1.1 Results compared to innovation adoption research in transport and logistics

Below in figure 5.1 and 5.2 , the factors that other researchers, from section 2.4, have found when researching innovation adoption in transport and logistics have been noted and highlighted per innovation. The table is divided unto two themes per table. Factors that imply the same are noted under one factor.

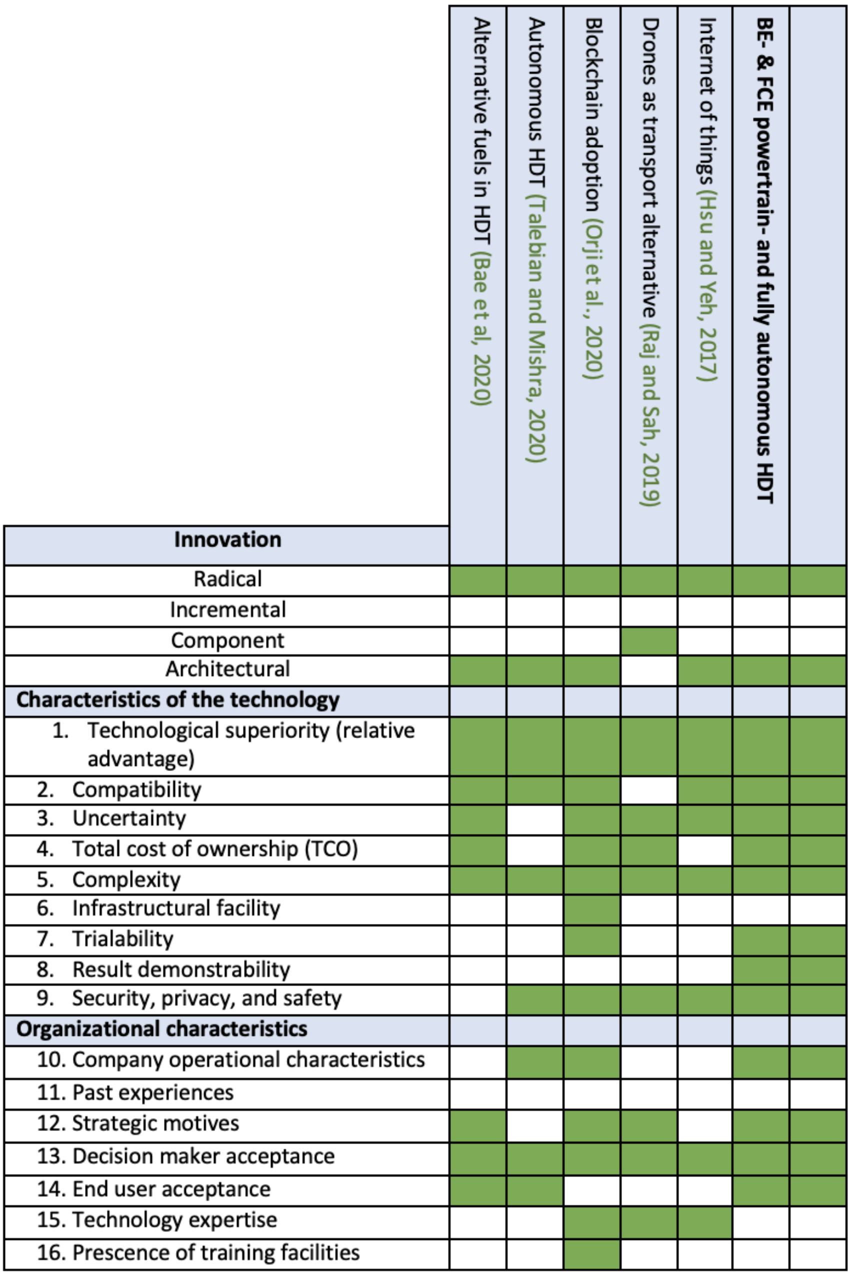

Figure 5.1: Factors for adoption by literature

What stands out from this figure is that this thesis confirms the research of Bae et al. (2022); Talebian and Mishra (2022); Orji et al. (2020); Raj and Sah (2019) and Hsu and Yeh (2017) that the factors 'technological superiority', 'complexity' and 'decision maker acceptance' are relevant in the adoption of radical architectural innovations in not only the transport and logistics industry (scope of those researchers), but also the heavy duty trucking industry in the Netherlands. This research also confirms that compatibility is a relevant factor in all radical architectural innovation adoptions. This results of this thesis also present the relevance of the factors TCO and strategic motives which is an addition to the research of Hsu and Yeh (2017) and Talebian and Mishra (2022).

