Master's Thesis – MSc Sustainable Business and Innovation

The Diffusion of Sustainable Product Service Systems: A systems perspective of e-bikes

Ryanne Pisa – 5537428

Ryanne.pisa@gmail.com

Faculty of Geosciences, Utrecht University

45 ECTC

22-08-2021

Word count: 21.621

Utrecht University

Supervisor: Dr. Giovanna Capponi

Second reader: Dr. Matthijs Punt

TNO, Utrecht

Supervisors: Jamilja van der Meulen & Ton Bastein

Acknowledgement

I would like to thank my supervisor Giovanna Capponi from Utrecht University for guiding me through writing my thesis. Especially during such an unusual period in light of COVID-19. I am thankful for your time and constructive feedback and putting up with my chaotic self. I would also like to thank Jamilja van der Meulen en Ton Bastein for their energy, feedback and knowledge during my internship period. I really enjoyed the moments we could talk about things I discovered during my research and their innovative perspective on these findings. Furthermore, I would like to express my appreciation to all the people who took the time to do an interview and shared data with me to conduct my research. Finally, Jisca van Bommel, without our sparring sessions I would be lost.

Abstract

In recent years, the demand for e-bikes in the Netherlands has grown significantly and is expected to grow more. Subsequent waste streams are cause for concern. Sustainable Product Service System (S.PSS) are seen as an interesting solution to reduce resource consumption. Research has suggested that a S.PSS business model provides firms with a strong incentive to improve the environmental performance of their product offering. Despite the numerous benefits of S.PSS, S.PSS business models remain part of a niche market.

This study therefore aimed to gain in-depth knowledge about the current drivers and barriers of the S.PSS diffusion process by taking the e-bike industry as a case study. This way, the theoretical discussion on S.PSS diffusion can be enriched by practical evidence, which can ultimately help industry actors with designing and implementing S.PSS. The following research questions are addressed: 1) *What drivers and barriers exist within the supply chain to move to a S.PSS business model?* and 2) *How can the development and diffusion of Sustainable Product Service Systems (S.PSS) be stimulated within the business-to-consumer e-bike market?*

This study used the Multi-Level Perspective, a case study and 12 semi-structured interviews to approach these research questions from a systems perspective. Interviews were thematically analyzed and identified factors were then ranked by interviewees. The findings show that the diffusion of use-oriented S.PSS in the e-bike market from niches to mainstream markets still has a long way to go. Persistent resistance to change of incumbent actors within the value chain that are benefitted by the current system show little willingness for alternative business models. However, clear signs on the landscape level show that changes in consumer preferences and (inter)national policy are slowly pressuring the dominant sales model. Overcoming barriers on the niche level could further challenge incumbent actors. Using the identified drivers and barriers and the recommendations from this study could contribute to further diffusion of S.PSS, as well as facilitate firms with finding sustainable ways to do business. Future avenues for research point to amongst others a more critical analysis of drivers and barriers and the opportunities presented for S.PSS by the rise in demand for delivery services. The results of this study can be improved by gathering more empirical data and interviewing more actors, amongst others.

Table of Contents

List of abbreviations

BMI = Business Model Innovation

CE = Circular Economy

EoL services = End of Life services

EPR = Extended Producer Responsibility

MLP = Multi-Level Perspective

PaaS = Product as a Service

PO = Product Oriented service system

PSS = Product Service Systems

RO = Result Oriented service system

SME's = Small and Medium sized Enterprises

S.PSS = Sustainable Product Service Systems

STS = Socio-Technical System

UO = Use Oriented service system

1. Management summary

Introduction

In recent years, the demand for e-bikes in the Netherlands has grown significantly and is expected to grow more. The move to electric vehicles is often seen as the technology that can help to decarbonize the transport sector and is therefore recognized as an enabler for the energy transition. The flipside of this coin is that with this growth in demand for e-bikes, subsequent waste streams of electric vehicles and especially their batteries are cause for concern. Currently, one of the most prominent environmental issues of e-bikes regards the lifetime of the battery, which is speculated to be 5 years depending largely on how it is used - sometimes even having to be discarded after the first year. Notably, the lifetime of the battery also determines the lifetime of the entire e-bike, as consumers often opt to buy a new bike after five years, instead of spending money on a new battery. As the Netherlands have proclaimed to aim for a 100% circular economy by 2050, finding alternative, sustainable ways to respond to the demand for e-bikes as well as incentivizing firms to improve the environmental performance of the e-bike is a necessary focus area.

A much-discussed solution that has the potential to reduce resource consumption regards the Sustainable Product Service System (S.PSS). The central idea behind S.PSS is that firms with a S.PSS model typically sell a service or a mix of products and services, and thereby provide customers with a particular result or function - a need fulfilment -, without customers having to own the physical product itself. Importantly, research has suggested that a S.PSS business model provides firms with a strong incentive to extend the lifespan of the products they sell or offer in a service model, as firms typically retain ownership of the product. With these insights, a S.PSS could serve as an interesting solution in the case of the e-bikes, but despite its benefits, S.PSS remain part of a niche market. Then, understanding what drives and challenges actors within the e-bike industry to start offering a S.PSS will give insights into how S.PSS can move from niches to larger markets. This study thus aimed to answer the following research questions:

How can the development and diffusion of Sustainable Product Service Systems (S.PSS) be stimulated within the business-to-consumer e-bike market?

1. *What drivers and barriers exist within the supply chain to move to a S.PSS business model?*

By answering these research questions, this study aimed to address the knowledge gaps of S.PSS diffusion by taking the e-bike industry as a case study, further the theoretical discussion on S.PSS diffusion and ultimately help industry actors with designing and managing S.PSS.

Theory

This study used the Multi-Level Perspective (MLP) developed by Geels (2004) to approach the research questions from a systems perspective. From this theory can be understood that the uptake of novel business models can be seen as the introduction of an innovation (e.g. business model innovation (BMI) in the case of already existing firms). Hence, the MLP showed that innovations such as S.PSS go through multiple phases and emerge in niche markets before entering mainstream markets. In order to facilitate this development process, overcoming or disrupting regime lock-ins, path-dependencies and inertia is necessary. This is consistent with overcoming barriers and enhancing drivers of S.PSS development and implementation in order to facilitate further diffusion. Therefore, internal and external drivers and barriers of these processes were identified.

Methodology

This study used the Multi-Level Perspective, took the e-bike sector as a case study and conducted 12 semi-structured interviews to approach the research questions and aims of this study from a systems perspective. Interviews were thematically analyzed and identified factors were then ranked by interviewees.

Findings

The following section will summarize the main findings from the interviews, which was focused on obtaining the drivers and barriers for (use-oriented) S.PSS diffusion.

First of all, the design-related theme regards factors that influence the initial development of the S.PSS itself. The most relevant barriers within this theme point to the complexity of offering an intensive level of service, the difficulty of scaling up and establishing a well-functioning inventory management. Furthermore, in this theme it became apparent that due to this intensive level of service, a certain coverage is necessary. This suggests that it will not be likely that S.PSS are able to completely replace traditional models, as this model will not work in less densely populated areas. No design-related drivers were identified.

Secondly, the economic theme regards financial factors that influence the diffusion of S.PSS. Here, S.PSS was recognized as an interesting new market opportunity, especially within the current timeframe where a trend towards ownerless consumption can be identified. Interestingly, services were seen as a form of differentiating from competitors, showing that the e-bike sector is already moving towards servitisation models. As for economic barriers, the economic feasibility of S.PSS are perceived as doubtful. This can be explained by the revenue streams and cost structures, which in use-oriented S.PSS entail cashflow uncertainties, high investment costs and a long amortization time. These lead to the perception of S.PSS being financially risky. Moreover, putting the subscription and share bikes in the context of the MLP, it is apparent

that these types of PSS are still in the initial phases of the development process. The lack of market acceptance, which regards the rate of market uptake on both the demand and supply side, is thus still lacking. However, the growth of the subscription companies interviewed in this research shows that the acceptance of these models is increasing. Most notably is that many factors (not only within this theme) seem to reinforce one another. For example, accounting for use-related costs leads to higher investments costs, thus higher financial risks, which ultimately leads to increasing prices and therefore a higher concern for costs from a consumer perspective.

Thirdly, in the themes knowledge and organizational, it is shown that firms acknowledge that the sustainable approach to business inherent in a S.PSS is an important driver for implementation. At the same time, the organizational fit is an important prerequisite, as resistance to change remains a significant barrier within this theme. Reasons behind this resistance point to a fear of over-diversification and a lack of adequate leadership due to, for example, a focus on short term goals.

Fourthly, the factors within the theme consumer are closely related to market acceptance. Important drivers within this theme are a wish to lose the responsibilities of ownership, a wish to disconnect from consumption needs and a demand for flexibility and certainty. Barriers consists of cost concerns, a wish for ownership, lack of knowledge of life cycle costs and a wish for a large variety of product choice. An important insight from this theme point to the apparent existence of two different types of consumers within this sector, which is different from more traditional consumer typification. The first type regards consumers who use the e-bike for its functional value, e.g. to get from point a to b (as efficiently, cheaply, most conveniently as possible). The other type regards consumers who value the e-bike beyond its functional utility. This latter group for example uses the e-bike as a hobby, feels strongly connected to a specific brand or might even perceive owning an e-bike as a status symbol. That is not to say that this group will never make use of a S.PSS. For example, when using an e-bike as part of a public transport system, then the activity itself only regards the functional utility and will not intrude on the other values. Nonetheless, this insight shows that the primary target group of S.PSS are people who fall into the former group and again suggests that a S.PSS will never be able to fully replace traditional models. In addition, multiple interviewees pointed to differences between countries, which suggests that market acceptance is also linked to cultural differences.

Lastly, drivers within the themes contextual and value chain regard a high demand for the e-bike itself, which Covid-19 increased even more. Especially the demand for e-bikes in delivery services has grown within this timeframe. Furthermore, a wish for more control over processes within the value chain and stimulating regulations are driving forces identified in these themes. Important barriers regard conflicting interests between actors within the supply chain, a reluctance to share information and fear of reputation losses. Here, the MLP sheds light unto some of the forces that keep the current regime in place. As S.PSS are niche innovations, the actors within this group are not powerful enough to change current production

patterns. More importantly, they are dependent on some of the actors that keeps the current regime in place, namely the supplier of electronical components such as the battery and motor. These suppliers currently benefit the most from a sales model. Furthermore, many interviewees point out that the e-bike market is still in the initial stages of the development process. This is especially the case for S.PSS models within this sector. In light of this, companies that currently offer a S.PSS within the e-bike sector seem to have a strong focus on growth and gaining market share. However, this focus results in a lack of perspective of the whole system on the long term. Due to the fact that e-bikes have been offered for a relatively short period of time, companies do not yet have significant waste streams of electrical components. As such, actors feel little urgency to either develop or change the current system. Furthermore, economically depreciated e-bikes, that still have some value, are often shipped to countries like Poland. Whilst here they get to have a longer functional life, it is also a form of waste leakage to another country with perhaps less strict EoL regulations.

Conclusion and discussion

From the analysis can be concluded that the current regime is locked into place by a variety of behavioral, consumption and production patterns and vested interests by incumbent actors. Whereas product-oriented S.PSS for e-bikes are often in a symbiotic relationship with the dominant regime, for use-oriented S.PSS for e-bikes to grow within its niche and enter the meso level of the regime, established patterns need to be broken first. Importantly, the MLP shows that solutions to barriers of S.PSS development and diffusion should take on a systems level, otherwise little change can be expected. In light of these findings, the following recommendations are given.

1) The analysis showed that current landscape dynamics, such as pressures from (inter)national directives, as well as landscape shocks such as Covid-19, have already proved to be opportunities to change established patterns. The most notable and perhaps most interesting insight here regard the trend of ownerless consumption which is a major driving force for firms to offer use-oriented S.PSS for e-bikes. This trend contrasts the still dominant consumer preferences of ownership, but further normalization and stabilization of this pattern could have significant impact on the wider diffusion of use-oriented S.PSS for e-bikes. Therefore, policy aimed at changing consumer norms and cognitions that facilitates the normalization of this trend can prove fruitful. For example, expanding already existing local policy on shared mobility and carless neighborhoods and city centers, but also stimulating developments on infrastructure for small electric vehicles and solutions such as MaaS. Here it is relevant to keep a critical view of the political interests regarding other transitions in order to find synergies that can facilitate the diffusion of multiple desired transition pathways, such as those that favor decarbonizing (urban) mobility.
2) The findings showed that the Dutch e-bike market already shows a strong focus on servitization and modularity of product design. The added value of use-oriented S.PSS of e-bikes really pertains to the focus on longevity and durability, which is now partly inhibited by vested interests from suppliers. In that sense, changing these production

patterns by overcoming the resistance to change of stakeholders can spur innovations on longevity and durability instead. The most obvious solution is to further extend the producer responsibility for products with high impact, such as the batteries, then is currently the case. However, perhaps a more interesting solution in the context of this research would be alternative business models for suppliers. For example, a PaaS model for batteries is also a form of EPR and would significantly change the focus of the current dominant model on sales. Not only would it decouple the lifespan of the battery from the lifespan of the e-bike (remember, the battery lifetime often determined if the e-bike would be thrown away), it would also spur innovations regarding re-use and recycling.

3) As not all barriers are equally relevant, it is recommended to focus efforts on the barriers that are most critical. For firms wanting to offer a S.PSS it is thus recommended to map these critical factors in order to account for challenges up ahead, and for firms that are already offering S.PSS to understand where further points of improvements lay that could improve their value proposition.

In conclusion, the diffusion of use-oriented S.PSS in the e-bike market from niches to mainstream markets still has a long way to go. However, clear signs on the landscape level show that changes in consumer preferences and (inter)national policy are slowly pressuring the dominant sales model. Overcoming barriers on the niche level could further challenge incumbent actors. In light of pressing climate issues such as dwindling finite resources and the degradation of land due to resource demand, a S.PSS serves as an interesting solution that incentivizes firms to improve the environmental performance of their product offering. Therefore, using the identified drivers and barriers and the recommendations from this study could contribute to further decarbonization of the mobility sector, as well as facilitate firms with finding sustainable ways to do business.

Avenues for further research point to exploring differences between cultures and countries for S.PSS diffusion, mapping possible waste leakages, analyzing new emergent markets of delivery services, and looking at further extensions of producer responsibility schemes. The results of this study can be improved by gathering more empirical data and interviewing more actors, amongst others.

2. Introduction

Since the first Climate Change Conference of Parties in 1995, member states have discussed and negotiated agreements to mitigate effects of climate change and prevent harmful global warming for years (United Nations, n.d.). One prominent theme in climate politics regards the rising demand for resources worldwide. Essentially, keeping up with this demand as well as concerns regarding dwindling finite resources requires changing current consumption and production patterns (Camacho-Otero et al., 2018; Kirchherr, Reike & Hekkert, 2017). Inevitably, this implies a need for fundamentally different ways of handling resources in production, consumption and waste management systems (Geissdoerfer et al., 2017). Whilst the responsibility for changing these systems traditionally lie with governmental bodies, a recent trend in climate politics has seen a collaboration between public and private entities. Worldwide, firms are taking responsibility for their environmental footprint and making efforts to reduce their impact (Lozano, 2015).

An often-cited strategy to reduce environmental impact of firms in academic literature regards changing the business model of the firm (Kirchherr, Reike & Hekkert, 2017). According to Teece (2010, p. 173), a business model "*articulates the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers. It also outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value.*" In particular, if a firm decides to change its business model by adopting a more sustainable approach, modifications at the strategic level in terms of product design, commercial strategy and supply chain management are necessary (Bocken, 2016). A much-discussed type of business model in the academic literature that has the potential to reduce resource consumption regards the Sustainable Product Service System (S.PSS) or the Product-as-a-Service (PaaS) model (Tukker, 2004). Mont (2002, p. 239) defines a S.PSS as: "*System of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models*". The central idea behind S.PSS is that firms with a S.PSS model typically sell a service or a mix of products and services, and thereby provide customers with a particular result or function - a need fulfilment -, such as warmth, light or mobility, without customers having to own the physical product itself (Rexfelt & af Ornäs, 2007). Importantly, research has suggested that a S.PSS business model provides firms with a strong incentive to extend the lifespan of the products they sell or offer in a service model, as firms typically retain ownership of the product (Maxwell & Van der Vorst, 2003; Bocken et al., 2014). In addition, one product is typically used by multiple users throughout its life, which results in an intensified use, and firms can more easily create value after the use-phase of the product has passed (Bocken et al., 2014). Ultimately, these points can lead to a reduction of resource- and material use.

However, adopting a new business model is not an easy venture for any firm, as it is often riddled with resistance from both up- and downstream stakeholders as well as many operational challenges (Bocken et al., 2016). Notably, changing to

or adopting a new business model is often more difficult in cases where this model is significantly different from what society is used to, since certain production and consumption patterns are safeguarded by powerful, mutually reinforcing interests (Berkeley et al., 2017). To exemplify, despite the numerous benefits of S.PSS mentioned in the literature, such as the wide range of business opportunities enabling distinction in competitive markets, customer need fulfilment and the environmental benefits mentioned prior, S.PSS business models remain part of a niche market (Schallehn, Seuring, Strähle & Freise, 2019; Mont, 2002). Researchers argue that this is partly due to the need for a cultural shift from ownership to ownerless consumption and thus a lack of market readiness and acceptance of S.PSS (Baines et al., 2007). According to Geels, for an innovation (such as S.PSS) to diffuse from niches to mainstream markets, first lock-ins, path-dependencies and inertia need to be disrupted and overcome. However, S.PSS diffusion is complex (Ceschin, 2010), and it can thus be expected that a multitude of drivers and barriers influence its development. In order to accelerate the diffusion of S.PSS business models, it is necessary to understand what factors contributed and sustained the shift to more service-oriented models, what difficulties new actors could avoid and what is needed to support such business models (Mont, 2002).

2.1. The Dutch e-bike market and PSS

In recent years, the demand for e-bikes in the Netherlands has grown significantly and is expected to grow more (Meulenkamp, van Bree & Geurts, 2019). The move to electric vehicles is often seen as the technology that can help to decarbonize the transport sector and is therefore recognized as an enabler for the energy transition (Meulenkamp, van Bree & Geurts, 2019). For example, a longitudinal research done in the Netherlands by Sun et al. (2020) showed an overall reduction in car use after purchasing an e-bike. Despite an even stronger reduction in conventional bike-use, the net environmental gain after e-bike adoption was found to be significant. The flipside of this coin is that with this growth in demand for e-bikes, subsequent waste streams of electric vehicles and especially their batteries are cause for concern (Harper et al., 2019). Currently, one of the most prominent environmental issues of e-bikes regards the lifetime of the battery, which is speculated to be 5 years depending largely on how it is used - sometimes even having to be discarded after the first year. Notably, the lifetime of the battery also determines the lifetime of the entire e-bike, as consumers often opt to buy a new bike after five years, instead of spending money on a new battery.[1] As the Netherlands have proclaimed to aim for a 100% circular economy by 2050, finding alternative, sustainable ways to respond to the demand for e-bikes as well as incentivizing firms to improve the environmental performance of the e-bike is a necessary focus area. With these insights, a S.PSS could serve as an interesting solution as it offers several (environmental) advantages and business opportunities. Most importantly, firms with a S.PSS business model will typically remain owners of the e-bikes, which will

[1] This knowledge was obtained through TNO and the CIRCO knowledge event, see section 4.2.3. for more information

serve as an inherent motivation to extend battery lifetime, to opt for more sustainable, long-lasting product design and eventually, less demand for new e-bikes (Mont, 2002; Annarelli, Battistella & Nonino, 2016). Additionally, opportunities also arise from an increase in information about the use-phase of the e-bike and a closer relationship to the customer, which could impact the quality of the service and thereby customer satisfaction (Moro, Miguel & Mendes, 2020; Richter et al., 2018). Then, understanding what drives and challenges actors within the e-bike industry to become part of a S.PSS will give insights into possibilities to accelerate diffusion of S.PSS business models to mainstream markets in the Netherlands.