Innovation	Alternative fuels in HDT (Bae et al, 2020)	Autonomous HDT (Talebian and Mishra, 2020)	Blockchain adoption (Orji et al., 2020)	Drones as transport alternative (Raj and Sah, 2019)	Internet of things (Hsu and Yeh, 2017)	**BE- & FCE powertrain- and fully autonomous HDT**
Radical	■	■	■	■	■	■
Incremental						
Component				■		
Architectural	■	■	■		■	■
External environment characteristics						
17. Supplier supporting efforts	■				■	■
18. Government policies	■	■	■	■	■	■
19. Social influences	■	■		■		
20. Coercive pressures			■	■		
21. Normative pressures			■			
22. Market turbulence			■			
Market characteristics						
23. Bandwagon effect						■
24. Network externalities						■
25. Collaborative marketing						■

Figure 5.2: Factors for adoption by literature

What can be concluded from of this table is that this research confirms the research of Bae et al. (2022); Talebian and Mishra (2022); Orji et al. (2020); Raj and Sah (2019) and Hsu and Yeh (2017) that the factor 'governmental policies' is a relevant factor in adopting innovations in the heavy duty truck industry in the Netherlands too. Although, the market characteristics have been weighed lowest in the BWM, the experts have stated them to be relevant in the exploratory interviews. This confirms the theory of the network economics Katz and Shapiro (1985) that the adoption is determined by the market mechanisms behind the market. As can been seen in the figure is that the papers of Bae et al. (2022); Talebian and Mishra (2022); Orji et al. (2020); Raj and Sah (2019) and Hsu and Yeh (2017) have not found the market effects to be relevant factors for innovation adoption. This research therefore came to new insights that these researchers have not found or have never considered to be relevant. Especially the factor 'collaborative marketing' has not been found to be a relevant factor in any theory or research about innovation adoption, in this research the experts rank it 11th out of 20. Therefore, this research is the first that finds the factor market collaboration to be relevant in the adoption of radical architectural innovations in transport and logistics.

5.2 THEORETICAL CONTRIBUTION

In this thesis we have worked toward to the establishment of a generally applicable framework for radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands. Multiple theories and researchers have studies what factors are important when adopting innovations. The outcome of this thesis confirms, contradicts and adds on these researches. The findings of this thesis has provided a framework of relevant factors that determine radical architectural innovation adoption in the heavy duty transport industry, in the Netherlands.

This thesis has focused on two radical architectural innovation adoptions BE- and FCE powertrain in heavy duty trucks and fully autonomous heavy duty trucks. Most of the factors from theory have been stated generally- or for other innovation adoptions, not focusing on BE- and FCE powertrain adoption in heavy duty trucks and fully autonomous heavy duty trucks in the Netherlands. Therefore, this research is a first.

This work aims to substantiate the relevance of these factors by including interviews with industry experts in the Netherlands. Therefore, this thesis does not only present which factors are relevant, but also NOT-relevant in the adoption of radical innovations in the heavy duty trucking industry, as perceived by industry experts. This paper also contributes to the emerging body of literature that assigns wights to factors for innovation adoption in various fields, using the BWM.

The main contributions of this work are:

1. Further analyzing of current and past literature on innovation adoption that will enrich the innovation adoption theory by setting up- and applying factors for radical innovation adoption by the heavy-duty trucking industry in the Netherlands.
2. Conducting interviews with industry experts will substantiate the relevance of the factors for radical architectural innovation adoption in the heavy duty trucking industry.
3. Setting weights to factors determine the key success factors for radical innovation adoption in the heavy duty trucking industry by conducting a Best-worst method.
4. Combining the best worst method and the list of factors from theory, and applying them jointly in the case of radical architectural innovation adoption in the heavy duty trucking industry has not been done previously.
5. The practical contribution is this research furthers the idea that there are identifiable determinants of the adoption of different radical innovations, within transport and logistics. It provides a framework for decision makers in the heavy duty transport industry and may help them prepare, evaluate and ultimately adopt radical architectural innovations.

5.3 LIMITATIONS

This thesis has several limitations. As the thesis is written in English, and the scope of this research is the Dutch heavy duty trucking industry, the industry experts often indicated that they don't speak English well. Therefore, the factors and definitions have been translated for their understanding, and sent to them before the BWM interview. However, this was written in academic language and some industry experts had difficulties with understanding some definitions. Besides, some industry experts did not have time to read and the study the list of factors before the interview. Therefore, during the first minutes of the interview, the factors and definitions had to be explained. If the experts had a full understanding of the factors before the interview, the chance of misunderstanding factors would decrease. This could have effected the outcome of the BWM.

There were 6 experts interviewed for the exploratory interviews. From these 6 experts, 1 experts was not significant in answering the questions and was removed. Therefore, 5 experts were interviewed, from these 5 interviewed experts, 3 worked at the same company. To ensure valid and consistent results, applicable for the entire industry, more companies could have been interviewed. A big limitation was finding the right industry experts, many companies only have 1 or 2 experts that could be approached for this research. These experts are often very busy and didn't have time to participate. Also, the experts interviewed could be biased towards certain factors depending on their preferences or experience. Furthermore, there is always a chance that experts forget to mention a factor during the interviews, which would result in not identifying that factor as relevant. Therefore, in further research, more experts from other companies could be interviewed for exploratory interviews to decrease this risk.

With regards to the BWM, 7 experts have been interviewed and conducted the BWM. Ideally, more experts should be interviewed to conduct the BWM. Due to scarce availability of experts, this could not be done. However, saturation of data is still reached as the key success factors remain consistent. Therefore, in further research, additional experts should interviewed (of different companies) to conduct the BWM. Then, result would be more reliable and applicable to the whole heavy duty trucking industry.

Another limitation of the BWM-approach is that no global optimal solution of the system will be identified. Only the criteria and it's weight affect the final result. Besides, when identifying to many criteria points, the calculation process becomes very complex (Bai, 2018). Another downside is that due to only closed questions being used in the survey, the expert can't elaborate on questions or the chance is that the experts can misunderstand the question.

6 CONCLUSION

This thesis aims to better understand the diffusion and adoption of radical architectural innovations in the heavy duty trucking industry. This research has focused on two radical architectural innovation adoptions BE- and FCE powertrain in heavy duty trucks and fully autonomous heavy duty trucks. The main objective was to determine the key-success factors of radical architectural innovation adoption in the heavy duty trucking industry, according to industry experts. This research identifies relevant factors determining innovation adoption amongst organizations. This has been done by conducting an extensive literature review, exploratory interviews industry experts and applying the best worst method to assigns weights to the factors. This methodology has resulted in a list of identified relevant factors for adoption, as key determinants for innovation adoption, all substantiated by industry experts. In order to reach this main objective, the main research question has been formulated as follows:

Which key-success factors determine the adoption of radical architectural innovations in the heavy-duty trucking industry in the Netherlands, according to industry experts?

To answer this main question the first sub-questions has been formulated:

SQ1. *Which success factors influence radical innovation adoption, according to current literature?*

To answer this question a extensive literature review was conducted. Here, different theories regarding innovation adaption were analyzed (Rogers, 1962; Moore and Benbasat, 1991; Farrell and Saloner, 1985; Katz and Shapiro, 1985; Meyer and Rowan, 1977; DiMaggio and Powell, 1983). Factors stated in those theories have been added to an conceptual model, as presented in table 4.1. Furthermore, literature on alternative fuel- and autonomous heavy duty truck adoption has been reviewed (Bae et al., 2022; Baker, 2012; Talebian and Mishra, 2022; Anderhofstadt and Spinler, 2020). New, not overlapping factors stated in those researches have been added to the conceptual model. Additional to factors from those theories and specific literature, prior research on factors of innovation adoption of all innovations in transport and logistic organizations were reviewed. Factors for adoption of innovations as blockchain technology (Orji et al., 2020; Beck and Müller-Bloch, 2017), drone technology (Raj and Sah, 2019; Sah et al., 2021) and internet of things (Hsu and Yeh, 2017; Tran-Dang et al., 2022) have been reviewed. Based on this literature review, a conceptual model of 20 factors has been put together, as seen in table 4.1.