2.2. Relevance and research questions

Since the first introduction of the PSS concept by Goedkoop et al. (1999), many studies have been conducted on PSS since (for example, see systematic review by Annarelli, Battistella and Nonino (2016) or by Baines et al., 2007). These studies have focused on amongst others, the environmental dimension of PSS, the application and implementation of PSS and the PSS design process (Annarelli, Battistella & Nonino, 2016). A recent systematic review done by de Jesus Pacheco et al., (2019) stated however that the wider adoption and diffusion of PSS remains very limited. Others have stipulated the need for further research into the PSS diffusion process and its critical factors in relation to wider system processes such as the socio-technical system (Vezzoli et al., 2015). A better academic understanding of this diffusion process on a system level is thus relevant. Moreover, most studies on PSS on mobility have focused on the automotive sector while neglecting small electric vehicles such as the e-bike. In perspective of the focus on changing mobility patterns, a PSS for e-bikes can serve as a viable alternative for the use of cars in the case of small to medium distances (Sun et al., 2020). In addition, as touched upon in the previous section, from a societal viewpoint, PSS could be an innovative solution to resource depletion and stimulating firms to focus on long-lasting, high quality product design.

In light of above, it has become clear that it is important to understand how S.PSS can be further implemented and diffused in the market. This study has done so by focusing on how the development and diffusion of S.PSS can be stimulated by looking at drivers and barriers within the value chain of the electric bicycle. The following research questions is answered:

How can the development and diffusion of Sustainable Product Service Systems (S.PSS) be stimulated within the business-to-consumer e-bike market?

2. *What drivers and barriers exist within the supply chain to move to a S.PSS business model?*

This study used the Multi-Level Perspective developed by Geels (2004) to approach these research questions from a systems perspective, whilst interviews were used to gain in-depth knowledge about the current drivers and barriers actors in the e-bike sector face. This way, the dynamics of multiple processes that potentially influence S.PSS diffusion in the e-bike

sector were studied. This study therefore aimed to address the above knowledge gaps by taking the e-bike industry as a case study, further the theoretical discussion on S.PSS diffusion and ultimately help industry actors with designing and managing S.PSS. This research is structured as follows. In chapter 3, the theoretical background with relevant academic literature is discussed. Chapter 4 provides an overview of the methods used in this study, followed by the results in chapter 5 and a conclusion and discussion in chapter 6 and 7, respectively.

3. Theoretical background

In today's society, it has become increasingly important for firms to create a business model that is unique, hard to imitate and able to fulfil customers' needs (Teece, 2010). Essentially, business modelling is a way to secure and expand competitive advantage (Wirtz et al., 2016). In traditional business models, firms are concerned with saturated markets. In order to maintain long-term sales levels, there has been speculation that firms purposely design their products in such a way that the lifespan of the product is lower than technologically possible in order to stimulate replacement buying by customers (Bulow, 1986). An example of this is shown by the research of Bakker, Wang, Huisman & Hollander (2014), who studied the lifetime of a variety of household products in the Netherlands. Except for lamps, all product categories were shown to have a lower expected lifetime in 2005, compared to five years prior. The idea that firms purposely design products with artificially limited useful life, was coined as the term *planned obsolescence* (Bulow, 1986). In contrast, a S.PSS stimulates the opposite behavior of planned obsolescence. Hence, this chapter starts with an introduction to PSS models and its relevance to sustainability (section 3.1). As mentioned, current (S.)PSS models remain largely part of a niche market. In order to understand the interaction between niches and mainstream markets and how S.PSS can move from niches to these broader markets, the Multi-Level Perspective developed by Geels (2004) is discussed in section 3.2. Stimulating the transition from niches to broader markets is consistent with enhancing drivers and overcoming barriers, as current production and consumption patterns are often defined by lock-ins, path dependencies and inertia (Markard et al., 2012). Therefore, the drivers and barriers S.PSS development and implementation are provided in section 3.3. Section 3.4. puts these drivers and barriers within the context of the e-bike sector and thereby provides an overview of the current market and actor landscape. Finally, section 3.5 very briefly summarizes the discussed literature and combines these in one theoretical framework.

3.1. Product Service Systems & Sustainability

A PSS can be described as an integrated system of products and services and is specifically designed to provide a particular functionality to customers (Goedkoop et al., 1999; Baines et al., 2007). Tukker and Tischner (2006) define PSS as "*consisting*

of tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs" (p. 1552). Thus, instead of one-time product sales, PSS offers a mix of both products and services while focusing on the satisfaction of customer demand. Typically, this results in extending the period of revenue and changes the relationship between buyer and seller to a long-term service relation. This long-term service relationship simultaneously works as an important economic driver, as it enables customer lock-in, customer loyalty and continuous cashflow from services (Beuren, Ferreira & Miguel, 2013). Moreover, it has been recognized that PSS allow for differentiation in highly competitive and saturated markets, as the addition of service elements can create more value for customers that are typically harder to imitate by competitors (Baines et al., 2007). PSS thus offer significant strategic market opportunities.

There are multiple forms of PSS business models, which vary on an axis from being more product-oriented to purely result-oriented. In the literature, three main categories can be classified (Tukker, 2004; 2015):

1. Product-oriented (PO) service systems. In this category, the business model is still mostly geared towards selling a product, but some service-oriented functions are added, such as after sales services or take-back agreements.
2. Use-oriented service (UO) systems. In this category, the business model is built around services surrounding the use of the product. Typically, the provider remains the owner of the product, while the product is made available in a different form to users for a specific period of time. An example of this is car renting.
3. Result-oriented service (RO) systems. In this category, the buyer and provider agree on a specific outcome. How this outcome is established, is up to the provider.

An illustration of a result-oriented PSS is Phillips' Light-as-a-Service. Instead of selling lamps, Phillips offers the service of providing light within buildings. The customer pays a monthly fee for the access to light. This means that when a lamp breaks, Phillips is responsible for reparation and the costs that come with it. In this way, customers do not need to purchase the lamps themselves (Phillips, n.d.). As can be inferred from this example, a PSS business model provides firms with an inherent motivation to elongate the product lifetime in cases where the firm remains the owner of the product, because the firm will have to pay for repair and replacement. As such, PSS is often recognized as a promising approach to reduce the environmental impact of product systems, improving resource efficiency and effectiveness and decouple value from the delivery and ownership of physical products (Kjaer et al., 2018; Bocken et al., 2014).

Despite expectations, multiple studies have shown that PSS is no automatic guarantee for (absolute) resource reduction, and neither for resource decoupling (e.g. Pigosso et al., 2010; Kjaer et al., 2018; Tukker, 2004). For example, Tukker (2004) argues that leasing would lead to less careful use by customers as they do not own the product themselves. This could ultimately lead to more frequent replacement of the product compared to a traditional sales model (Kjaer et al., 2018). Furthermore, second-hand products obtained from End-of-Life (EoL) services do not always replace new products and could instead lead to an overall increase in consumption due to their lower prices (Kjaer et al., 2018). According to Pigosso

and McAloone (2016, p. 33), the environmental performance of a PSS is dependent on "the product and systems' design and on the efficiency of the networks and infrastructure within which the PSS is operated." They therefore state that the PSS design process is one of the most influential factors in the development of sustainable PSS. Kjaer et al. (2018), acknowledge this viewpoint and conclude that realizing the sustainability potential for PSS is dependent on a firm's ability to direct and control resource use, and its ability to design and implement services that influences consumer behavior and dematerializes consumers' need fulfillment. Therefore, this study distinguishes between a PSS and a S.PSS as from the above points it can be expected that developing and implementing a S.PSS is (even) more challenging compared to a PSS. Before discussing these challenges in more detail, it is first relevant to understand the larger system behind certain production and consumption patterns, as will be done in the following section.

3.2. The Multi-Level perspective

In order to understand how S.PSS can move from being offered and adopted mostly in niche markets to mainstream markets, this study looked at the Multi-Level Perspective (MLP) developed by Geels (2004). The MLP states that innovation does not happen in isolation, and its development and diffusion are driven by larger systematic processes within socio-technical systems (STS). STS can be understood as complex systems with multiple dimensions and actors that essentially fulfil societal functions, such as mobility, housing or food provision. These interdependent dimensions include a mix of technology, infrastructure, supply chains, cultural meanings, regulations, user practices and markets, which can be coupled to specific actors within a particular STS (Geels et al., 2017; Geels & Schot, 2007). STS develop over a long period of time and the alignment of the different elements in this process typically lead to significant lock-ins, path dependency and resistance to change (Geels et al., 2017). In particular, the MLP explains how technological transitions develop, and it consists of three core concepts: the socio-technical regime, niche innovations and the socio-technical landscape.

The MLP stipulates that existing STS are maintained by incumbent actors, who in turn are influenced by deeply seated rules and institutions called 'socio-technical regimes' (Geels et al., 2017). On the other hand, niche innovations are radically different from the dominant regime and emerge in the periphery where they can be protected against mainstream market selection (Geels & Schot, 2007). Typically, these innovations are still underperforming and under development by a small network of actors but are able to gain a foothold in particular market segments (niche markets). The socio-technical landscape refers to the exogenous context that is beyond the influence of actors but does have a significant influence on the socio-technical regime. These landscape developments consist of both slow-changing trends such as demographics, ideologies and climate change, and 'exogenous shocks', such as wars or economic crises. Importantly, the key message of the MLP is that "transitions come about through the alignment of processes within and between the three levels" (Geels et al., 2017, p. 465), as depicted in figure 1.

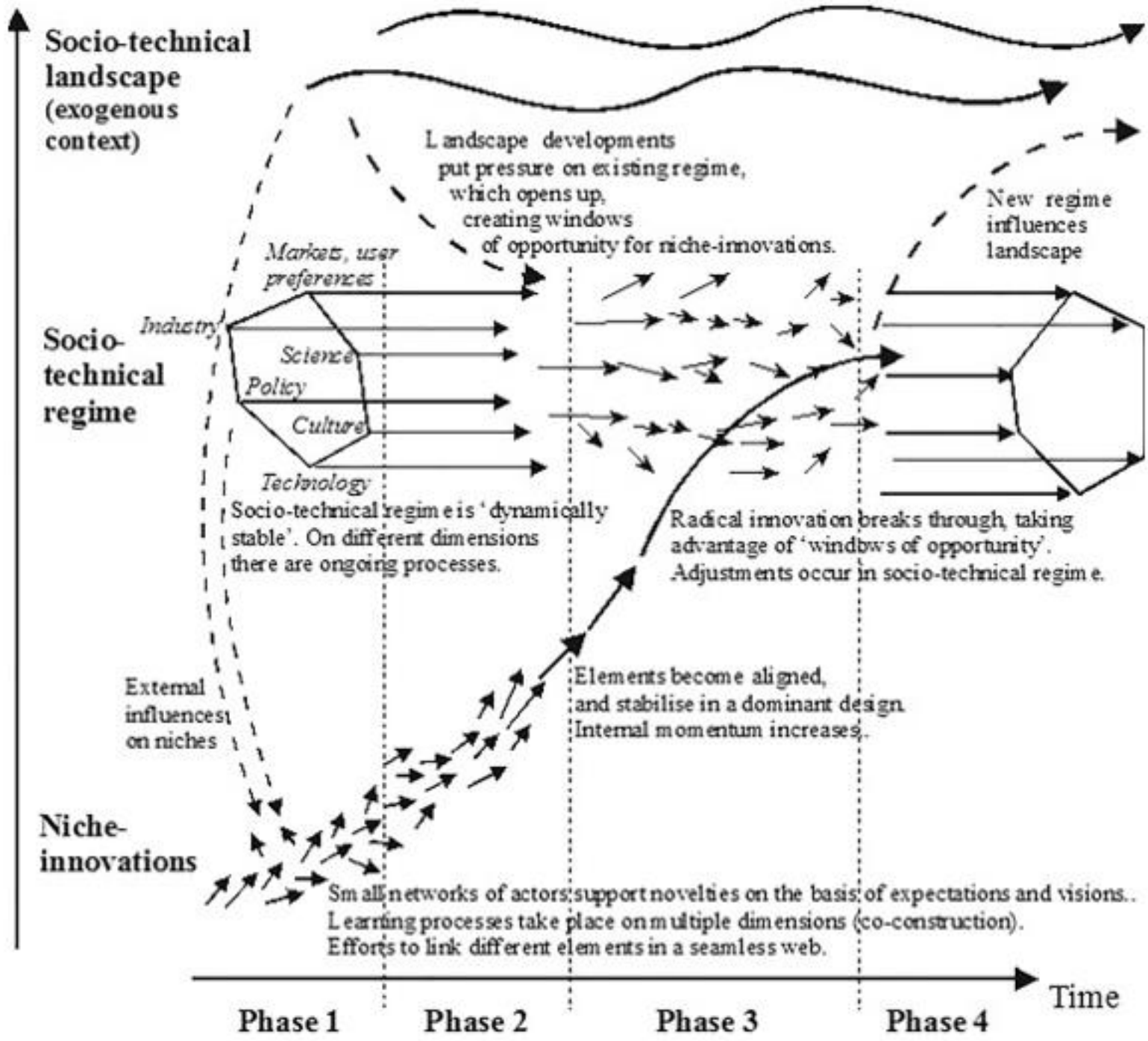


Figure 1: The Multi-Level Perspective on socio-technical transitions from Geels & Schot (2007)

As shown in figure 1, the MLP stipulates that innovations go through four phases. In the first phase, innovations emerge in niches where they are still under development. Initially, actor networks in these niches are characterized as mostly unstable, uncertain and experimental (Geels et al., 2017) and this phase is therefore mostly associated with slow growth. Most of these innovations fail, but some innovations are able to build momentum through for example learning processes and improvements in the price/performance ratio (Geels & Schot, 2007). This momentum, or take off point, marks the second phase. In the third phase, the innovation breaks through to the mainstream market and becomes more widely adopted. This is when it starts to directly compete with the dominant regime. Mostly, this acceleration phase is characterized by a focus on manufacturing economies of scale, developing systems to expand the volume and spatial extent

of the market, and price reductions (Wells & Nieuwenhuis, 2018). Eventually, in the last phase of this technological transition, the radical innovation will replace the dominant regime and find a stable position. Firms will then start to focus on cost reduction and price competition (Wells & Nieuwenhuis, 2018). These phases show that firms take up different strategies depending on what phase the innovation is in.

From the dominant regime perspective in the MLP it becomes clear that on both the demand and supply side, society is locked into certain production and consumption patterns where powerful, mutually reinforcing interests ensure the status quo (Geels et al., 2012; Berkeley et al., 2017). For niche innovations, of which S.PSS is an example, to enter mainstream markets and therefore disrupt an already established regime is consistent with overcoming or disrupting regime lock-ins, path-dependencies and inertia. S.PSS diffusion is complex (Ceschin, 2010), and it can thus be expected that a multitude of drivers and barriers influence its development. These will be discussed in the next section.

3.3. Business drivers and barriers for S.PSS development

In order to accelerate the development and diffusion of S.PSS business models, it is necessary to understand what factors can contribute to the shift to more service-oriented models, what difficulties new service providers could avoid and what is needed to support such business models (Mont, 2002). Many studies have looked at drivers and barriers that influence the transition to a service model from a firm's perspective. Moreover, a multitude of literature reviews exist that combine the literature on drivers and barriers on (S.)PSS (e.g. Mont, 2002; Annarelli, Battistella & Nonino, 2016; de Jesus Pacheco et al., 2019). The findings of these literature reviews are summarized here and are used as a basis for the analysis of the interviews, further elaborated on in section 4.2. and 4.3. For practical reasons, the identified drivers and barriers will be categorized following Lozano (2015)'s distinction between internal and external drivers for corporate sustainability. Internal drivers regard the internal elements and processes of a company that drive change. External drivers on the other hand regard external pressures that spur action. They will be further divided into meaningful subcategories. Understanding these drivers and barriers and applying them to the case study of e-bikes provided an in-depth view on the many challenges' actors face in order to adopt and implement an S.PSS business model in the Dutch e-bike industry. In turn, this overview can help with analyzing how S.PSS can develop beyond the niche environment more generally. Hence, the next sections will discuss drivers of S.PSS development (3.3.1) and barriers of S.PSS development (3.3.2). A comprehensive list of the drivers and barriers is included in Appendix I.

3.3.1. Internal drivers of S.PSS implementation

Most internal drivers of S.PSS implementation regard economic or financial considerations. According to the study by Moro, Cauchick-Miguel and Mendes (2020), *differentiation* from competitors is the most cited internal driver in the literature. Adding services to the portfolio offers the opportunity of *extending the current market offer* and increase the

added value of using the product (Annarelli, Battistella & Nonino, 2016; Baines et al., 2007; Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). Furthermore, services are often harder to copy and imitate, which can give firms a competitive edge (Baines et al., 2007). This is especially relevant in saturated markets, where adding services would mean *new market opportunities* to grow (Mont, 2002; Richter et al., 2018), but can also be used to *create market barriers* against new entries and to *protect market share* (Richter et al., 2018; Annarelli, Battistella & Nonino, 2016).

By *leveraging on servitisation,* firms can increase their brand positioning, partnerships and marketing opportunities, among other things (Hidalgo-Carvajal, Carrasco-Gallego and Morales-Alonso, 2020). In line with the latter, by implementing a S.PSS, *stronger coordination with value chain partners* will be necessary, which often means that a firm takes a more a focal position in the supply chain and thereby gains more visibility within the value chain (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Moro, Miguel & Mendes, 2020; Annarelli, Battistella & Nonino, 2016). As for brand positioning, *image enhancement* through marketing the firm as a sustainable organization is a direct result of the driver *reducing environmental impact.* According to Mont (2002), firms can decrease their environmental impact through efficiency gains in consumption and dematerialization, the facilitation of reuse and recycling and the production of more durable products, among other things. The implementation of reverse logistics also increases the number of second-hand components and materials that are collected, which would be an especially relevant driver in cases where certain materials have large fluctuations in price and availability (Mont, 2002). Furthermore, the aim of some S.PSS solutions regards the maximalization of utility and limit redundancy in idle products. As such, *the efficient utilization of assets* could ideally even decrease the need for manufacturing (Annarelli, Battistella & Nonino, 2016).

Unsurprisingly, many authors also discuss the changed cash flow of the S.PSS model (e.g. Moro Cauchick-Miguel & Mendes, 2020; Schoonover, Mont & Lehner, 2021; de Jesus Pacheco et al. 2019; Richter et al., 2018; Vezzoli et al., 2015). In an use-oriented S.PSS business model, revenue is generated over time based on a leasing contract, compared to short-term profit generated in a sales model. Whilst some see this changed cashflow as a barrier (discussed in section 3.3.2), others acknowledge the changed cashflow as a driver (Moro Cauchick-Miguel & Mendes, 2020; Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). The main reason behind this perception regards the continuous revenue stream, which ensures a *reduced volatility* in earnings. Essentially, seasonality of sales is eliminated, and risks are spread due to risk pooling (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Richter et al., 2018). Additionally, the possibility of *cost reductions* (accomplished by efficiency gains in energy and materials due to the remanufacturing and reuse of components) and *high profit margins* for services are seen as motivations for implementing S.PSS (e.g. Mahut et al., 2016; Moro, Miguel & Mendes, 2020; Richter et al., 2018; Baines et al., 2007; Kuo et al., 2009).