The second sub question has been formulated as follows:

SQ2.*What factors do heavy-duty trucking industry experts identify when adopting radical architectural innovations?*

To answer this question, industry experts have been approached for exploratory interviews. A total of 5 interviews were held, consisting of open questions regarding innovation adoption. These interviews aimed to identify relevant factors, stated by the experts, without being biased, knowing the conceptual which was the outcome of SQ1. From the 25 factors in the conceptual model, 19 were identified by at least one expert in the exploratory interviews. Furthermore, one additional factor 'collaborative marketing' was added to the list of factors due to several experts stating it's relevance for their adoption decision making. Through conducting these interviews, a new list of factors has been set up consisting of relevant factors that determine radical architectural innovation adoption, identified by industry experts. This list is presented in chapter 4.2

The third sub question has been formulated as follows:

SQ3.*What is the importance of these factors according to heavy-duty industry experts?*

This question was proposed to identify the key success factors for radical architectural innovation adoption. The results were provided by conducting a multi-criteria decision making tool, the best worst method. Here, 7 industry experts of different companies have been asked to assign weights to the list of earlier identified relevant factors, which was the output of SQ2. Derived from these results, presented in table 6.1 below, the key success factors for radical architectural innovation adoption are **'government policies'**, **'strategic motives'** and **'supplier supporting efforts'**. The factors that have been weighed least critical are accordingly **'bandwagon effect'**, **'trialability'** and **'end user acceptance'**. Furthermore, the most important theme was external market characteristics, whilst the lease weighed theme was market characteristics.

Table 6.1: Best worst method results

Themes & Sub-factors	Local avg weight	Global avg weight	Ranking
Characteristics of the technology	0,3347		2
1. Technological superiority	0,0972	0,033	14
2. Compatibility	0,2099	0,070	5
3. Uncertainty	0,0730	0,024	16
4. Total cost of ownership (TCO)	0,1933	0,065	6
5. Trialability	0,0308	0,010	19
6. Result demonstrability	0,0870	0,029	15
7. Complexity	0,1279	0,043	10
8. Safety	0,1808	0,061	7
Market characteristics	0,1027		4
9. Bandwagon effect	0,0833	0,009	20
10. Network externalities	0,5075	0,052	8
11. Collaborative marketing	0,4092	0,042	11
Organizational characteristics	0,2114		3
12. Fleet operational characteristics	0,2295	0,049	9
13. Strategic motives	0,5305	0,112	2
14. Decision maker acceptance	0,1712	0,036	12
15. End user acceptance	0,0689	0,015	18
External environment characteristics	0,3996		1
16. Supplier supporting efforts	0,2705	0,108	3
17. Government policies	0,3448	0,138	1
18. Social pressures	0,0879	0,035	13
19. Pressures from customers	0,2392	0,096	4
20. Normative pressures	0,0576	0,023	17

As seen in these results, 'governmental regulations' has been weighed most. According to industry experts this is seen as an key success factor for radical architectural innovation adoption. With regards to the second sub question, the market characteristics theme is ranked least important of all themes.

6.0.1 Key findings

The key findings of this research are:

1. The key success factors for radical architectural innovation adoption in the heavy duty trucking industry in the Netherlands are 'governmental regulations', 'strategic motives' and 'supplier supporting efforts'. The least important determinants are 'bandwagon effect', 'trialability' and 'end user acceptance'
2. This research finds 'governmental regulations' to be the most important factor for the implementation of BE- or FCE powertrain HDT and fully autonomous heavy duty trucks, which confirms the neo-institutional theory by DiMaggio and Powell (1983) and Meyer and Rowan (1977). Due to the high purchasing costs and complexity, logistic service providers are dependent on the governmental subsidization and regulations regarding (as indicated by industry experts) maximum weight, allowance on public roads and ethical jurisdiction.
3. This research confirms the network economics theory by Katz and Shapiro (1985) that market mechanisms influence adoption as the factors are identified as relevant by experts in the heavy duty trucking industry. Industry experts have stated that when network externalities arise, it may have positively affect their adoption. Although, they do not weigh all factors significantly important when adopting radical architectural innovations. However, this is in contradict with the research of Bae et al. (2022); Talebian and Mishra (2022); Orji et al. (2020); Raj and Sah (2019) band Hsu and Yeh (2017) who have not found or neglected these factors in their research.
4. The factor 'collaborative marketing' has not been found to be a relevant factor in any theory or research about innovation adoption, in this research the experts rank it 11th out of 20. Therefore, this research is the first that finds the factor market collaboration to be relevant in the adoption of radical architectural innovations in transport and logistics.
5. This paper confirms that the attributes of the diffusion of innovation theory by Rogers (1962) are relevant in the decision making process of innovation adoption. However, due to the radicalness of the innovations the 'technological superiority' is not an important factor in the heavy duty trucking industry in the Netherlands due to external pressures to adopt.

6.1 RECOMMENDATIONS FURTHER RESEARCH

This research identified the factors that determine the rate of radical innovation adoption in the heavy duty trucking industry. An interesting topic for further research is on how logistic service providers can influence certain factors, and thus, may influence the market. Also, as governmental regulations is ranked as most important key success factor. Further research may study how logistical service providers can make use of their incentives or influence the Dutch government to incentivize companies that make that transition. Also, how logistical providers can influence governmental regulations, that in turn, may be seen as an incentive for these companies to make that transition.

Furthermore, an additional market characteristic factor 'collaborative marketing' has been found. Apperantly, logistical service providers weigh this collaboration. However, this doesn't take place. Therefore, further research may study how this collaboration may arise and the effect is may have on the innovation adoption of these companies.

A REFLECTION

In this chapter a reflection is given on how I've experienced writing this thesis.

A.1 SELF-REFLECTION

I knew that I wanted to write my thesis about innovation in transport an logistics for quite a long time. In my motivational letter when applying to study Complex Systems Engineering I had to state some ideas for my thesis. Researching innovations in transport and logistics was one of the. After following a course by Van de Kaa, technology battles, I knew that he was the suitable first supervisor for my thesis. During that course, we studied an technology battle and conducted a best worst method to determine which technology becomes dominant.

During the master thesis preparation course and the first month of writing my thesis, I was focusing on writing my thesis about a such a 'technology battle' in transport and logistics. However, slowly, I wanted to shift my focus more on sustainability aspects and was curious why logistical service providers are hesitant when adopting these radical innovations. For me, it was challenging and difficult to discover what I was willing to write, and simultaneously, to be already writing in order to complete the thesis circle deadlines. However, after the first month, I knew exactly what I wanted to research and could focus on writing my thesis.

Although I had roughly one month delay, the meetings with my thesis circle peers and van de Kaa has helped me gain insights in what to focus on. The feedback sessions of van de Kaa have helped to structure my thesis. These meetings, his feedback and seeing/reading my fellow students progression has been extremely helpful. Without this, I was not sure if I could finish the research this school-year. For me, there was a lot of pressure to finish my academic career this year as I will be traveling to south-America for 6 months starting September. Due to this, I was under a lot of stress many days when I thought that I was lagging.

If I would start this thesis project again, in the first month I would try to shift my focus solely on finding a subject I wanted to write about in. Now, it has given me quite some stress to write about a subject to reach the deadlines, but knowing that this is not the subject I wanted to write about. Also, a very difficult part of this thesis was finding the right industry experts who wanted to participate. I have spent many days cold-calling, sending mails and Linkedin messages without any answers. I've realized that the industry I was researching was very conservative, and the companies sometimes only have 1 relevant expert, with a very busy agenda. This caused stress and sometimes drained my motivation. Next time, I would plan more time to find experts and hold interviews, as it may be more difficult than expected. However, in the end I am very happy with the results my research has provided and think I have learned a lot of this process.