Due to the strong service orientation in S.PSS, a shift also occurs in the way a firm has to approach customer management. While this shift can also be challenging (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020), gaining a *closer*

relationship to the customer is an often-cited driver (Moro, Miguel & Mendes, 2020; Richter et al., 2018; Annarelli, Battistella & Nonino, 2016). Most notable is that the relationship with the customer shifts to an intimate, long-term service-relationship that allows firms to better understand and thus respond to customer needs (Reim, Parida & Ortqvist, 2015). Partly, this can result in both *customer lock-in* and *creating dependency* between the service provider and the customer (e.g. Mahut et al., 2016; Kuo et al., 2009). The understanding of customer needs is further stimulated by a *better harvest of usage information*, considering both the intensified service moments and, depending on the S.PSS solution, the interconnected devices that can convey real-time data (Mahut et al., 2016; Moro, Miguel & Mendes, 2020; Richter et al., 2018). Here, there is strong potential to optimize the data-driving decision-making process, as well as product design and maintenance operations (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). According to Baines et al. (2007), these customer usage insights simultaneously allow for *greater customization and functionality* and higher quality products, resulting in offers with a higher value in-use.

Lastly, organizational processes such as aligning *cultural and social values* of society with those within the organization (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020), the necessity to set up organizational structures that favor *innovation* (Richter et al., 2018) and *strong leadership* as well as support from the top management team to implement S.PSS (Mont, 2002) are seen as driving forces behind S.PSS implementation.

3.3.2. External drivers of S.PSS implementation

Most external drivers fall into the consumer sub-category. For example, Mont (2002) stated that an external driver for S.PSS regard the *demand for services* that reduces the risks and liabilities associated with using the product. This is in line with another observed driver by Moro, Miguel and Mendes (2020), who mention that consumers wish to *disconnect from the responsibilities of ownership* and that there is a general trend of wanting to *disconnect from consumer needs*. Furthermore, in a typical use- or result-oriented S.PSS, the products are often *maintained by professionals* and are thus able to stay in top condition for a longer period of time (Moro, Miguel & Mendes, 2020). To add to this, when taking into account life cycle costs, S.PSS solutions can be very *beneficial in financial terms*, especially in cases where products are expensive and require a lot of maintenance (Annarelli, Battistella & Nonino, 2016). Other consumer-related drivers regard *public concern* for sustainable solutions to consumer needs (Mont, 2002), *a shift of administrative and monitoring tasks* from the consumer to the producer (Baines et al., 2007) and a *reduced effort for product operation* (Moro, Miguel & Mendes, 2020).

Next to consumer-related drivers, many authors state that *staying ahead or complying to regulations* is the main external driver for S.PSS implementation (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Mont, 2002; Annarelli, Battistella & Nonino, 2016). Generally, environmental regulations are seen as the main driver in this category, but other opportunities also exist. For example, firms can set new industry standards or propose new regulations that puts the firm

in an advantageous position (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). Other context-related drivers include the creation of a *more effective take-back system* (Kuo et al., 2009), the *creation of jobs* (Kuo et al., 2009; Moro, Miguel & Mendes, 2020)*, providing access to more people* (Moro, Miguel & Mendes, 2020), and implementing S.PSS in order to become a *sustainable business* (Baines et al., 2007; Kuo et al., 2009). Figure 2 displays the complete number of internal and external drivers according to the subcategories (please refer to Appendix I for a longer explanation of each factor).

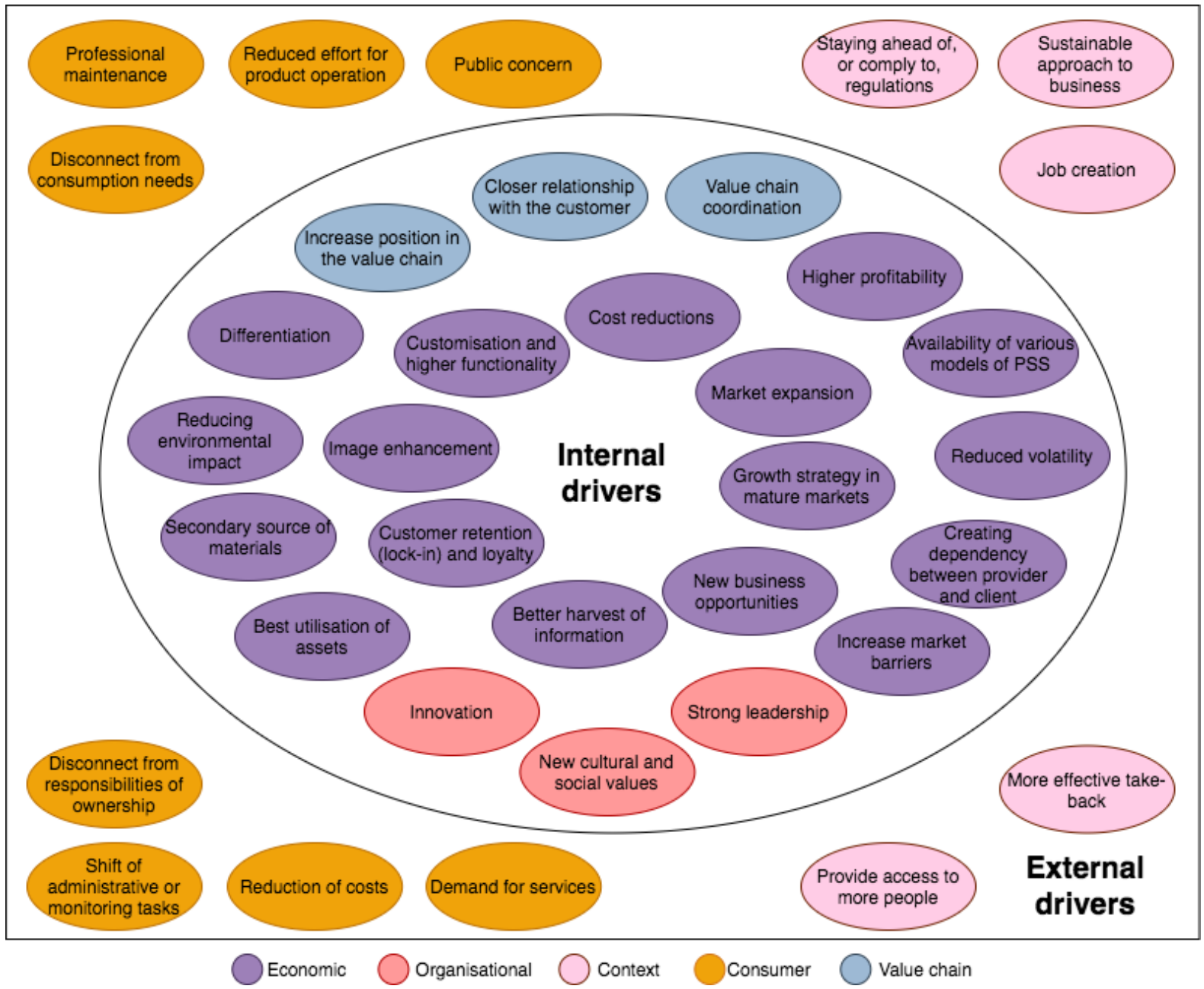


Figure 2: Drivers of S.PSS development, divided into internal and external categories and into sub-categories as identified from the literature study

3.3.3. Internal barriers to S.PSS implementation

In comparison to drivers, there are far more barriers to S.PSS implementation (see also Appendix I) (Moro, Miguel & Mendes, 2020). Major challenges companies face when shifting to a S.PSS have to do with *(re)designing their business model* from selling products to providing services. This shift does not only impact relevant processes such as product design, but also issues such as operational risks, scalability, customization, customer management and engagement, and so on

(Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Michalik, Besenfelder & Henke, 2019). Most notably, the very core of the company – e.g. their value proposition – has to change from being product-centric to service-centric (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). This process can be especially challenging when firms *lack experience in structuring a PSS model* (e.g. Baines et al., 2007; Michalik, Besenfelder & Henke, 2019; Annarelli, Battistella & Nonino, 2016), *lack an understanding of the PSS concept* itself (e.g. underestimating the required changes or not seeing its value) (de Jesus Pacheco et al., 2019; Moro, Miguel & Mendes, 2020) and/or when they do not have *a strategic planning and focus* prior to implementing the S.PSS (Kuo et al., 2009; de Jesus Pacheco et al., 2019; Michalik, Besenfelder & Henke, 2019). Moreover, the value of services is often harder to measure than products, thus a *lack of experience in pricing service offerings* can have a major impact on the profitability of the new business model, especially in its initial stages (Baines et al., 2007; Moro, Miguel & Mendes, 2020; Michalik, Besenfelder & Henke, 2019). Sometimes, *conflicts between the design of the traditional products and service offerings* occur (e.g. Michalik, Besenfelder & Henke, 2019; de Jesus Pacheco et al., 2019; Mont, 2002). For example, design attributes that make sense for a product owned by one person for a longer period of time would make less sense for a product whose owner constantly switches (Schoonover, Mont & Lehner, 2021). Thus alignment between product design and service design is a necessity (Michalik, Besenfelder & Henke, 2019).

Another important design challenge regards the reverse flow of products. In some countries, or for some products, there is *a lack of external infrastructure and technologies* in place for collection, sorting, remanufacturing and recycling (Kuo et al., 2009; Moro, Miguel & Mendes, 2020; Vezzoli et al., 2015). As most S.PSS solutions are dependent on this reverse flow of goods, having to set up this system as a first step can be a major challenge. In addition, even if such a system exists, an adequate *maintenance system* also has to be established, as, for example, service stations in relevant locations need to be opened or customer service points need to be set up (Mahut et al., 2016; Kuo et al., 2009). Creating a streamlined maintenance system is also dependent on the customers themselves. In the initial stages of S.PSS implementation, usage data is still unknown. This makes it difficult to predict when customers return their products, but also in what state (Kuo et al., 2009). Therefore, *managing and controlling the quantity and quality of components and materials* that can be reused for maintenance and repair services is often perceived as a significant challenge (e.g. Mont, 2002; Moro, Miguel & Mendes, 2020). One way to overcome this challenge is by establishing a *technology management system*, which for example includes data strategies. However, creating such a system is often a challenge in itself as it requires investments in technology and new skills and competences (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Michalik, Besenfelder & Henke, 2019). As mentioned in section 3.3.1., leveraging on usage data has enormous potential to further develop services that create customer advantages and increase efficiency of inventory management and resource use in general. Overcoming these challenges is thus a necessary step in order to obtain the benefits of S.PSS.

As with the drivers, most internal barriers consist of economic or financial challenges. *Cash flow uncertainty and financial risks* is one of the most cited barriers to S.PSS implementation (e.g. Kuo et al., 2009; Hidalgo-Carvajal, Carrasco-Gallego &

Morales-Alonso, 2020; Schoonover, Mont & Lehner, 2021). As mentioned, revenue streams in S.PSS models are typically spread out over time, which means that firms have to adjust to long term profit instead of short-term gains from product sales. Whilst in some cases the benefits of this are clear (e.g. elimination of seasonal revenue and risk pooling on the long term), in other cases it can lead to significant uncertainty of cash flow. In turn, this revenue uncertainty can lead to financial vulnerability, which is especially the case for small to medium sized enterprises (SME's) (de Jesus Pacheco et al., 2019). Furthermore, S.PSS require *large (re)investments in the initial phases*, which not all companies have the means for (de Jesus Pacheco et al., 2019; Moro, Miguel & Mendes, 2020; Michalik, Besenfelder & Henke, 2019). For example, a *lack of technological equipment* requires large investments beforehand (Michalik, Besenfelder & Henke, 2019), but employees also *need to develop the necessary competences and skills* in order to run a smooth S.PSS operation (such as skills regarding reverse logistics, inventory management, product maintenance and design, selling services instead of products, managing new information flows, customer management etc.) (e.g. Schoonover, Mont & Lehner, 2021; Annarelli, Battistella & Nonino, 2016). Moreover, these investments can also lead to financial vulnerability in light of the *long amortization time* (Michalik, Besenfelder & Henke, 2019). Perhaps it is unsurprising then, that there are *doubts about the economic feasibility* of S.PSS solutions (e.g. Schoonover, Mont & Lehner, 2021; Moro, Miguel & Mendes, 2020; Richter et al., 2018; Vezzoli et al., 2015). These concerns are mainly based on the fact that systems such as reverse logistics and inventory management systems need to be established, which requires more individualized work and thus higher labor costs.

Another important economic barrier to S.PSS implementation that is often mentioned regards the *fear of absorbing risks that were previously assumed by consumers* (e.g. Baines et al., 2007; Richter et al., 2018; Mont, 2002). In an use- and result-oriented S.PSS, the producer remains owner of the product and offers its use to consumers. As service and maintenance is typically included in the price, it is recognized that users tend to be less careful with the product when they do not own it themselves and when they are not responsible for damage (Reim, Parida & Örtqvista, 2015). Firms are therefore hesitant to internalize use-related costs, as these costs can rapidly increase and typically need labor to solve them (Mont, 2002). This *change in the cost structure* thus often requires anticipating unexpected costs, managing insurances, creating different types of contracts and other practices that are significantly different from traditional sales models (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). Other economic barriers include a *reduced control over core competences* due to an increase in and possible interdependence on partners (Vezzoli et al., 2015), the *fear of cannibalizing sales of new items* and the risk of *over-diversification* (in cases where companies offer multiple models) (Schoonover, Mont & Lehner, 2021; Mont, 2002).

As for organizational barriers, *resistance to change* is recognized by many authors as a significant barrier to implement a new business model, such as a S.PSS (e.g. Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; Moro, Miguel & Mendes, 2020; Mont, 2002). There can be several reasons for resistance from internal stakeholders. For example, Richter et al. (2018) states that employees might not be aware of the benefits and value of a S.PSS business model. Furthermore,

S.PSS often requires internal changes in the organizational structure, such as a shift in *corporate culture* (Richter et al., 2018; Vezzoli et al., 2015; Michalik, Besenfelder & Henke, 2019) and an *extended involvement with the product beyond the point-of-sale* (Richter et al., 2018; Michalik, Besenfelder & Henke, 2019), which might cause resistance. In cases where products are sold simultaneously with S.PSS offerings, *conflicts may occur between departments* that focus on sales on the one hand and services on the other (de Jesus Pacheco et al., 2019; Mont, 2002; Vezzoli et al., 2015). Notably, *lack of support from senior management* or other *leadership* due to a *focus on short term goals* is even more impactful, as leadership has been recognized as a driving force behind successful implementation (Kuo et al., 2009; Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020; de Jesus Pacheco et al., 2019; Vezzoli et al., 2015).

3.3.4. External barriers to S.PSS implementation

The most widely recognized external barrier to S.PSS implementation regards the *lack of market acceptance* (Annarelli, Battistella & Nonino, 2016). Market acceptance can be understood as the degree in which a product or service is able to satisfy customer needs and whether it is thus a feasible business venture when eyeing future growth opportunities (Doyle, 2016). Researchers have pointed out that stakeholders both up- and downstream of the value chain are resistant to S.PSS solutions, which influences the degree of market acceptance (e.g. Kuo et al., 2009; de Jesus Pacheco et al., 2019; Moro, Miguel & Mendes, 2020).

For consumers, *lack of ownership* remains a significant issue that has been often cited in academic literature regarding use- or result-oriented S.PSS (e.g. Vezzoli et al, 2015; Mahut et al., 2016; Baines et al., 2007). One explanation for this barrier is the fact that people tend to form *an emotional attachment to products* and thus eventually wish to own them (Schoonover, Mont & Lehner, 2021). However, it is more complex than that. For example, Vezzoli et al. (2015) point out that owning a product is often connected to one's *personal image*, as product ownership is perceived as a measure of success in life and can be an indication of a certain social status. On a similar note, there is a *negative perception of 'used' products* as they are sometimes perceived as inferior in quality or as less hygienic (Schoonover, Mont & Lehner, 2021; Vezzoli et al., 2015). Moreover, Schoonover, Mont and Lehner (2021) recognize that consumers often *value uniqueness*, that is, choosing a specific product with specific features that fit their personal preferences. In use-oriented S.PSS, uniformity of products is pursued in light of easy maintenance and repair, which limits the variety of product designs.

Cost concerns also remain an issue for consumers. S.PSS are often perceived as more expensive in the long run (Schoonover, Mont & Lehner, 2021; Richter et al., 2018; Mont, 2002; Vezzolli et al., 2015). This can be partly explained by the fact that there is a lack of knowledge of the life cycle costs of product ownership, regarding both economic as well as environmental costs (Schoonover, Mont & Lehner, 2021; Moro, Miguel & Mendes, 2020). This is further complicated in cases where a *strong secondhand market is present*, which makes buying the product more attractive because part of the invested value can be regained through re-selling (Schoonover, Mont & Lehner, 2021). On the other hand, it is also recognized that it is

harder to value intangible services in comparison to tangible products (Moro, Miguel & Mendes, 2020). Interestingly, Michalik, Besenfelder and Henke (2019) even state that there is a *service paradox* – which essentially entails that consumers are more satisfied with firms that solved a problem they caused, compared to firms that have impeccable services or products where a problem never occurred in the first place. Additionally, multiple authors have pointed out that a general *distrust of service providers* concerning, for example, liability and contract terms make consumers hesitant to take up a S.PSS offer (Schoonover, Mont & Lehner, 2021; Moro, Miguel & Mendes, 2020; Vezzoli et al., 2015). These challenges negatively impact the market acceptance of S.PSS solutions and therefor form significant barriers to the diffusion of S.PSS to wider markets.

Other stakeholders in de value chain can also be *resistant to change*, thereby hindering S.PSS development. Typical S.PSS require collaboration along the value chain and are usually delivered by a group of companies. Important stakeholders thus need to change along with the new business model of the focal firm, which can lead to significant operational and financial challenges (Moro, Miguel & Mendes, 2020). Think for example of changes regarding sourcing decisions, closing the loop (e.g. collection, recycling), managing supply chain disruptions and so on (Hidalgo-Carvajal, Carrasco-Gallego & Morales-Alonso, 2020). According to Richter et al. (2018) trust and regulatory tools are essential in this cooperative relationship. As this is something firms can struggle with, s*upply chain management* is recognized as a barrier for many firms (Mahut et al., 2016; Michalik, Besenfelder & Henke, 2019; Richter et al., 2018). Interestingly, strong coordination with actors in the value chain can at the same time mean gaining more control over core resources and competences. However, collaboration in itself can also lead to disadvantages. A number of authors acknowledge that firms are *hesitant to share information* with others in the value chain (Kuo et al., 2009; Richter et al., 2018; Vezzoli et al., 2015). This is mainly the result of competitiveness – e.g. in fear of possibly leaking a business secrets, core advantages, technological know-how and so on, which is especially relevant in cases where multiple suppliers supply to one firm (Kuo et al., 2009). Other relevant barriers regarding the value chain are *unclarity of responsibilities* (Schoonover, Mont & Lehner, 2021) and *potential conflicts of interests* (Mont, 2002; Vezzoli et al., 2015).

Another contextual barrier identified in the literature regard the *lack of support from laws and regulations* (e.g. Mahut et al., 2016; de Jesus Pacheco et al., 2019 ; Moro, Miguel & Mendes, 2020). It is widely recognized that governmental tools are essential to change (consumption) habits and culture (Vezzoli et al., 2015; Schoonover, Mont & Lehner, 2021). For example, implementing Extended Producer Responsibility (EPR) policies and increasing *public procurement* for S.PSS are governmental tools that can both directly and indirectly address S.PSS development, but is currently lacking in many countries (Mont, 2002; Schoonover, Mont & Lehner, 2021).

Figure 3 displays the complete number of internal and external barriers according to the subcategories (please refer to Appendix I for a longer explanation of each factor).

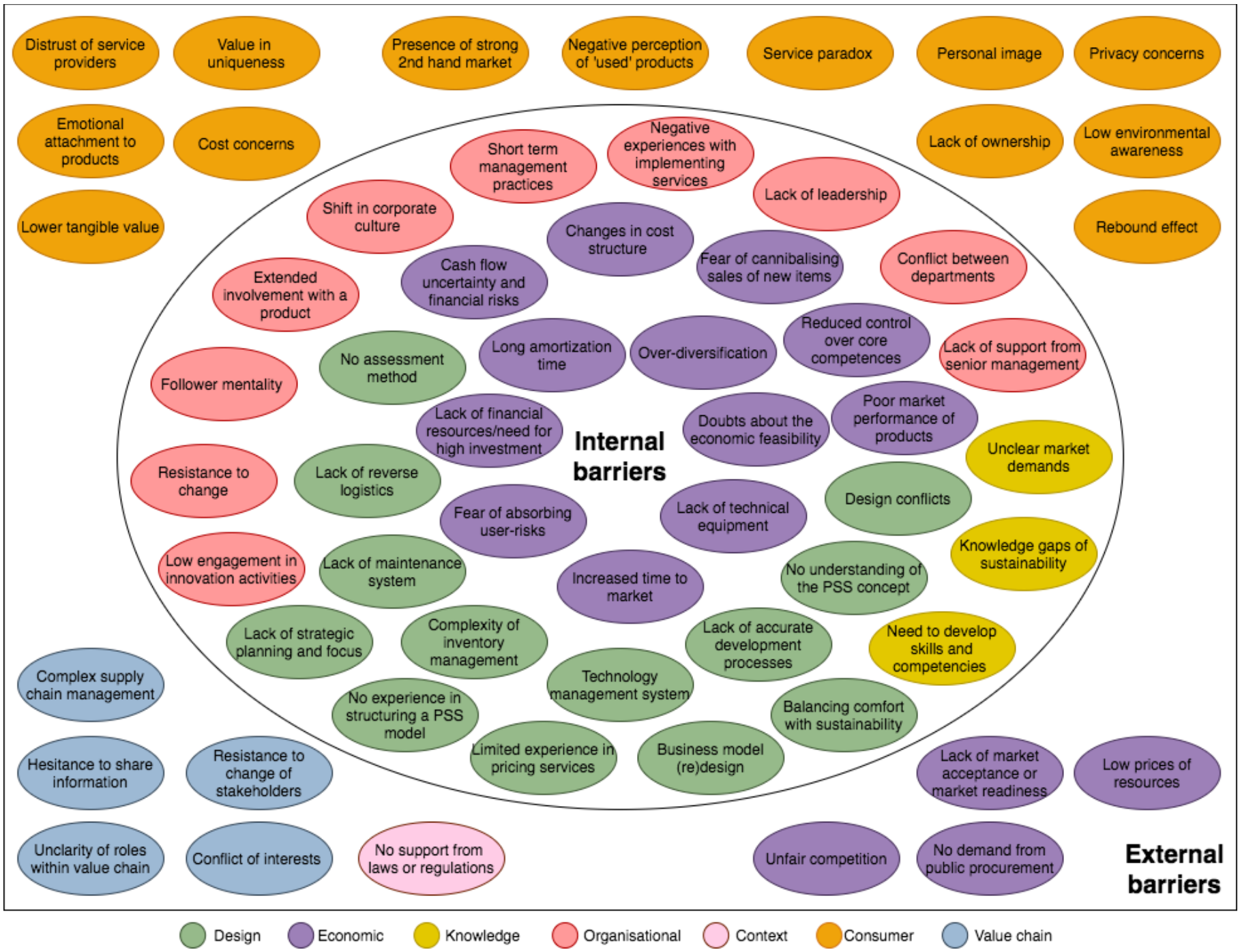


Figure 3: Barriers of S.PSS development, divided into internal and external categories and into sub-categories as identified from the literature study

3.4. Market overview

In order to place the drivers and barriers of S.PSS diffusion into context, this section briefly explains the supply chain and actor landscape for e-bikes. The (e-)bike industry is an established market that has been around for many years. Figure 4 illustrates the basic structure of the supply chain of e-bikes and its actors[2]. The components and parts from the 1st tier suppliers are assembled and manufactured by the bicycle brands. Thereafter, the e-bikes are distributed to the service

[2] Data for this figure is based on the interviews. See chapter 4, Methodology, for more information about the interviews.

providers, which include dealers (bike shops), lease companies, subscription companies and renting companies, who sell their product and/or services to the consumers. It is important to note that some e-bike brands also sell directly to end-users. The service providers are typically the ones that offer repair and maintenance services for which they need parts and components. These can be bought at the manufacturers or directly at the 1st tier suppliers. In many cases, lease companies have partnerships with multiple dealers, and do not provide the e-bikes directly to consumers nor do they offer repairs themselves. Finally, when the e-bike reaches its end-of-life, consumers can give their e-bike back to the service providers or bring them to waste facilities themselves. The discarded e-bike is then dismantled (often by dealers) and collected by collection and sorting facilities, after which parts and components either go to recyclers or to waste facilities to be incinerated.

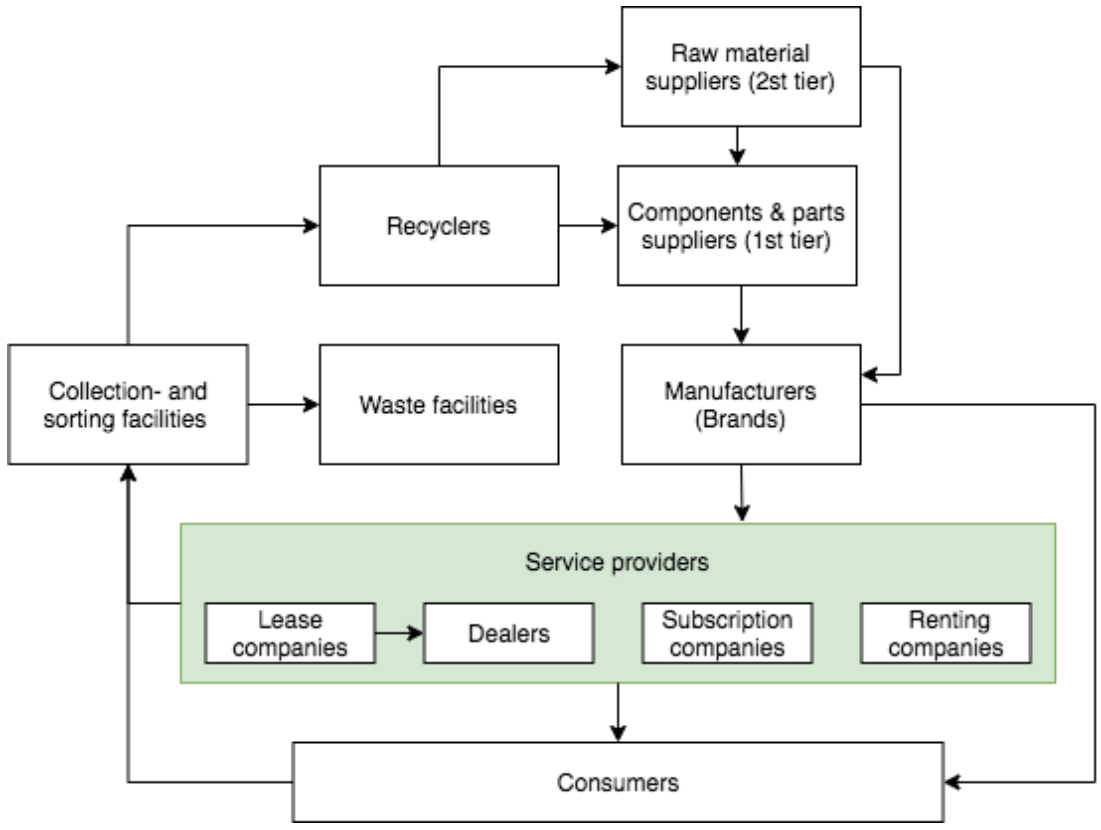


Figure 4: Supply chain and actor landscape for e-bikes

The increase in demand for e-bikes in the last decade spurred the development of other type of offerings for e-bikes. A S.PSS can be divided on a horizontal axis from product-focused to result-focused. There are five main models that can be distinguished: the sales model with after sales agreements, the lease model, the subscription model, the sharing model and Mobility as a Service (MaaS) model. These business models are taken up by service providers and are thus the focus actors in this study. Figure 5 shows the five types divided into the categories of PSS as discussed in section 3.1. In the following sub-sections, each of these models will be explained in further detail.

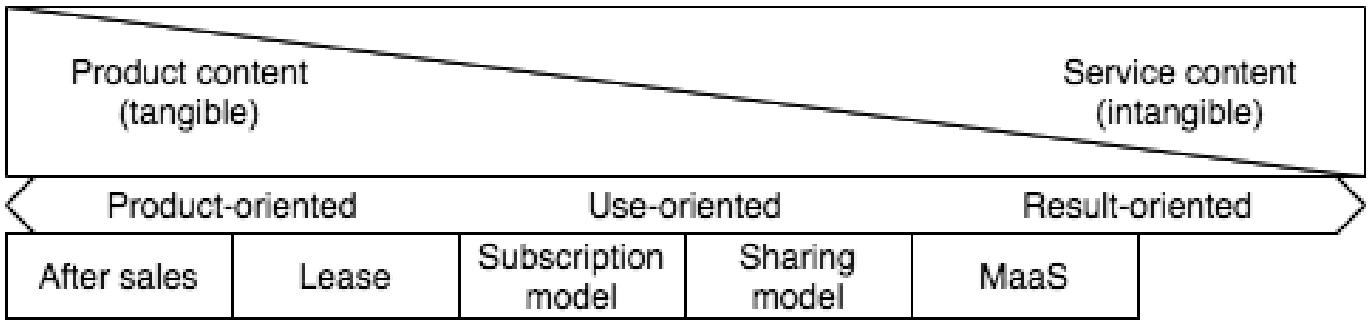


Figure 5: E-bike PSS offers categorized according to Tukker (2004)

3.4.1. Product-oriented PSS

Product-oriented PSS are mostly geared towards selling the product, but with the addition of some service components in the form of maintenance and repairs (Tukker, 2004). Most (physical) bike shops in the Netherlands have some form of after sales services. They often offer service- and warranty packages for an additional charge (see for example Fietsenwinkel.nl and Fietsvoordeelshop.nl).

Next to selling (e-)bikes, parts and services, many bike shops or bike dealers also offer lease-options through a partner organization. There are three different lease types: financial lease, business lease and operational lease. In financial lease, an individual takes out a loan in order to buy the bike. The duration of such a contract typically ranges from 3 to 5 years, after which the individual paid off the e-bike (ANWB, n.d.). The price per month differs per e-bike model and the length of the contract, but the cheapest option most lease-companies offer start from €60,- a month (see for example Leasegemak.nl or Fietsleaseholland.com). In contrast to financial lease, in operational and business lease, the lease company will remain owner of the e-bike during the contract period and will thus be responsible for maintenance and repair. This often means that the lease-company partners with bike dealers, where employees can buy, service and fix their e-bikes. Though it must be noted that many companies who offer financial lease or only sell e-bikes also give options for additional service packages and insurance for an additional charge. At the end of the contract period, the employee receives the option to buy the bike for a small charge based on the remaining value of the e-bike or get a new lease contract (with a new model) entirely. According to one interviewee, this is typically around 10 to 15% of the original value. The only difference between business lease and operational lease is that in the former the employer pays part of the lease price for his or her employees. Due to a somewhat new Dutch regulation called the 'Fiets van de zaak regeling' (established in January 2020), employees themselves only pay taxes over the e-bike, which is a considerably lower amount per month in comparison to private lease. At the same time, they can use the bike for both work-travel purposes and private use (Rijksoverheid, n.d.-a).

3.4.2. Use-oriented PSS

The business models of use-oriented S.PSS are built around services in regard to the usage of the product (Tukker, 2004). Two general types can be distinguished for e-bikes in the Netherlands: the subscription model and the sharing model. Currently, there are only four companies that offer e-bikes in a subscription form, namely Swapfiets, Urbee, E-bike to go

and QonQer. In contrast to lease models, an e-bike subscription model consists of a monthly terminable contract with integrated services such as repairs, maintenance and insurance. Typically, the range of e-bikes offered is small, but the value proposition states that customers are instead ensured of an e-bike that works at any time (see for example Swapfiets.nl).

Another e-bike renting option is the shared e-bike, for which the user has to pay for usage only, ranging from a fixed amount per minute, hour or day (Tour de Force, 2017). These e-bikes are typically placed in strategic places, such as stations or popular tourist spots. In some cases, the e-bikes are parked in unmanned stations or in places where the last user left them (the latter called the free-floating system) (Tour de Force, 2017). Customers can rent these by unlocking the e-bike via an application on their mobile phone. For both subscription and shared models, the company remains owner of the e-bike (Tukker, 2004).

3.4.3. Result-oriented PSS

No 'standard' business model exists yet for the result-oriented S.PSS. In this quadrant, it is important to realize that the organization(s) purely focus on need-fulfillment, regardless of what products may be necessary. When looking at e-bikes, the need people want fulfilled is mobility. Thus Mobility-as-a-Service (MaaS) has been proposed as a result-oriented PSS. MaaS typically manifests itself as a digital platform that offers multi-modal transportation (both public as private transport) and includes trip-planning and payment services, all on real time conditions (Goodall et al., 2017). In a sense, it requires a digital transition in the mobility sector with as goal to connect various forms of mobility with the user as the central player. MaaS therefore relies mostly on connecting use-oriented S.PSS models and public transport systems. One initiative of MaaS is currently being piloted by the Dutch government in seven different cities (Rijksoverheid , n.d.-b).

When comparing the five business models with each other, table 1 illustrates the distinctions between the various business model building blocks of the business model canvas by Osterwalder and Pigneur (2010). As can be seen, there is both overlap and fundamental differences between the models.

Table 1: the four PSS business models divided by the nine business model building blocks (Osterwalder & Pigneur, 2010)

Building block	Description	After sales	Lease	Subscription	Share	MaaS
Value proposition	The bundle of products and services the company offers to create value	The product(s)	The product and services	Use of the product and services	Use of the product and services	The end-result or function
Customer segments	The customer groups or organizations the company delivers value to	Traditional target groups	New target groups	New target groups	New target groups	New target groups

Customer relationships	The type of link that is established with the customer	Short term	Long term	Long term	Short or long term	Short or long term
Channels	The means of reaching the customer	Direct-to-consumer sales	Through employers or bike dealers	Direct-to-consumer sales	E-commerce or employers	E-commerce
Key partners	The network of key suppliers and partners	Second tier suppliers (e.g. Bosch, Shimano), bike manufacturers (e.g. Gazelle, Accell) and EoL services (e.g. Stibat)	Employers, bike dealers	Second tier suppliers (e.g. Bosch, Shimano), and EoL services (e.g. Stibat)	Second tier suppliers (e.g. Bosch, Shimano), and EoL services (e.g. Stibat)	Network
Key activities	The main activities and tasks that need to be completed in order to deliver value	Sales and maintenance	Sales and account management	Sales, maintenance, EoL management and customer relations	Sales, maintenance and EoL management	E-commerce, platform management and partnerships
Key resources	The strategic assets that are required to deliver the value proposition	Human resources, service technicians	Human resources, bike dealers	Human resources, logistics, service technicians	Logistics, service technicians	platform
Cost structure	The incurred costs from resources and activities	Products and services	Products and services	Product, services, logistics and EoL management	Product, services, logistics and EoL management	Product, services, and platform management
Revenue streams	The way the company obtains its income and monetizes its sources of value	One-time sales	Monthly recurring revenue for 3 – 5 years	Monthly recurring revenue	Recurring revenues	Recurring revenues

3.5. Theoretical framework

This study aimed to contribute to the understanding of how the development and diffusion of sustainable business models in general, and S.PSS specifically, can be facilitated. The theoretical discussion in prior sections can be outlined in the following way. First of all, S.PSS were explained in more detail, showing that these type of business models inherently incentivizes firms to consider environmental factors such as product longevity and EoL, and can be an important strategic decision for firms to differentiate from competitors. Despite these benefits, wider uptake of S.PSS remains limited. The

uptake of novel business models can be understood as the introduction of an innovation (e.g. business model innovation (BMI) in the case of already existing firms). Hence, in order to look at S.PSS diffusion from a systems perspective, the MLP was introduced. From this theory it became clear that innovations such as S.PSS go through multiple phases and emerge in niche markets before entering mainstream markets. In order to facilitate this development process, overcoming or disrupting regime lock-ins, path-dependencies and inertia is necessary. This is consistent with overcoming barriers and enhancing drivers of S.PSS development and implementation in order to facilitate further diffusion. Therefore, internal and external drivers and barriers of these processes were identified. To put these drivers and barriers into the perspective of the case study, the Dutch e-bike sector and its actors were shortly explained and related to the S.PSS business model categories that are currently being offered in this sector.

The theoretical framework of the diffusion process is presented in figure 6. This framework was applied to the Dutch e-bike market. Within this context, a multi-level and multi-actor approach was taken in order to understand the diffusion process of S.PSS in the Dutch e-bike sector. To understand the decision-making context of these actors, the drivers and barriers of S.PSS implementation within this sector need to be made explicit as a first step. In this way, novel and interesting insights into the practical application of a S.PSS can be gained. These insights can thereafter serve as a way to validate existing literature on the one hand and serve as a practical example for other industries with designing and implementing a S.PSS on the other hand.

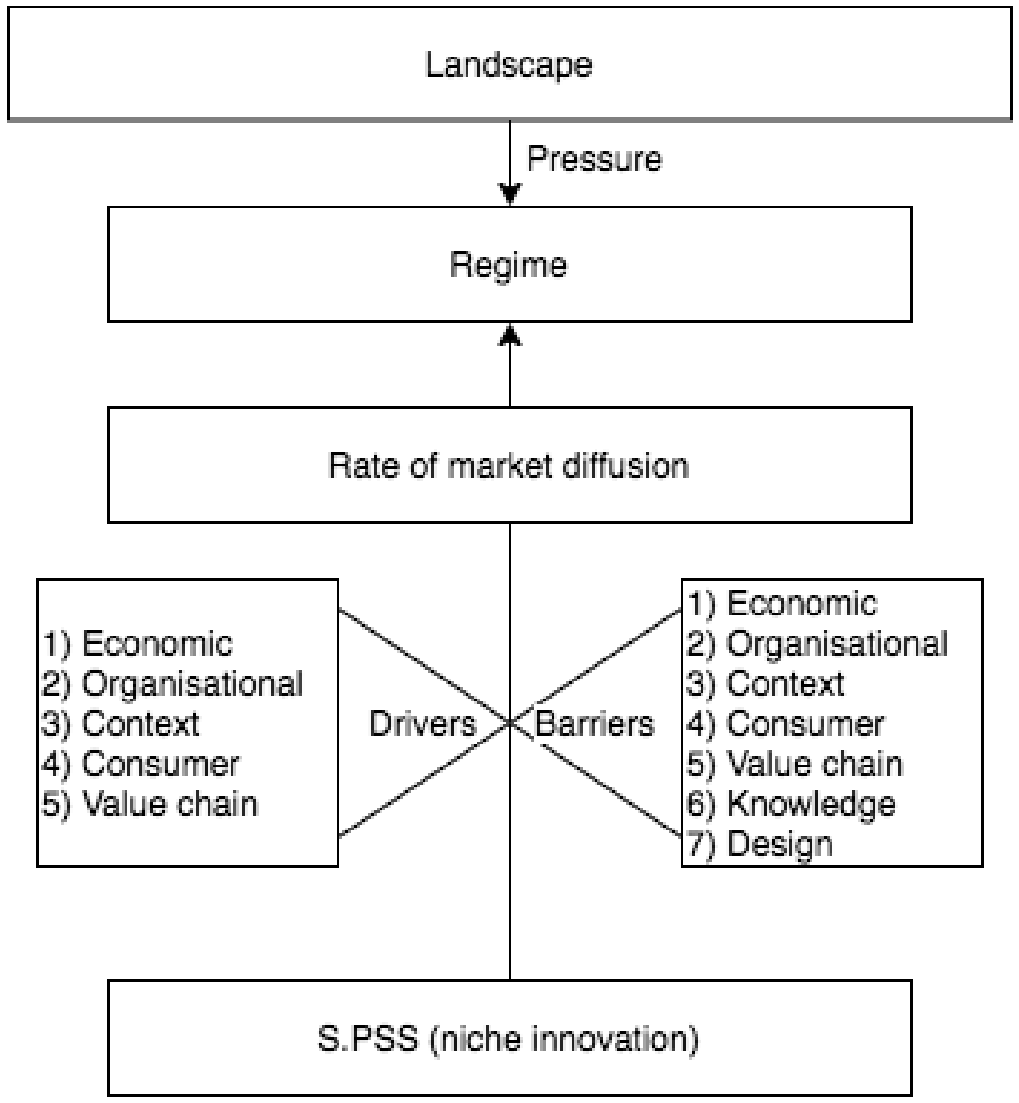


Figure 6: Conceptual framework of S.PSS diffusion from a multi-actor perspective.