B FACTOR RELEVANCE

B.1 FACTORS ADDRESSED BY EXPERTS

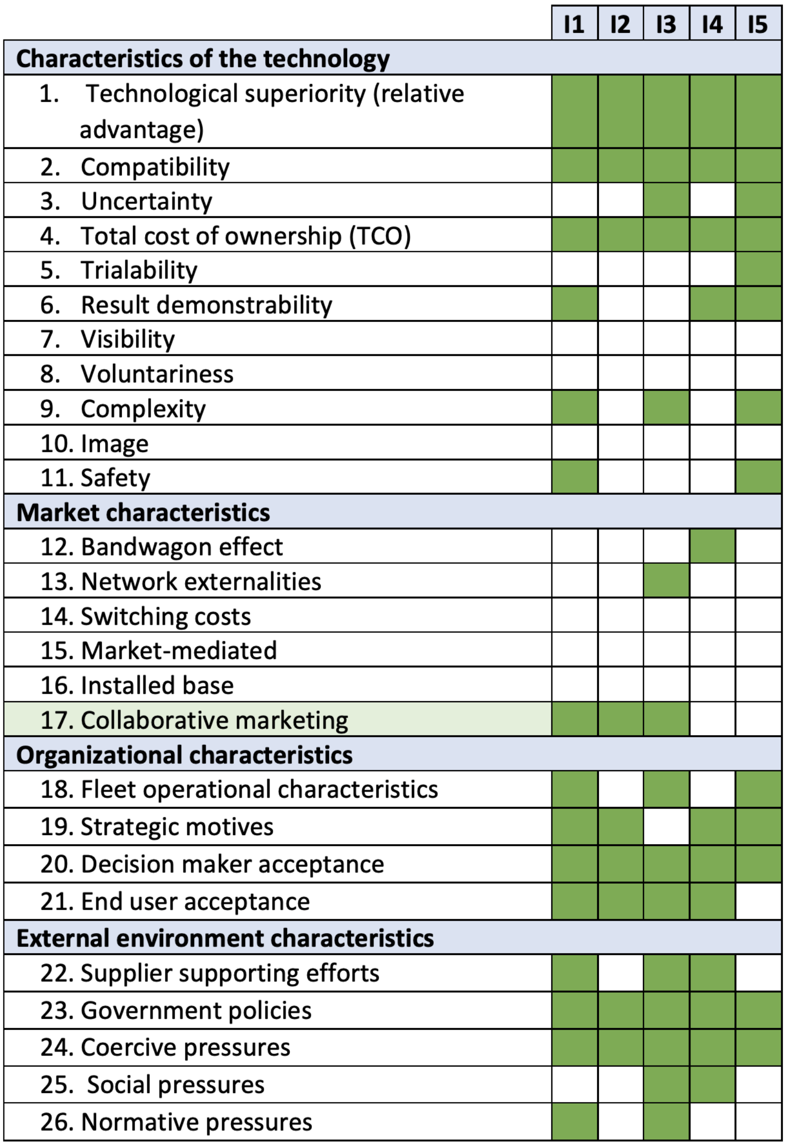

Figure B.1: Factors addressed by industry experts

B.2 DEFINITION OF ALL REVIEWED FACTORS

B.2.1 Technology characteristics

Characteristics of the technology	Definition
Technological superiority (relative advantage)	The degree to which an innovation is "perceived as being better than the innovation it supersedes" (Rogers, 1962).
Perceived compatibility	The degree to which AFVs are "perceived as consistent with the existing values, past experiences and needs of potential adopters" (Rogers, 1962). i.e., The vehicle needs to be functionally suitable in terms of vehicle power, payload and/or driving range.
Complexity	The degree to which an innovation can be used and is understandable to potential adopters (Rogers, 1962; Bae et al., 2022). i.e., fleet operation issues associated with inadequate refueling/charging infrastructure.
Uncertainty	"The degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives" (Rogers, 1962). i.e., vehicle safety concerns and operational risks
Total cost of ownership (TCO)	Monetary evaluation on overall cost of ownership (Bae et al., 2022). I.e., how much does it cost and what it costs to operate.
Trialability	The degree of which the innovation is able to be 'tried out'. This decreases the uncertainty and risk of potential adaptors and increases the rate of adoption. (Rogers, 1962)
Result demonstrability	The result demonstrability focuses on the results and communicability of using a product (Jeyaraj et al., 2006).
Visibility	Focuses on the easy of enabling social learning through observation (Jeyaraj et al., 2006).
Voluntariness	A power of the will or of motivation to get to implement an innovation.
Image	A good public image sensitive to environmental influences, which could be earned by adopting innovations, can be regarded as an additional benefit of an organization's business strategy (Bae et al., 2022)
Safety	The perceived degree of danger of an innovation.

B.2.2 Market Characteristics

Market characteristics	Definitions
Bandwagon effect	This is the process of organizations imitating other organizations in the same environment. They tend to do this to minimize risks in uncertain environments (Tornatzky and Klein, 1982). A phenomenon where early movers influence later movers' decision
Network externalities	A change in the benefit, or surplus, that a company derives from an innovation when the number of other companies making use of that innovation increases. (Gallagher and Park, 2002)
Switching costs	The amount of cost an organization pays because of switching products (Katz and Shapiro, 1985).
Installed base	The number of users of a certain innovation, that can affect the amount of complimentary goods.
Collaborative marketing	When process where two or more organizations work together to define common problems and develop joint solutions, for mutual gain. (Hartley et al., 2013) i.e. through sharing knowledge or past experiences.