4. Methodology

4.1. Research design

The aim of this study was to analyze the development and diffusion process of S.PSS in the Dutch e-bike market in order to understand how S.PSS diffusion can be stimulated. This was done by placing the actors who are in direct contact with consumers (e.g. service providers, see figure 4) in the center of the analysis. Furthermore, in order to understand design challenges for S.PSS, insights from other relevant actors within the value chain were used as well. According to Yin (2003), a case study design is especially relevant in cases where the research seeks in-depth knowledge of the situation at hand. By using a case study, new knowledge towards the research subject can thus be gained, simply because the approach aims to study an object in a real-life context (Yin, 2003). Therefore, this approach is in line with the goals of this study; by gaining an in-depth understanding of drivers and barriers for S.PSS implementation, this research aims to help industry actors with designing S.PSS and thereby increase the development and diffusion of such models. The data collection methods will be explained in the following sections.

4.2. Data collection

In order to develop the interview guide and coding system for the interviews in the next section, this study conducted a literature review and secondary data analysis on the drivers and barriers of S.PSS diffusion (see section 3.3.). In order to generate a list of relevant drivers and barriers corresponding to the theoretical framework, this research has looked at a combination of academic literature on drivers and barriers of S.PSS development, implementation and diffusion. A keyword search for reviews on drivers and barriers for S.PSS was done. For a systematic approach, the list of drivers and barriers were categorized into two main categories (internal and external, following the distinction made by Lozano (2015)) and further divided into subcategories such as economic, organizational, design, and so on. The creation of the categories was based on the distinctions made by previous studies on S.PSS drivers and barriers (for example, see Annarelli, Battistella and Nonino (2016)) and the knowledge of the researcher. See Appendix I for the completed list.

4.2.1. Interviews

Semi-structured interviews were conducted with actors in the value chain of e-bikes. Qualitative data typically provides more explanatory power compared to quantitative data (Bryman, 2012), and it is thus deemed as an appropriate method to study the barriers and drivers for S.PSS adoption and diffusion. Furthermore, semi-structured interviews can provide novel insights into the case study and the application of the theoretical framework. This thus aligns with the aims of this study. This research used semi-structured interviews as they will allow for flexibility in the order and content of the interview. Nevertheless, an interview guide was created in order to ensure comparability between interviews and to provide guidance

in order to answer the research question(s) (Bryman, 2012). The interview guide was based on the literature review done in the previous step. The interview guide includes a verbal informed consent at the start of the interview based on the informed consent form by Utrecht University (see Appendix II). Interviews were recorded if the participant has given consent and then transcribed. Interview data was then analyzed through coding the mentioned barriers and drivers with Nvivo[3], further explained in section 4.3. Recordings were deleted after the interviews were transcribed. Participants are made anonymous in order to protect privacy. Due to Covid-19, all interviews were conducted through Microsoft Teams, Zoom or regular phone calls.

4.2.2. Sampling strategy

Three sampling strategies were used. First of all, the interviews were conducted with actors in the e-bike market. The host organization, TNO, has several contacts with organizations in this industry. This network was used to acquire relevant participants. Furthermore, after every interview, participants were asked whether they know any other relevant actors for this study, either within his or her own organization or another organization entirely (the snowballing sampling technique). Thirdly, the platform LinkedIn was used to search for and approach participants of relevant companies. To identify relevant companies, the actor landscape discussed in chapter 3.4. was used as a guiding point. Multiple participants per actor-category were interviewed, in order to ensure validity. Table 2 shows an overview of the interviewees.

Table 2: Overview participants interviews. *Company name was deleted for privacy.

Company*	Type of Company (PSS)	Job function interviewee
	Subscription	Management Trainee
	Subscription	Sales B2C & B2C
	Subscription	Owner
	Lease	Partner
	Lease	Account manager
	Dealer	Owner
	MaaS	Project manager MaaS
	MaaS & sharing	Consultant sustainable mobility
	Manufacturer	Bike mechanic
	Manufacturer	Project manager
	Manufacturer	Project manager
	Manufacturer	Product Manager

[3] The latest version of Nvivo was used which was released in March 2020, which does not have a version number attached to it. It supersedes Nvivo 12. Please refer to QSRinternational for more information.

4.2.3. Internship context

This research was done in the context of an internship. The internship company, TNO, is an independent research organization that aims to create joint value on economic, environmental and social scale. At the start of this research, TNO was interested in servitization models in relation to electric bikes and in particular the battery of an electric bike. On the one hand, TNO wanted to know whether and why this type of business model would be attractive for a company to pursue in this industry. On the other hand, they wanted to why people would want to purchase a product-service package and whether this would work for electric bikes. Within this context, some basic knowledge was obtained from attending a workshop by CIRCO on circular business models in light of the battery waste problems. See a summary of the findings in appendix III. Furthermore, this study conducted four additional interviews with consumers. These interviews were not used in the coding process, but rather served as a way of gaining insights into the consumer perspective as well as validate the findings of the other interviews regarding consumer preferences.

4.3. Data analysis

4.3.1. Coding

The interviews were analyzed using thematic coding. Essentially, thematic coding focuses on identifying relevant (reoccurring) themes throughout the data set (Aronson, 1995). According to Ryan and Bernard (2003), themes are abstract constructs that flow from data and the theoretical understanding of the researcher regarding the topic under study. Thematic coding is a suitable method to use when identifying opinions, experiences and values (Bryman, 2012) and thus suits the purpose of this research. The coding process used in this research consisted of four steps.

In the first step, interviews where transcribed and coded using the list of drivers and barriers in Appendix I. Both deductive and inductive coding was used, as deductive coding regards using concepts already identified in the theoretical framework while inductive coding regards identifying potential new concepts that come forward in the interviews. As such, this method fits with the aim of this study. Importantly, the coding process was iterative, meaning that the identified codes where constantly under reflection and change. In the second step, the identified codes where analyzed for patterns and combined into broader themes and subthemes. Guidelines for retrieving themes are presented in table 3 but are mostly guided by the main categories already identified from the theory (e.g. economic, organizational, value chain etc., see Appendix I), which is in line with the 'theory-related material' guideline in table 3.

Table 3: Guidelines for identifying themes, based on Ryan and Bernard (2003)

What to look for	Definition	Value
Repetitions	Topics that occur and recur	Important themes appear
Indigenous typologies or categories	Local expressions that are unfamiliar or used in an unfamiliar way	Important for identification of subthemes
Metaphors and analogies	Particular representation of thoughts	Can give more meaning to statements

Transitions	How topics shift	May be markers for themes
Similarities and differences	Discussing similar topics in different ways	Keeps researcher focused on data instead of theory
Linguistic connectors	Examining use of words such as *since* or *because*	Can generate themes and signifies relations
Missing data	Reflecting on what is not in the data	Can signal important themes for further exploration
Theory-related material	Using scientific concepts as springboards for themes	How data illuminates questions and contribution to science

In the third step, the Framework methodology developed by the National Centre for Social Research in the United Kingdom was used to organize and synthesize the themes and subthemes into matrices (Ritchie et al. 2003; Bryman, 2012). The main idea behind this methodology is to construct an index of central themes and subthemes of all interviews in one spreadsheet and serves as a meaningful way to give an overview of the identified themes. An example of one matrix is giving in table 3. The complete matrix can be found in Appendix VI.

Table 4: The Framework approach to thematic analysis, adapted from Bryman (2012)

Theme: Economic barriers - internal			
	Cash flow uncertainty and financial risks	**Doubts about the economic feasibility**	**Fear of absorbing risks previously assumed by customers**
Interviewee 1			"We are currently really busy with improving the information [on how to care for the battery], because there is really work to be done there."
Interviewee 2		"Look at [subscription company]; it's not like you can say that they make a lot of money, because I think their numbers are still in the red, right?"	
Interviewee 6	"The monthly subscription is of course super nice, but someone who pays for three years, which you are sure of, is of course even better. So you have certainty."	"You also see that the hourly rate in the Netherlands is quite high, so you also see that the bicycles are also collected by other countries and that they are then refurbished or reused there."	I think [subscription company] does have a challenge with the batteries. Because people just leave them outside in the rain, in the cold. While if it's your own bike, my mother always puts her battery inside. If it is indoors, and not in the freezing cold and not in the rain, it will last longer"

Finally, the final themes and subthemes identified by the interviewees were ranked in order of importance from 3 “plays an important role” to 1 “plays no role” in a separate survey. This allowed to both check the validity of the identified drivers and barriers with the participants and give meaningful insight into a large amount of data.

4.3.2. Quality indicators

The following quality indicators have been taken into consideration to ensure the validity of the findings as well as the qualitative value of this research. First of all, it can be said that one company does not represent a whole industry, which is why this research interviewed multiple actors of different companies within the Dutch e-bike sector. In this way, the findings were based on multiple, diverse viewpoints that more closely represent reality. To add to this, multiple people of the same type of company were interviewed (e.g. multiple lease companies), which further enriched the findings. Moreover, the data collection phase of this research ended only after knowledge saturation was reached, meaning that no more new themes emerged from the interviews.

Secondly, to be able to compare and analyze the interview data, consistency between the data is necessary. As mentioned in the section 4.2.1., an interview guide was created prior to the interviews. The use of the interview guide thus enabled comparability between and analysis of the answers. The survey sent to the interviewees combined all findings together, and served as a way to validate the found drivers and barriers further.

Lastly, both primary and secondary data was used. Primary data was obtained from the interviews, whilst secondary data was obtained from the literature research done in chapter 3. As these were compared to each other, it served as a way to validate the obtained results. At the same time, by comparing the primary data with secondary data, the robustness of the findings is underscored as these findings are largely verified in previous peer reviewed research.

5. Results

Implementing new business models, especially models that stray far from a firm's original model, can be a fundamental challenge. One way to make the diffusion of SPSS models more accessible is to identify drivers and barriers that firms face prior to developing, adopting and/or implementing S.PSS business model(s). In the literature review done previously, a multitude of drivers and barriers were identified. The interviews done in this study serve as a way to identify whether these drivers and barriers also play a role in S.PSS business models in the e-bike industry, or if other factors influence this specific diffusion process. Furthermore, by ranking the drivers and barriers, a more relevant dialogue is created to fully understand the complexity of the issue at hand. In the following section, the drivers and barriers found during the interviews are discussed in accordance with the themes identified from the codes in step 1 of the data analysis. As mentioned, themes found were mostly guided by theory, and include themes such as economic, organizational, contextual etc. (see Appendix I). The overall results of the coding process can be found in Appendix VI. In the section 5.2., the most important drivers and barriers, as ranked by the interviewees, are further elaborated on. Finally, in the last section the drivers and barriers are discussed in context of the MLP. By identifying key focus areas and linking these to larger system processes and corresponding literature, this analysis will dive deeper into what would be needed to stimulate the adoption and diffusion of S.PSS business models.

5.1. Drivers and barriers

In total, 27 drivers and 60 barriers were identified during the coding process. As can be seen in figure 7, Interviewees identified more barriers than drivers. Moreover, for both the drivers and the barriers, consumer-related factors play a relatively large role in influencing the diffusion process for external factors (referenced 15% of the time, for both drivers and barriers), whilst design-related barriers (15%) and economic drivers (11%) play the largest role for internal factors. Most of the identified factors coincided with the previously identified list of drivers and barriers. As this list was seen as non-exhaustive, it was not surprising that a small number of drivers and barriers specifically relevant for the Dutch e-bike market were identified. For an overview of these unique factors, please see the table in Appendix VI.

In the following sections, each theme will be discussed extensively and linked to existing literature. Here a short summary of the drivers and barriers unique to this case study are summed up, but some will also be more elaborated on in the following sections.

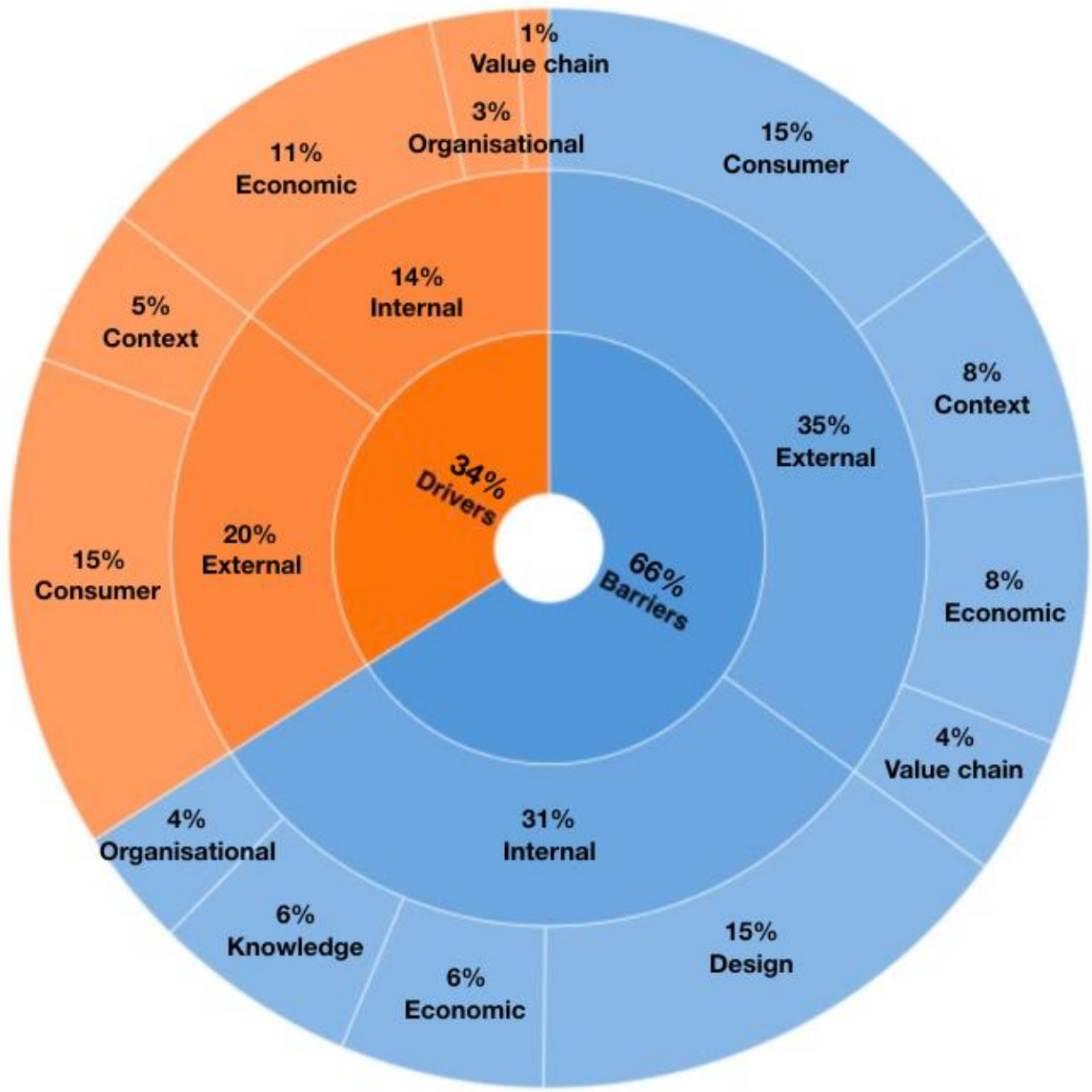


Figure 7: Overview of the identified drivers and barriers

5.1.1. Design factors

In the interviews, several companies brought up issues such as the complexity of designing service components, the difficulty of scaling up and adequate inventory management as major internal barriers for implementing use-oriented S.PSS models. One interviewee mentioned that offering an e-bike 'as a service' might sound easy, but requires that a company completely unburdens the customer, which many firms often underestimate. According to this interviewee, one of the most critical steps for a company offering an use-oriented S.PSS model, is to develop an adequate system of reverse logistics. This statement is echoed by other studies, such as Mont (2002), Vezzoli et al., (2015) and Moro, Miguel & Mendes (2020).

"I think the whole service part. That sounds very broad but selling your product for a monthly price is easy, but completely unburdening your customer, that is the biggest challenge of all. Maybe that's kicking in an already open door, but I think that there a lot of complexity is involved which companies can underestimate." – Interviewee 1

"Yeah that's right, but look, delivering a bike is very easy but making sure that your service and maintenance is also on the right track, that is really a challenge."– Interviewee 6

Moreover, use-oriented S.PSS models require an intensive level of service, as the e-bikes should be able to be swapped or repaired at any moment in time. As e-bikes are products that are used often, especially in a country like the Netherlands, it can be expected that repairs and maintenance are necessary from time to time. This is recognized by the interviewees in this study, as one interviewee states: "*You have to have many bikes. How much do you have in storage? Because if you need to swap a lot of them suddenly, this has to be quick*" (Interviewee 1). In other words, being able to offer the required level of service, a key capability to develop regards inventory management. This challenge is validated by other researchers, such as Kuo et al., (2019) and Mont (2002). Another interviewee (interviewee 4) echoes these statements and cautions for loss of capital due to wrong estimates. Making these mistakes in inventory management runs the risk of having a large number of unused bikes in storage, which eventually corrode over time (e.g. tires go flat, frames corrode, etc.) and will thus lead to losses in capital.

Another complication with being able to offer the required level of services is connected to the locations of service stations, as one interviewee stated that:

> *"People are not willing to travel more than 5 km for service and maintenance. Because we make use of that network [of e-bike stores] we can offer a certain level of service. And I think that that's a challenge you have at one point, or that [subscription model company] has. – Interviewee 6*

This quote suggests that a certain level of coverage is necessary before being able to make this model economically feasible. This raises several questions, one of which regards the diffusion of these use-oriented models to different geographical locations, especially those outside city boundaries. Interestingly, several companies have mentioned differences between citizens of different countries as well, suggesting that culture might also have an influence on the acceptance and thus diffusion of use-oriented S.PSS models.

> *"Yes, a challenge is, look in Amsterdam, there you have a lot [of people] with a subscription model, but what if you go to a village with 10.000 citizens? There a subscription model doesn't work." – Interviewee 5*
>
> *"I suspect that it is also more in other countries [than the Netherlands], where you have bigger distances. So according to me, I'm not sure if it is already in Milan, but in Germany for example, an e-bike is a lot more relevant: also when there are more hills or if you live in a bigger city like Berlin. I think Berlin is bigger. In those kinds of cities it is much more interesting to get an e-bike. In the Netherlands we tend to think just cycle a little harder and within half an hour you are on the other side of Amsterdam, so to*

The mentioned barriers above reinforce the challenge of scaling up use-oriented S.PSS business models – especially when not being partnered with already existing bike shops (which is a strategic choice lease companies interviewed in this reseach made for this exact reason). It must be noted that both companies who offered subscription models started off with

a small number of bikes. One company mentioned that the company's ability to provide adequate service grew over time as the number of contracts increased. The other subscription company also started with a small fleet before increasing the number of bikes after noticing the large demand for their product. Interestingly, another barrier that came up when talking about the first fleet of e-bikes regards the necessity of having a small number of product designs. As shown by the quote below of interviewee 11, in order for maintenance and repair services to become a smooth and fast operation, an use-oriented company cannot offer a variety of e-bikes.

"But okay, you don't start with 10.000 bikes. Our first fleet of e-bikes was only 10. And I was alone then. And offering services for 10 e-bikes is a lot easier than for 10.000. So you slowly grow in numbers, which makes it eventually possible to also do it in that way [offer service for bigger numbers]." – Interviewee 9

"A service like what [subscription company] has, only works because they only have 1 model, and it can be done efficiently. So [if you] have 100 different bike design, you have to be able to switch them, to repair everything. That's a really big challenge." – Interviewee 11

It must be noted that there is also a downside to scaling up, especially when this growth happens rapidly. Two interviewees, as stated in the quotes below, mentioned that growing too fast leads to negative consequences for service, product quality and sustainable choices. Despite this challenge, both interviewed companies with a subscription model pointed out that the revenue streams of their business model are dependent on the amount of resources they need to fulfill the promised services to their customers. In other words, the less service and maintenance they have to perform, the less costs they will incur. Due to this, the e-bike of use-oriented offerings is manufactured with a "design to last" (interviewee 1). According to this interviewee, if their firm needed to make a choice between a high quality, more durable component and a cheaper component with lesser quality, the choice would always fall on the more expensive choice, as on the long run they will save money on service and maintenance. Nonetheless, it must be noted that these choices influence the barriers of high investments in product quality and the need for balance between comfort and durability (both discussed in section 5.1.2.) and the previously mentioned barrier regarding the complexity of establishing a well-functioning inventory management.

"But I think that if the company has to make a trade-off between choosing sustainability or scaling up with 20.000 new subscriptions, the choice would always be subscriptions. […] Yes, and that really comes from the idea that we want to be the first everywhere and then we'll look further. That's also a tactic. The only disadvantage with that, is that at one point you'll be so big that you cannot adapt anymore and that everything goes much slower." – interviewee 4

"Because if you for example put a product on the market and you sell a lot, and your service cannot keep up with it… I constantly compare with Van Moof [bike manufacturer] because I'm very familiar with them, and they time and again have the problem that they sold so many bikes, but their service stays behind. They just can't keep up with it. And then you get a lot of unsatisfied customers and the product quality, yes that sucks, but it [product quality] just declines and that is really not what you want." –

5.1.2. Economic factors

The most cited driver to implement S.PSS models is making use of new market opportunities. For example, some companies stated that they "needed to look for new business models" (interviewee 8) and "move with the changes in society" (interviewee 10). Notably, it is exactly the demand for use versus ownership that is recognized by companies as an important trend and driving force behind use-oriented offers. As one interviewee stated:

"As far as I know was the biggest driver [of starting this business] that we had to do something with that 'as a service model', because people want to be unburdened. And yes, that is just easy, with the whole Netflix, Spotify, everything that's starting up, it's just a trend." – Interviewee 1

Interestingly, the word used by almost all interviewees to explain the value proposition of both use-oriented business models and lease models was that they wanted to 'unburden' the customer as much as possible. Interviewees mentioned that consumers want certainty and flexibility (elaborated on further in section 5.1.4.) and that is something use-oriented S.PSS take advantage of. This is in line with the driver 'customization and higher functionality', previously recognized in the literature review. According to Baines et al. (2007), use- and result-oriented S.PSS firms are able to offer a higher value in use to their customers, as they take away burdens of ownership and instead offer certainty and flexibility. Furthermore, due to the increase of service moments, use-oriented S.PSS firms gain a large influx of user data, which is strategically used to improve the product and its services (see quote below by interviewee 1). These points are recognized as important drivers by the interviewees as a way of leveraging on servitization.

"I think that we, also for the subscription model… We are not really a subscription model, but we do completely unburden the employee. Only within a period of three years. And that's where it's going more and more, you can see that." – Interviewee 6

"You just know that people get enthusiastic because we take the burdens from them." – Interviewee 8

"So we design the e-bikes ourselves, also based on the data we gather of when a bike is swapped. Through that you can really see which components work well and which don't work." – Interviewee 1

Notably, some interviewees suggest that services are used as a way of differentiating from competitors. For example, where traditionally service and maintenance were done in bike shops, now some companies are also offering repairs at home. From this it can be cautiously inferred that the (e-)bike market is already strongly oriented towards its customers, which includes a service-oriented mindset. This also means that most firms in the industry do have some expertise in supplying services, which could be helpful for the diffusion of models even more oriented towards servitization, such as use- or result-oriented S.PSS models.

To move on to the economic barriers, several companies brought up internal challenges regarding the economic feasibility of use-oriented S.PSS models such as cashflow uncertainties and financial risks, echoing the financial barriers found in the literature review done previously (e.g. Kuo et al., 2009; de Jesus Pacheco et al., 2019; Mont & Lehner, 2021). As one interviewee stated:

"A monthly subscription is of course very nice, but when someone pays that for three years, that you have that guarantee, is of course even better. So you have certainty." – Interviewee 6

This quote shows that the more product-oriented business models such as after sales and lease models are either ensured of their investment being returned on the long run (e.g. in three to five years) or have their investments returned at the point of sale. In contrast, in the case of use-oriented models, there exists a risk of not earning back the investments made because the contract between firm and customer can be cancelled after a short period of time. The obvious result of this is that use-oriented firms have to increase their prices to somehow lessen these risks, which ultimately leads to other user-related barriers such as cost concerns (discussed in section 5.1.4). Interestingly, Besch (2005) suggested a minimum renting period as a solution to this problem in the case of furniture renting but cautions for cooperation with leasing companies as this will reduce the incentives to improve product longevity.

Another barrier related to financial risks regards an often-cited problem with ownerless consumption: the risk of users being less careful with the product because it is not theirs. This could ultimately lead to products being written off on a faster rate than in traditional models, which would not only nullify but might even worsen any resource reduction gains

(Tukker, 2004). It also increases the financial risks for firms. As the quotes underneath suggest, companies are often hesitant to internalize use-related costs, as they cannot influence the end-user. In contrast to these perceptions, the subscription companies interviewed in this study state that they do not see this back in their own data. As interviewee 1 suggested, this can be partly explained because the e-bikes of a subscription company are built as sturdy as possible in contrast to a 'normal' e-bike (again, in order to lessen service and maintenance moments) and thus there is no evidence that consumers are unnecessarily careless with the product. Furthermore, a benefit of the subscription model is that essentially you do not have to share the bike and you have it at all times. This might result in customers growing attached to the product anyway, which might lessen the negative effect of not being owner of the bike. As one interviewee states, "it's a vague line. It grows quickly and then it still feels like your bike" (interviewee 1). This is however not the case for share bikes. Still, the renting price will account for the risk of high user costs, which again leads to user-related barriers regarding cost concerns. Moreover, the necessary investments (and thus financial risks) become even higher when taking into consideration that the e-bikes provided by a use-oriented firm must also be designed to last as long as possible, which in general means offering high quality bikes. These are naturally more expensive than bikes of lesser quality (see quotes below). This leads to another (user-related) challenge, which regards finding a balance between comfort and durable design, as interviewee 1 stated: "you can make tires that don't go flat but riding on them will be very cumbersome." Finding this balance could pose a challenge for companies that just started offering an use-oriented S.PSS.

"So all those scooters from [company offering share scooters] and all the share bikes, they will just have to be written off after three years. So that's an enormous risk. Because if it is written off after three years, you also need to earn your money in those three years. So it's also expensive. And to what extent is it still sustainable then?" – Interviewee 7

"I think that [subscription model company] really has a challenge with the batteries. Because a lot of people just leave them outside in the rain, in the cold. But when it's your own bike, my mother she always brings her battery inside. If it is kept inside, and not in the frost or rain, then it will last longer. So I think that that is also a challenge for subscription models, regarding that ownership: from ownership to use. There should be more knowledge about that." – Interviewee 6

In addition, to be able to provide the level of service discussed in section 5.1.1., an use-oriented company must have a fleet of e-bikes ready to be deployed in case of swapping and requires even more in order to grow. This means that the firm needs to make high initial investments in order to acquire these assets whilst the amortization time is long. Small(er) companies will not be able to make these investments without a large investor behind them. Deciding on the right pricing that considers these financial risks, that customers are willing to pay for and gaining investors are thus key strategic points that will decide the actual economic feasibility of an use-oriented business model.

"If I would suddenly say okay our company thinks that's a really good idea. I have someone for the old batteries, I sell bikes without batteries and I lease the batteries with them. But I stay owner. That will require so much cash. Look we have 600.000 e-bikes. Then I have to [invest] 600.000 times 300 euro, you know." – Interviewee 12

"Yes, so what is the barrier for companies like [subscription model company]. I think you already know it, but our motivation is really that the better our product is, the less maintenance service we have to provide and the more profitable it is for us. So when you need to make a choice between saving money on an expensive front tire or rear tire or not, the choice in our case is more often that you won't [choose the cheaper option], then that you will." – Interviewee 4

"Look, you can offer an e-bike everywhere, but you really have to see to what extent people are willing to pay, because you do give them an e-bike worth 2500,- euros. So that is for sure a barrier to see how we were going to do that. The payments." –

Next to these internal financial barriers, companies also point to one important external barrier, which regards the lack of market acceptance. Both the demand side (see quote from interviewee 2 underneath) and the supply side (see quote interviewee 6) show signs of lack of market acceptance. From the interviews can be inferred that the preference still lies at buying and selling e-bikes, despite literature proclaiming the demand for use instead of ownership (e.g. Moro, Miguel & Mendes, 2020). The statements by the interviewees show that use-oriented S.PSS for e-bikes are still somewhere in the second phase of the technical transition process. As mentioned in section 3.2., this phase is characterized by slow growth, but the innovations have some foothold in niches where firms are able to go through learning processes and price/performance improvements (Geels et al., 2017). Despite these inferences, both companies that offered subscription models interviewed in this study have seen an amazing growth in demand in the last few years, hinting that this model is becoming increasingly popular.

"Yes, because look, if you look at private lease for example, that is done relatively little in my opinion. It is done sometimes, that someone wants to ride on an e-bike but financially it just doesn't work out at once. But most still just want to buy the e-bike. The demand is not really there." – Interviewee 2

"I think that in the end that is a really big challenge, because we are ultimately not equipped to NOT sell new products." – Interviewee 6

"So yes, you do of course see a switch, the sharing economy. So paying for use and not for ownership, and you also see it in the biking industry but it's not, that's what I think, it does grow, but very slowly." – interviewee 7

"When they [company] started we said the market is still in its infant shoes, and now it might have become toddlers', but we still

5.1.3. Knowledge and organizational factors

In the interviews, two drivers emerged for the knowledge and organizational themes, namely a sustainable approach to business and organizational fit. As echoed by literature (e.g. Baines et al., 2007; Kuo et al., 2009), interviewee 1 stated that despite the subscription model also being a good business case, there "was always an awareness that it also has a sustainability side to it." Other companies recognize sustainability as a driver as well, relating it for example to pressure from the government, but also to user demands for sustainable products. Importantly, being able to use sustainability as a marketing strategy is an important facet of choosing to offer S.PSS models as this is more and more demanded from society (Lozano, 201). Furthermore, one company admits that the value proposition of some S.PSS models, such as share bikes, is already aligned with what the company stands for in general (interviewee 8). As multiple authors mentioned, changing to an use-oriented S.PSS model requires a shift in corporate culture which can be a significant barrier to S.PSS implementation (e.g. Richter et al., 2018; Michalik, Besenfelder & Henke, 2019). The opposite then is also true: when this shift does not require much internal change and is a good fit with current organizational values, culture and the already existing market offerings, it is much easier for a company to take up this particular business model. Not only will it be recognized as a new business opportunity to expand current market offerings, there will also be less resistance to change of the internal employees.

Interestingly, when inquiring manufacturers whether they would consider a shift to a use-oriented S.PSS model, one interviewee stated that their core competences were in the field of bike manufacturing and not services, and that they should stick to what they were good at (see quote by interviewee 5 underneath). According to this interviewee, their "company was not made for that. Then we leave gaps and so other parties have stepped in and they put the focus on service and on what the customers want." On the one hand, this statement illustrates the fear of overdiversification as cautioned by Mont (2002), but on the other hand also illustrates a form of resistance to change. On a similar vein, taking the example given by interviewee 10, when offering e-bikes to employees, firms should be aware of the energy they will need to put into changing the behavior of their workforce. According to this interviewee, many pilots for share bikes have failed because the companies participating in the pilot would simply offer the solution and then leave it to the employees to commit to it. According to literature, leadership is key for overcoming challenges related to resistance to change, however, the commitment of leaders within an organization to these solutions is often lacking (de Jesus Pacheco et al., 2019; Vezzoli et al., 2015). As one interviewee states "it really doesn't get through to the big people on top who make the decisions" (interviewee 4). Resistance to change – whether this change is adopting a new business model or changing mobility habits – is very hard to overcome. This is often underestimated by firms.

"We just have traditional business models and honestly we don't want to get rid of that. We just want to make bikes and sell them. And then we can look around the world, like maybe they [the bikes] can last longer and stuff like that, but we are good at making bikes. […] And it's better to stick to doing what you are good at." – Interviewee 5

Another barrier identified by the interviewees that may influence the development of a sustainable PSS specifically, regard short term management practices. Multiple interviewees mentioned that the market is very new and thus a lot of important decisions regarding the EoL of electric components have not been made yet. As one interviewee stated, "we stopped that because we felt that within [company], there is not yet any urgency for this" (interviewee 1). Moreover, relevant data to improve the system has not yet been gathered yet, for similar reasons. Moreover, some interviewees mentioned that providing maintenance and repair services for e-bikes is distinctly different from regular bikes. Not only do electric bicycles need more frequent maintenance, repairing the electronic components of the e-bike such as the battery and motor requires a different set of skills and capabilities. This leads to two related barriers. First of all, it means that companies that traditionally only offered services for regular bikes need to invest in new capabilities and skills in order to offer the same quality of service for e-bikes. Secondly, some batteries need a specialized system to read the data on the battery, which only the supplier has access to. Thus here, the need for close collaboration with partners (e.g. battery suppliers) becomes necessary, as currently this system seems to limit offering the provision of adequate services. However, it must be noted that this phenomenon might also be the consequence of conflicting interests between parties in the supply chain, which will be discussed in section 5.1.5.

"Because I think that the bike is very circular, at least the city bike. As for an e-bike, I don't know yet, we don't have those long enough." – Interviewee 5

"That's of course hard, because look, 80% of our contracts are still ongoing. And 20% has finished, and of those a number choose to have a new contract, but a few also not anymore. But yes, because it's still such a young market, I can't really say anything about that. That's very hard." – Interviewee 7

"No we stopped that because we felt that within [subscription model company] there was not yet any urgency for this [parterning

5.1.4. Consumer factors

For S.PSS, consumer acceptance is one of the most important conditions for successful diffusion (Rogers, 2003). It is therefore not surprising that the companies interviewed in this study mentioned barriers and drivers concerning the end-user the most often (see figure 7). The four most significant drivers that interviewees pointed out regard wanting to lose the responsibilities of ownership, a wish to disconnect from consumption needs, a demand for the product itself and flexibility in use.

According to Baines et al. (2007), a PSS model offers various benefits to consumers, one of which regards releasing consumers from the responsibilities of asset ownership. In line with this statement, several interviewees noted, as can be seen below, that consumers really want the insurance of not having to pay any unexpected costs. Choosing a S.PSS model gives them a certain sense of security, as they already paid for anything that might break or get damaged.

"Yeah, so really not having trouble with buying an expensive product of which all kind of things are wrong, and what you then have to solve yourself." – Interviewee 4

"It's a little bit of convenience. So if you are insured, for theft, and damages, but also for service and maintenance." – Interviewee 6

Furthermore, in line with the trend of ownerless consumption mentioned in section 5.1.2., other often cited drivers from a user-perspective regards the wish to disconnect from consumption needs and the flexibility that a use-oriented model offers. For example, one interviewee mentions that if you don't need the bike for a longer period of time, you can just hand it back, so the bike does not "gather dust in the shed" without anyone using it (interviewee 1). So this model is especially interesting for people who only wish to use an e-bike in warmer seasons or for a short period of time only. Interestingly, one interviewee disconnects the trend towards ownerless consumption with a demand for more sustainable consumption, and states that their customers are simply lazy and there is no real regard for the fact that it is also a sustainable model. She states that they probably "just find that a nice addition" (interviewee 4). Moreover, several interviewees see this ownerless consumption trend as something that only young people feel connected to, while older people prefer traditional models.

"We are really of the generation that doesn't want to consume but do want to use something." - Interviewee 1

"Yes, I think it's a generation thing. I think that if you look at 30, 30 and older, they just want to buy the bike and everyone younger than that doesn't care whether that is on credit. In my opinion there is a dividing line there. Of course there will be a bit of overlap there, but in my opinion it's really a generation thing." – Interviewee 2

Next to the aforementioned drivers, the interviewed companies also identified a number of barriers concerning end-users. A barrier mentioned by multiple interviewees regard the expenses associated with purchasing an use-oriented S.PSS. As can be inferred from prior sections, lease, sharing and subscription companies need to incorporate the financial risks of their product and service offerings into their asking price. Especially in the cases where the user will never become the owner of the product, consumers could perceive it as quite an expensive solution on the long term. One interviewee even stated that some people could just not have peace with themselves for taking a subscription on an e-bike without the perspective of owning it on the long run (interviewee 4). Here it must be repeated that consumers are often unaware of the lifecycle costs of a product, and don't take these into the equation (Schoonover, Mont & Lehner, 2021; Vezzolli et al., 2015). For example, the lifetimes of e-bike batteries are currently expected to be around 5 years, which many consumers are not aware of. As the quote by interviewee 7 shows, the costs of a new battery are relatively high. This knowledge could potentially change consumer perceptions regarding the high costs of use-oriented models.

"A barrier would be that it is all too expensive". – Interviewee 4

"After 5 years the battery is done and then people have to choose between a new battery from [e-bike brand] for 600 or 700 euro, then a new e-bike for 1500 or 2000 euro is suddenly a choice." – Interviewee 7

In line with this last point, perhaps the real problem that arises when looking at the apparent discrepancy between the lifetimes of various components of the e-bike. An example of this discrepancy is the battery and the frame. As mentioned previously, the battery has an expected lifetime of 5 years, while the frame has a lifetime of 10 to 20 years. According to multiple interviewees, when the battery needs to be replaced after five years, many consumers choose to purchase a new bike instead of a new battery. This has partly to do with the fact that battery prices are almost one-third of the entire e-bike (between 500 – 800 euro). One interviewee also pointed to the fact that consumers wish for a new e-bike after five years because it will then have all the up-to-date technology. As such, even though almost all e-bikes have a completely modular design in both product- and use-oriented models, the e-bikes in traditional models will be discarded earlier than in the use-oriented models. In addition, one interviewee pointed out that after five years, the bike will be economically depreciated, and it will thus not be worth it to re-use or refurbish such e-bikes. Often, these e-bikes will be shipped to countries such as Poland, where they will be given a second life (see quote underneath). However, though the e-bike will be partly reused, it will also shift the burden of the EoL of the battery, previously assumed by the Netherlands, to another country with perhaps less strict regulations regarding reuse and recycling.