B.2.3 Organizational characteristics

Organizational characteristics	Definition
Fleet operational characteristics	The characteristics of the company such as size, vehicle vocation and past experiences (Bae et al., 2022).
Strategic motives	Extrinsic motives that an organization strives for improving their competitive position in the market and industry.
End user acceptance	Attitude of vehicle drivers towards using an innovation, which may confirm the compatibility of the technology.
Decision maker acceptance	The attitude towards an innovation of a key decision maker can initiate discussions and persuade other decision makers to adopt an innovation.

B.2.4 External environment characteristics

External environment characteristics	Definition
Technology supplier supporting efforts	Vehicle manufacturers / fuel providers can influence the adoption process. For example, by unavailability of vehicles or no opportunities to test a vehicle (Bae et al., 2022).
Governmental policies	Monetary incentives or regulations by the government that can affect the adoption of an innovation.
Social influences	Direct or indirect social interactions between a member in an organization and others, which influences innovation adoption in organizations, such as via information sharing activities [Rogers, 1962], and social norm (Gallagher and Park, 2002).
Pressures from customers	Result of formal and informal pressures of other organization a firm may be dependent on. The pressure exerted on these organizations and decision maker results in incorporating certain institutionalized rules and practices (Tornatzky and Klein, 1982).
Normative pressures	This is the process of imitation. Although, this is done through professionalization of actors within firms, due to similar education, training, or professional networks (Tornatzky and Klein, 1982).

B.3 BEST-WORST-METHOD

B.3.1 Weights assigned by experts

Table B.1: Weights assigned by experts

Categorties & Factors	E2	E6	E7	E8	E9	E1	E10
Characteristics of the technology	0,3673	0,3129	0,2527	0,2979	0,3802	0,1988	0,5329
1. Technological superiority	0,1373	0,0618	0,0895	0,0686	0,1034	0,1388	0,0813
2. Compatibility	0,1569	0,3026	0,2204	0,2514	0,2562	0,2005	0,0813
3. Uncertainty	0,0588	0,1237	0,0671	0,1143	0,0225	0,0668	0,0580
4. Total cost of ownership (TCO)	0,1765	0,1855	0,2013	0,1714	0,1034	0,2005	0,3145
5. Trialability	0,0196	0,0260	0,0192	0,0229	0,0775	0,0257	0,0247
6. Result demonstrability	0,0980	0,0530	0,0671	0,0857	0,1034	0,1003	0,1016
7. Complexity	0,1765	0,1237	0,2013	0,1143	0,0775	0,0668	0,1354
8. Safety	0,1765	0,1237	0,1342	0,1714	0,2562	0,2005	0,2032
Market characteristics	0,0612	0,0491	0,0440	0,0638	0,3802	0,0585	0,0623
9. Bandwagon effect	0,0667	0,0667	0,0667	0,1091	0,0833	0,1000	0,0909
10. Network externalities	0,2533	0,2111	0,6667	0,8000	0,6667	0,7000	0,2545
11. Collaborative marketing	0,6800	0,7222	0,2667	0,0909	0,2500	0,2000	0,6545
Organizational characteristics	0,4286	0,1043	0,2527	0,1489	0,1570	0,2982	0,0900
12. Fleet operational characteristics	0,4188	0,1883	0,3077	0,2397	0,0778	0,1935	0,1805
13. Strategic motives	0,4607	0,4843	0,4923	0,5594	0,6333	0,4516	0,6316
14. Decision maker acceptance	0,0628	0,2825	0,1538	0,1438	0,1444	0,2903	0,1203
15. End user acceptance	0,0576	0,0448	0,0462	0,0571	0,1444	0,0645	0,0677
External environment characteristics	0,1429	0,5337	0,4505	0,4894	0,4215	0,4444	0,3149
16. Supplier supporting efforts	0,2684	0,2052	0,1778	0,4005	0,4812	0,1765	0,1842
17. Government policies	0,3158	0,5084	0,4406	0,2579	0,2949	0,4118	0,1842
18. Social pressures	0,0632	0,0446	0,0387	0,1290	0,0843	0,1765	0,0789
19. Pressures from customers	0,3158	0,1539	0,2667	0,1719	0,0983	0,1765	0,4912
20. Normative pressures	0,0368	0,0879	0,0762	0,0407	0,0414	0,0588	0,0614

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