"No, that's possible, but such a battery is 600-700 euros. Yesterday there happened to be a woman who had to replace the battery and the motor, and she had to pay 1000 euros. She said, 'well you know I just think it's a shame if I trade it [for a new bike], because I can still cycle on it just fine, the frame is still good'. Because in principle the bike is economically depreciated. Even though there are accelerating gears in there which can last 20 years and a frame that can last a long time. So she handled it that way, so I just put a new motor and battery in it. But others say, it is now 6 years later and the technology has progressed, so now I choose a different bike and I trade in my current bike. And then the e-bike goes to Poland, so to speak, because we are no longer going to put a new battery and new motor in it. That just can't be done."

– Interviewee 2

"You can cycle around 5 years with it, and I think that's still too short in the end, because that e-bike will last longer than 5 years.

To continue on with the discussion on cost concerns, one interviewee mentioned that the 2020 regulation for business lease was supposed to increase the demand for leasing electric bicycles, but this never really came to fruition (interviewee 7). Some explanations for this echoed by other interviewees regard that end-users and employers (in case of business lease) find leasing too expensive as well. Despite these perceptions, leasing does seem to be quite an easy addition to offer

alongside a sales model. This could be due to the fact that key activities do not really change, unlike in the case of use-oriented offerings, which could explain the widespread coverage of lease options.

"But lease always makes you think a little bit of the car lease, right, so the moment that you have it for three years, you already paid for it one and a half times. And then with bike lease I really have to explain that there is a tax advantage."
– Interviewee 2

"It's also not free, but you pay the addition while your employer pays the other 90 euros of the lease costs. And often it is that part, at least that is what I noticed, that companies would put a brake on it, because it costs a lot of money."

This is however not the case for use-oriented S.PSS. Many interviewees pointed to various user-related challenges related to ownerless consumption. For example, what all interviewed lease companies pointed out, is that consumers want to be able to choose their own bike. A large amount of product choice (of different brands, design and so on) is not something use-oriented S.PSS are able to offer – the e-bikes need to be identical in order to ensure that service and maintenance runs as efficient as possible. Interestingly, one interviewee mentioned that consumers should get their dream bike instead of a subscription bike, because then they are much more likely to opt to travel with an e-bike instead of the car (interviewee 6). Vezzolli et al. (2015) also pointed out that status might negatively affect the adoption of use- and result-oriented S.PSS. This is also something that can be seen currently for e-bikes (see for example the news article by Termaat (2020) and the quote underneath). As can be seen from the quote by interviewee 6 below, consumers want a bike that fits them, which goes beyond just its functional value. As one interviewee stated: "There are a lot of people who see the bike just as a means, just as a form of mobility from a to b, and then it doesn't really matter whether that bike is yours or if you pay for it monthly" (Interviewee 7). This statement suggests that there might be a significant difference between people who use their bikes purely as a form of mobility (e.g. its function) and between people who see it as something more than that (e.g. a status symbol, a hobby and so on). To nuance this distinction slightly, it also depends on the type of movement that is made: if it's for a short (unexpected) trip, or as a hobby, or as a primary source of transport.

"So is it about function, or about something more? When I go to London and grab a share bike, for me it's about its function. But here, I bike in my own environment, then it's not just about the function, but also about really wanting to own a bike that fits you. So I think that's a challenge [for subscription models]: choice of products" – interviewee 6

"Look, in the past the car was a status symbol. If you rode in a fat car than you had status, and that's of course the case with a lot of products, and obviously also with the bike. So if you have a really nice bike, and you see that strongly with cyclists and race

5.1.5. Contextual- and value chain factors

In this section, the contextual and value chain drivers and barriers are discussed. A contextual driver behind various S.PSS offerings in the e-bike industry that multiple interviewees have mentioned regard the demand for the electrical bikes itself. Currently, electric bicycles are extremely popular in the Netherlands. This rise in popularity can be seen for both consumers and businesses and has been rising for years. For example, according to one interviewee, many new e-bike brands were created in this period, and whilst in the past e-bikes were designed by requiring almost hiding the fact that it was an electric vehicle, now e-bikes have become much more accepted in Dutch society. Notably, Covid-19 also has had a strong influence on the demand for e-bikes. Not only did consumers wish for more outdoor activities, the demand for delivery services that used e-bikes grew enormously as well. Especially for delivery services, an e-bike subscription or lease has many benefits, which could explain its rising popularity. As one interviewee stated, "the major growth really is at the business level" (interviewee 7).

"If you look back at 20 years ago, you had to be either handicapped or really old if you wanted an e-bike. 15 years ago you would buy an e-bike, but you should not be able to see that. The battery had to be integrated or a bicycle bag had to be thrown over it, but nobody was allowed to see it. That's all in the past. The e-bike really has become a cool means of transport. […] But we really went in 10 years' time from 12 brands to 150 brands. Yes, there is no keeping up with that, but there are some really nice ones [e-bike models] there." – interviewee 2

"Corona contributed to that for sure. So our company definitely stood on the right side of the coin at the moment of the whole corona story. Because people used public transport less often, more food was ordered, people wanted to go outside more. And the

On another note, a driver categorized under the value chain factors mentioned by interviewee 9 regard a wish for control over their industry (see quote underneath). According to this interviewee, their choice to have a vertically integrated S.PSS business model enabled them to influence threats posed to their business. This statement is echoed by Moro, Miguel and Mendes (2020). According to these authors, by taking up multiple roles within the supply chain, firms can increase their position as they ultimately play a larger, more focal role in the value chain. The other company with a subscription model also integrated many core aspects, such as design, logistics and sales, suggesting that obtaining the skills and capabilities themselves is a key strategy for companies offering these models.

"And also because we do everything ourselves, we have our own factories, our own e-bike brand, we actually have everything ourselves. And because you do everything yourself, you also control it completely, and you can exert a lot of pressure on things that pose a threat to your industry." – Interviewee 9

In addition, an external driver often mentioned by the interviewees regard the role of regulations. As the quote underneath by interviewee 2 shows, the Dutch government is putting effort into ensuring that the (e-)bike will play a more central

role in the mobility sector by, for example, handing out subsidies to stimulate cycling. The aforementioned 'Fiets van de zaak' regulation (see section 3.4.) is an example of this. Unsurprisingly, the lease companies interviewed in this study state that this regulation has been an important driving force behind their business model. For example, one interviewee mentioned that all their competitors "entered [the market] in the fall of 2019, all the big guys, Pon, Friesland Lease, and a few smaller companies, they all started then." Furthermore, the Dutch government is paying special attention to shared mobility and MaaS, especially in urban areas, to reduce emissions and traffic in cities in general (van der Linden & de Geeter, 2021).

However, some interviewees also point to policy that oppose these developments. One example can be seen from a previous experience in Amsterdam with free floating share bikes. In this particular case, a large number of shared bikes were left everywhere in Amsterdam, which led to complaints from local residents. As a result, strict policy was made that regulated the areas where such bikes were allowed to be left (called geofencing) (Tour de Force, 2017). Whilst this policy can ease complaints and thus heighten acceptance of local residents of such models, it also negatively influences the building of efficient infrastructure for charging the shared e-bikes. As the "important criteria [for users of shared mobility] are availability and location" (interviewee 10), the success of share bikes (both free floating and those with charging stations) is dependent on where they are located and is essentially about a mobility system as a whole, otherwise it will never be successful. Furthermore, the electric vehicles with a free-floating system are currently picked up by a van in order to charge them, which is arguably not a very efficient nor sustainable method. A number of innovations to make this charging process more efficient, such as a charging tile, are being developed at this moment (see for an example of the charging tile Tilercharge.com). Innovations such as this can among other things control where the bikes are left as to not cause disturbances and improve the charging process itself. These types of innovations can only be placed in agreement with the local municipality.

"Look, there is a lot of national policy to give the bike a much more central position. And I also see that happen in Europe, in Milan, in Rome, and in Paris, they are all starting to wake up. Also because of the whole Covid story, you see a lot of subsidies stimulating cycling. We are of course a cycle country, but you also see more cycle paths being built there." – Interviewee 2

"If you look at the government and the policy on shared mobility within municipalities, they are working on covenants to make share bikes providers more uniform in technology and connectivity. So slowly steps are being taken and I think that will lead us to acceptance of shared mobility." – Interviewee 10

As for barriers pertaining to the value chain, it is relevant to understand that the whole industry is based on the traditional sales model which has impact on the environmental performance of the S.PSS (see quote by interviewee 12 underneath). This ultimately means that both the battery supplier and the e-bike dealer have more stakes in selling the battery than

repairing it, as this is where their actual revenue is based on. As one interviewee stated, "most bike shops earn zero with repair and maintenance. That's only 10% of their revenue. What their revenue model really is all about is selling bicycles, mainly new bicycles" (interviewee 6). To a certain extent, this model ensures that battery suppliers are not stimulated to significantly prolong the lifetime of their batteries. Another related problem to this, is that in general, battery suppliers are reluctant to allow repairs of external parties on their batteries due to possible reputation losses when 'things go wrong'. These two points form a big obstacle for the use of secondhand batteries in all business model types but are especially relevant for companies with use-oriented S.PSS models, who benefit the most from electric components that last for a long time or that can be repaired. From this can be inferred that these conflicting interests within the value chain might limit successful collaboration between the two parties. At the same time, when demand for such models increase and a bigger market share is obtained, it will significantly stimulate innovations on battery lifetimes. Now, as one interviewee mentioned, "they have little influence" (interviewee 5).

In addition, there are a very small number of actors that currently offer battery repairs. One interviewee pointed out that for their company (subscription company), it would be too risky to be dependent on one small company for their battery supply as they are dependent on fast service and maintenance and need to be able to switch batteries within a short timeframe. This could pose a potential problem on the short and long term for electronical products that are deprecated earlier than expected, as these might be deposed off less efficiently.

"The biggest part of that goes to e-bike suppliers. For us, those are [battery supplier] and a few small ones. They too, their business model is also focused on selling. And the bike industry, that is traditionally about making a bike and selling it." – Interviewee 12

"That [repairing the battery] would be nice, but they [battery suppliers] are not really open to that, because it's very precise and you will have to know every detail of that battery, and for that you need to be able to access the BMS and the management system. And that's a system with information about Bosch. They don't just share that." – Interviewee 11

"Because it's also the case that with [company] it can very suddenly be about a lot [of products]. So if we really go up exponentially, so also with our e-bikes, and you only have one actor in the Netherlands who can do repairs, maybe it will be about a lot of batteries in the future. That's certainly a future problem." – Interviewee 1

5.2. Quantifying drivers and barriers

In order to give more meaning to the large number of identified drivers and barriers, the interviewees were asked to fill out a survey in which they could rate the drivers and barriers with the scores 1 (plays no role), 2 (plays a small role) and 3 (plays a large role). Though 87 drivers and barriers were identified in the interviews in total, only factors that were mentioned multiple times were taken into consideration. This resulted in 55 drivers and barriers that interviewees were

asked to rank (see appendix VII or the complete list, including tables of the results). It must be noted that only 5 out of 12 interviewees completed this last step. As such, this study opts to be a bit careful with making conclusions from these results. This section will shortly discuss the most striking findings.

First of all, as can be seen from figure 8, the survey showed that the barrier '*a lack of market acceptance or demand'* was ranked as playing a small to medium role for firms in regard to implementing a use-oriented S.PSS for e-bikes. This is slightly surprising, as both literature and the interviews hinted at a stronger role for this barrier. What is even more striking however, is that the subsequent consumer-related barrier *'no perspective of eventually owning the product'* ranks quite low, which is in complete contrast to the literature, the interviews done in this study and the '*lack of market acceptance'* barrier that was just mentioned. A possible explanation for this discrepancy could be that the previously discussed societal trend that pointed to a switch in preference for use instead of ownership is perceived as more important than current consumer patterns. This is evidenced by the fact that the driver *'following trends in society'* is rated as one of the biggest influencers on S.PSS development (see table 5).

Another striking result regards the low ranking of the barrier '*internalizing user costs.'* In academic literature, such as Mont (2002), this barrier is often mentioned to be an impediment to S.PSS implementation. This is because firms cannot control how consumers take care of their products and any repair requires (expensive) labor costs, not to forget the high costs that firms had to invest in the first place for purchasing enough stock. One way to explain this is that for the e-bike sector specifically, this barrier is of less relevance. As mentioned earlier, the industry is already very service-oriented. One interviewee even mentioned that bike shops earn almost nothing from repairs and maintenance, yet this study pointed out earlier that servitization is still used as a differentiation method. Internalizing user costs is thus already a normal occurrence for many of the current business models being offered for e-bikes, which could explain why the ranking of this barrier is so low.

Thirdly, the barriers '*perceiving financial risks due to the long return on investment', the necessity of high investments in stock'* and *'scaling up the business case'* are ranked as having a medium to large role in the use-oriented S.PSS development and diffusion, whilst *'doubts about the economic feasibility of the business case'* is perceived as playing a very small role. This difference is quite surprising, as these four barriers rather seem to be interrelated and therefore reinforce each other. Regardless, perhaps this misalignment has more to do with the fact that firms believe that use-oriented S.PSS have the potential to be profitable, whilst the wording of this barrier points to doubts about this profitability.

Another somewhat surprising result regard the low ranking of the barriers pertaining to the factors that have to do with the sustainable design of the S.PSS (see Appendix VII). Despite these being an obvious theme during the interviews, this same inference was not translated into empirical evidence. This could mean several things. It could be that the firms who filled in the survey do not see figuring out EoL processes as part of the responsibilities of the firm offering the S.PSS.

Another explanation would be that firms do not see this as a barrier for initial development and implementation, but rather a barrier on the long term. Both explanations point towards a lack of complete understanding of the S.PSS concept.

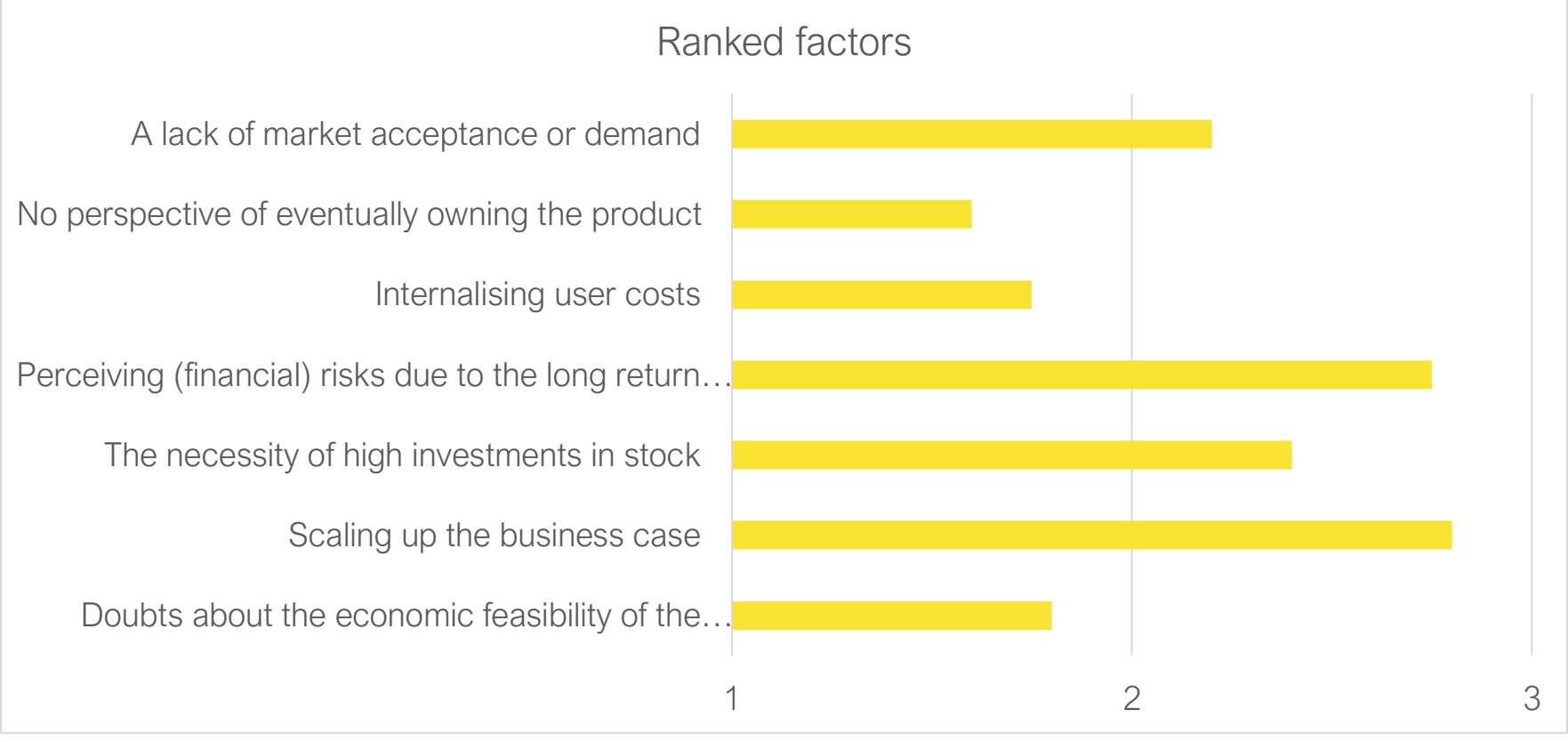


Figure 8: A small overview of the ranked factors that were deemed most striking in light of previous findings. The factors are ranked according to their mean score. For the complete list, please refer to Appendix VII.

Finally, the table underneath shows the factors that had the highest score (and thus played a bigger role) and the factors that had the lowest score (and thus played no role). What is interesting is that while both the interview data and the literature review identified significantly more barriers than drivers, the survey data points out that there are more drivers that play a large role than barriers in the development process of S.PSS for e-bikes.

Table 5: Overview of factors that were rated the highest (with a score > 2.5) and the lowest (score < 1.5)

Biggest role		
Factor	**Type**	**Theme**
The complexity of developing reverse logistics of used products	Barrier	Design
Developing adequate inventory management	Barrier	Design
Scaling up the business case	Barrier	Design
Too expensive	Barrier	Consumer
New market opportunities	Driver	Economic
Following the trends in society	Driver	Economic
Gathering and using user-data in order to deliver better service	Driver	Economic
Wanting to unburden the customer	Driver	Economic
Wanting to offer a sustainable business model	Driver	Organizational
Increase position in the value chain	Driver	Value chain
High degree of flexibility	Driver	Consumer
Insurance of always having a working e-bike	Driver	Consumer

Smallest role		
Factor	**Type**	**Theme**
Finding a balance between sustainable product design and comfortable e-bikes	Barrier	Design
Risks of over-diversification	Barrier	Economic
Unfair competition from Asian countries	Barrier	Value chain
As a company, there is little influence in the value chain to bring about change	Barrier	Value chain

5.3. Context of the MLP

In order to put the identified drivers and barriers into a system perspective and give a broader view of the diffusion process, this section will give a short description of use-oriented S.PSS in the context of the MLP. As the previous sections have stipulated, though S.PSS within the e-bike sector are a growing phenomenon, they are still in the early phases of development and not even close to being a dominant choice to offer or purchase. The lack of market acceptance that interviewees pointed out supports this statement. Within this context, the traditional sales model can be seen as the current regime with which S.PSS of e-bikes compete. Technically speaking, the after sales model and lease models are also a form of S.PSS – that is, they are product-oriented PSS (see table 1 in section 3.4.). However, these two models are typically offered alongside the traditional sales model. Geels (2004) called this a form of add-on or hybridization, in which these models do not have to compete with the current regime head on but form some sort of symbiotic relationship. Use-oriented S.PSS such as subscription models and share models are distinctly different from the current regime and seem therefore less able to form a symbiotic relationship. Instead, the interaction between use-oriented S.PSS and traditional models is characterized more by competition. The MLP literature suggests that when pressure is put on the regime from either the landscape or the niche (or both), opportunities can be created in which niche innovations diffuse faster into mainstream markets. Eventually they might even trigger a transition by overthrowing the dominant regime (Geels & Schot, 2007; Geels, 2004). It is widely acknowledged however that these transitions do not occur easily because the socio-technical regime is characterized by considerable stability due to lock-ins, path dependencies, established patterns of behavior, vested interests and favorable regulation (Geels, 2004). From the analysis of drivers and barriers in the previous section, some of the elements that keep the current regime in place can be identified and are discussed here.

First of all, the most obvious element within this context that keeps the current regime in place regard the preference for owning a product, which can be understood as an established pattern of behavior. As pointed out in the interviews, the wish for ownership remains a strong challenge for use-oriented S.PSS. Here it is relevant to realize that this pattern is kept in place through the system as a whole: society's current consumption and production patterns are almost completely based on the ownership of goods. As one interviewee states: "I think that's a big challenge, because we are ultimately not equipped to not sell new products" (interviewee 6). In addition, as S.PSS are niche innovations, the actors within this group are not powerful enough to change current production patterns. Instead, they are dependent on some of the actors that keep the

current regime in place, such as the suppliers of electronical components. These suppliers currently benefit the most from a sales model as they get a commission every time a new battery is needed. A transition to S.PSS as the dominant regime within the e-bike industry would mean a preference for long lasting batteries, which would have significant impact on their current revenue streams. These vested interests are thus expected to impede the diffusion of S.PSS. However, (slow) changes in consumer preferences, as evidenced by the survey, seem to slowly pressure this established norm.

Furthermore, most external barriers discussed in 6.1. pertain to the regime level, whilst most internal barriers pertain to the niche level directly. This is unsurprising, because this study was focused on understanding the drivers and barriers of S.PSS implementation from a firm perspective. As these have already been extensively discussed in previous sections, the only thing that is relevant to mention here is that the identified barriers seem to strongly reinforce each other. For example, accounting for use-related costs leads to higher investments costs, thus higher financial risks, which ultimately leads to increasing prices and therefore a higher concern for costs from a consumer perspective. This has two important implications. Firstly, it illustrates how path dependencies formed over long periods of time accumulate, making any (radical) change increasingly difficult. In addition, simply overcoming one barrier will not be enough to significantly stimulate the uptake of use-oriented S.PSS business models within the e-bike sector. Solutions that tackle the barriers on a system level are thus required.

When looking at the landscape level, two important processes on this level are currently putting pressure on the dominant regime. Most notably perhaps are the national and international regulations that are putting more and more emphasize on the transition to electric vehicles. Especially in urban areas, where pollution, space and parking are becoming increasingly difficult, local municipalities are putting significant pressure on changing behavioral patterns. Examples of this are trends of building car-less neighborhoods, offering limited parking spots or even offering shared vehicles as transportation instead (Natuur & Milieu, 2019). That is not to say that these regulations impede the traditional model much, as the traditional model also benefits from favorable policy, such as the 'Fiets van de Zaak' directive. These regulations are focused on decarbonizing the mobility sector by stimulating alternatives for car-use. This shows that there are multiple agendas being pursued when it comes to environmental policy. Whilst some of these directives strengthen each other, in other cases it can be the opposite; as is the case here. Another landscape pressure that can be identified from the analysis is the Covid-19 pandemic, which saw widespread impact on people's lifestyles. Covid-19 is a perfect example of a landscape shock that had a sudden but large impact on the status quo. For the e-bike sector specifically, it caused major disruptions in supplies and an enormous increase in demand. For S.PSS specifically, the demand for subscription models increased as well, which could be seen especially in companies offering delivery services in urban areas. Nonetheless, it remains to be seen if this landscape shock is enough for use-oriented S.PSS to gain a stronger foothold in larger markets or if companies offering delivery services will simply become the new niche environment for firms offering S.PSS.

Interestingly, the companies that currently offer a use-oriented S.PSS within the e-bike sector seem to have a strong focus on growth and gaining market share. As discussed in previous sections, this results in a lack of focus on the environmental performance of the business model. Partly, this choice is in line with the current phase the S.PSS is in, as these firms need to go through learning processes and focus their energy on creating an efficient system. However, in the long run it can become problematic when the business becomes more established, as changing the then established patterns will be increasingly difficult. As the main societal benefit of S.PSS is its environmental performance, the relevance of adequate development processes that takes this performance into consideration is highlighted. Without these sustainable development processes, stimulating the diffusion of these models will make little to no sense.

6. Conclusion

In this study, the drivers and barriers for developing and implementing S.PSS for e-bikes in the Netherlands were studied in order to understand how the diffusion process of such models can be facilitated. Twelve semi-structured interviews with multiple actors were conducted, which lead to the identification of 27 drivers and 60 barriers. The combination of these factors forms the answer to the first research question: "*What drivers and barriers exist within the supply chain to move to a S.PSS business model?*" 7 themes were then identified that categorized these factors, namely design, economic, knowledge, organizational, consumer, contextual and value chain. As a last step, these drivers were ranked by interviewees to see to what extent specific factors really play a role in the diffusion process of use-oriented S.PSS for e-bikes. As these findings have already been discussed extensively in previous chapters, three important insights are raised here.

First of all, the first thing that is noticeable from the results are that there are significantly more barriers than drivers. This does not automatically mean that this leads to stagnation of development. The reason for this skewness could be that people in general emphasize barriers more than drivers, as these could be potential challenges that need to be actively solved. Regardless, not all factors play a significant role for the development and diffusion of use-oriented S.PSS for e-bikes. As the quantification of factors exemplified, there is a clear distinction between critical and non-critical factors. This distinction is relevant from multiple perspectives: it points to focus areas for development of firms currently offering S.PSS in the market; it points out the most relevant opportunities and biggest challenges to overcome for emergent firms; and shows potential areas for policy intervention.

Secondly, the combination of the interviews and the survey showed some surprising, contrasting findings. The most relevant being the discrepancy between the barriers regarding the sustainable design of the use-oriented PSS and the relative low importance attached to these barriers by interviewees. These findings are concerning because the waste streams of e-bikes regard electrical components that have a high social and environmental impact, as emphasized in the introduction of this research. These results point to a lack of understanding of the S.PSS concept, which stipulates the necessity of circularity of the business model. On the other hand, it can also point to feeling no responsibility for this particular waste stream, and/or feeling little urgency to change the current processes. This latter point also comes to the fore during the interviews.

Lastly, an important insight that emerged from the consumer-related theme point to the apparent existence of two different types of consumers within this sector, which is different from more traditional consumer typification. The first type regards consumers who use the e-bike for its functional value, e.g. to get from point a to b (as efficiently, cheaply, most conveniently as possible). The other type regards consumers who value the e-bike beyond its functional utility. This latter group for

example uses the e-bike as a hobby, feels strongly connected to a specific brand or might even perceive owning an e-bike as a status symbol. That is not to say that this group will never make use of a S.PSS. For example, when using an e-bike as part of a public transport system, then the activity itself only regards the functional utility and will not intrude on other values. Nonetheless, this insight shows that the primary target group of S.PSS are people who fall into the former group and suggests that a S.PSS will never be able to fully replace traditional models.

This last statement brings the discussion to the main research question, namely: "*How can the development and diffusion of Sustainable Product Service Systems (S.PSS) be stimulated within the business-to-consumer e-bike market?"* In order to answer this research question this study took the MLP as a framework to analyze the current systems dynamics of the e-bike sector. From the analysis can be concluded that the current regime is locked into place by a variety of behavioral, consumption and production patterns and vested interests by incumbent actors. Whereas product-oriented S.PSS for e-bikes are often in a symbiotic relationship with the dominant regime, for use-oriented S.PSS for e-bikes to grow within its niche and enter the meso level of the regime, established patterns need to be broken first. Importantly, the MLP shows that solutions to barriers of S.PSS development and diffusion should take on a systems level, otherwise little change can be expected. In light of these findings, the following recommendations are given.

Firstly, the analysis showed that current landscape dynamics, such as pressures from (inter)national directives, as well as landscape shocks such as Covid-19, have already proved to be opportunities to change established patterns. The most notable and perhaps most interesting insight here regard the trend of ownerless consumption which is a major driving force for firms to offer use-oriented S.PSS for e-bikes. This trend contrasts the still dominant consumer preferences of ownership, but further normalization and stabilization of this pattern could have significant impact on the wider diffusion of use-oriented S.PSS for e-bikes. Therefore, policy aimed at changing consumer norms and cognitions that facilitates the normalization of this trend can prove fruitful. The logical next step would then be to connect the analysis of the current system with possible future transition pathways and adjusting policy to stimulate the pathway of the favored scenario. Less abstractly this will mean expanding already existing local policy on shared mobility and carless neighborhoods and city centers, but also stimulating developments on infrastructure for small electric vehicles and solutions such as MaaS. Here it is relevant to keep a critical view of the political interests regarding other transitions in order to find synergies that can facilitate the diffusion of multiple desired transition pathways, such as those that favor decarbonizing (urban) mobility.

Secondly, an important recommendation on the level of the regime pertains to the resistance to change of stakeholders within the e-bike value chain and the subsequent impact this has on the environmental performance of the S.PSS. The findings showed that the Dutch e-bike market already shows a strong focus on servitization and modularity of product design. The added value of use-oriented S.PSS of e-bikes really pertains to the focus on longevity and durability, which is now partly inhibited by vested interests from suppliers. In that sense, changing these production patterns by overcoming

the resistance to change of stakeholders can spur innovations on longevity and durability instead. The most obvious solution is to further extend the producer responsibility for products with high impact, such as the batteries, then is currently the case. However, perhaps a more interesting solution in the context of this research would be alternative business models for suppliers. For example, a PaaS model for batteries is also a form of EPR and would significantly change the focus of the current dominant model on sales. Not only would it decouple the lifespan of the battery from the lifespan of the e-bike (remember, the battery lifetime often determined if the e-bike would be thrown away), it would also spur innovations regarding re-use and recycling.

Lastly, barriers pertaining to the niche level remain significant for the development of the S.PSS. As not all barriers are equally relevant, it is recommended to focus efforts on the barriers that are most critical. A first try has been made in this research to map these critical factors; however more robust empirical data is needed to make sound recommendations for specific barriers. In a way, overcoming these barriers might prove to be an opportunity for new entrants, but also partly show the development path and learning processes current S.PSS firms still have to go through. For firms wanting to offer a S.PSS it is thus recommended to map these critical factors in order to account for challenges up ahead, and for firms that are already offering S.PSS to understand where further points of improvements lay that could improve their value proposition.

In conclusion, the diffusion of use-oriented S.PSS in the e-bike market from niches to mainstream markets still has a long way to go. However, clear signs on the landscape level show that changes in consumer preferences and (inter)national policy are slowly pressuring the dominant sales model. Overcoming barriers on the niche level could further challenge incumbent actors. In light of pressing climate issues such as dwindling finite resources and the degradation of land due to resource demand, a S.PSS serves as an interesting solution that incentivizes firms to improve the environmental performance of their product offering. Therefore, using the identified drivers and barriers and the recommendations from this study could contribute to further decarbonization of the mobility sector, as well as facilitate firms with finding sustainable ways to do business.

7. Discussion

This final chapter will focus on three main discussion points. First, the implications of this research will be discussed on a theoretical as well as a practical level by relating them to the initial aims of this study. Then, the limitations of this study are highlighted. The last section consists of the avenues for further research.

7.1. Implications research

Drivers and barriers for S.PSS implementation have been thoroughly discussed in academic literature. Although the magnitude of drivers and barriers identified in this research corresponds to previous peer reviewed research and have already been extensively related to research in chapter 5, some relevant new implications emerged which are discussed here.

First of all, this research adds to the current academical discourse by placing the drivers and barriers within the context of a case study, namely the Dutch e-bike sector. This case study served as a way to validate existing literature with practical evidence. Though a small number of 'unique' drivers and barriers were identified in this study, the vast majority of factors corresponds to existing literature (see section 3.3.). This points to possible saturation of knowledge on this specific topic in S.PSS literature. In a sense, the importance of stepping beyond the 'simple' identification of drivers and barriers is highlighted to look at deeper system processes that impede or enhance the development of S.PSS beyond niches. This latter statement is in line with Vezzoli et al. (2015) and Jesus Pacheco et al. (2019), who both pointed to the necessity of relating the critical factors of S.PSS diffusion to wider system processes as mentioned in the introduction of this research. By analyzing the drivers and barriers through the MLP, this study followed these recommendations. In fact, the use of the conceptual framework that combined theory of S.PSS and the drivers and barriers with sociotechnical transition theory from a multilevel perspective proved to be useful in highlighting specific dynamics within the e-bike industry in general, and of S.PSS diffusion specifically. As such, the incorporation of the MLP resulted in a more in-depth understanding of how drivers and barriers of S.PSS from a firm's perspective intersect with relevant dynamics on a systems level.

Secondly, in the literature typically no value is given to drivers and/or barriers. The reason for this is that the ranking of these factors is dependent on the case that is under study (e.g. the sector, type of innovation, relevant actors and so on), meaning that any form of ranking varies case by case. In addition, the interrelations between various factors showed that many barriers only served to strengthen each other, resulting in strongly vested impediments reinforcing the status quo. In light of the large number of studies done on general drivers and barriers for S.PSS development and implementation, the necessity of more insightful findings that truly highlight critical factors for diffusion of S.PSS and their interrelationships are necessary. After all, the reality is that some drivers and barriers are significantly more important to

firms than others. This research contributed in this area by gathering empirical data on what factors were perceived as more important than others in the case of S.PSS for e-bikes. Though conclusions can only be made very cautiously due to the small number of respondents, better insights into the critical factors were gained. For example, whereas literature pointed to the challenge of internalizing user costs as a major barrier for S.PSS diffusion, the results of this research showed that this barrier plays but a small role in the case of use-oriented S.PSS for e-bikes. As such, this study additionally contributed to literature by highlighting the need for gathering empirical data on case studies that can actually serve to be useful beyond the theoretical discourse.

To continue onwards with the discussion on more practical implications, this study's case study approach resulted in an overview of drivers and barriers and their relative importance in regard to S.PSS for e-bikes. These findings are made in light of the current market dynamics and developments, which led to more detailed evidence of critical factors that are especially relevant for the e-bike industry. This overview can thus serve as a way for firms wanting to implement a S.PSS for e-bikes to understand the challenges ahead and plan accordingly, as well as point to the necessary developments that current actors with a S.PSS will have to go through. Essentially, it also highlights potential focus areas for policy makers if they wish to further facilitate the diffusion of more sustainable business models such as S.PSS.

7.2. Limitations

This research is not without its limitations. First, the chosen approach of qualitative research has its limitations. As this study is done by only one person, bias is one of the highest risks. For example, the coding process might have been slightly different if this research was by someone else or in collaboration with several others. Furthermore, there are multiple ways of coding. For example, de Jesus and Mendonça (2018) choose to code the drivers and barriers into 'hard' vs. 'soft' categories. This could lead to slightly different results. Coding is a necessary aspect of structuring the data to enable clear analysis. Therefore, this study tried to stay as closely as possible to the theoretical concepts identified in previous literature through the thematic coding approach. This diminished the probability of bias. Moreover, the combination of qualitative and quantitative research further eliminates bias, which was done very basically through ranking the identified drivers and barriers with the survey.

Secondly, this study aimed to research the e-bike sector as a whole, whilst the sample size in this research might not necessarily represent the whole industry. This study mostly chose to interview service providers, which was in line with the goals of this study. However, some actors, such as battery suppliers, might enrich the findings in this study. Furthermore, the sampling method was mostly a convenience sample, which might have created bias in the results. Moreover, this research takes a more general perspective on use-oriented S.PSS models, which includes both subscription and share models. This led to more generalized barriers and drivers for this category instead of a more detailed perspective.

Despite these points, the findings mostly validated already existing research, which funnels the robustness of the conclusions in this study.

Lastly, the data collection of the survey was done in August, which turned out to be the vacation period for many of the interviewees. Therefore, only a small number of responses were collected. This has some significant impacts on the validity of the results of the survey, which is why this study choose to be careful with making assumptions based on these results. Instead, the results of the survey were used to point out that the method in itself is a useful approach to map and rank drivers and barriers, as it shows how critical and non-critical factors can be distinguished and the added value of doing this.

7.3. Avenues for future research

In light of the previous sections, some avenues for future research can be identified. To start, the exact relationship between factors and further ranking with a higher sample size would be an interesting point for future research. This way, a more realistic overview of the drivers and barriers can be given that shows critical factors that are truly relevant beyond the theoretical discourse.

Furthermore, the findings showed differences between countries and cultures, and even within a country. Whether these differences are significant for further diffusion of S.PSS remains unexplored. In addition, economically depreciated e-bikes, that still have some value, are often shipped to countries like Poland. Whilst here they get to have a longer functional life, it is also a form of waste leakage to another country with perhaps less strict EoL regulations. Gaining more insight into this waste stream would be an interesting point for future research.

On another note, the analysis of the case study showed the rise of a new market due to Covid-19, e.g. firms in need of delivery services. In the context of S.PSS for e-bikes, the b2b market and its dynamics is completely different from the b2c market. It would thus be an interesting topic for future research.

Finally, EPR is often mentioned as method to decrease environmental impact of firms. An EPR scheme for batteries in the Netherlands already exists, and even points to a mature status (Tijm, Dimitropoulos & in 't Veld, 2021). Despite the differentiating fees for recycling these batteries, it would be interesting to find out if these fees actually impact innovations on battery lifespan and durability, and how battery suppliers would react to alternative business models with a further increase of EPR. This could be especially relevant within the surrounding discourse of the European WEEE directive.

8. Sources

Annarelli, A., Battistella, C., & Nonino, F. (2016). Product service system: A conceptual framework from a systematic review. In *Journal of Cleaner Production, 139*, 1011-1032. https://doi.org/10.1016/j.jclepro.2016.08.061

ANWB (n.d.). Leasen versus kopen, huren of autodelen. Accessed from: https://www.anwb.nl/auto/kopen/huren-delen-of-leasen

Aronson, J. (1995). A pragmatic view of thematic analysis. *The qualitative report, 2*(1), 1-3.

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., ... & Wilson, H. (2007). State-of- the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: journal of engineering manufacture*, *221*(10), 1543-1552.

Bakker, C., Wang, F., Huisman, J., & Den Hollander, M. (2014). Products that go round: exploring product life extension through design. *Journal of cleaner Production, 69*, 10-16.

Bawangade, P. P., Bhende, K. S., & Rakhonde, B. S. (2018). Performance Analysis of Electric Bike using Battery and Supercapacitor. *Electric Bicycle*, *5*(12).

Berkeley, N., Bailey, D., Jones, A., & Jarvis, D. (2017). Assessing the transition towards Battery Electric Vehicles: A Multi-Level Perspective on drivers of, and barriers to, take up. Transportation Research part A: policy and practice, 106, 320-332.

Besch, K. (2005). Product-service systems for office furniture: barriers and opportunities on the European market. *Journal of Cleaner Production, 13(*10-11), 1083-1094.

Beuren, F. H., Ferreira, M. G. G. & Miguel, P. A. C. (2013). Product-service systems: a literature review on integrated products and services. *Journal of Cleaner Production, 47,* 222-231.

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering, 33*(5), 308-320. https://doi.org/10.1080/21681015.2016.1172124

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. In *Journal of Cleaner Production, 65*, 42-56. https://doi.org/10.1016/j.jclepro.2013.11.039

Brennan, G., Tennant, M., & Blomsma, F. (2015). *Business and production solutions: Closing loops and the circular economy*. H. Kopnina, J. Blewitt (Eds.), Sustainability: Key Issues. Routledge, London: United Kingdom.

Bryman, A. (2012). *Social Research Methods.* Oxford: Oxford University Press.

Bulow, J. (1986). An economic theory of planned obsolescence. *Quarterly Journal of Economics*, *101*(4), 729-749. https://doi.org/10.2307/1884176

Camacho-Otero, J., Boks, C., & Pettersen, I. N. (2018). Consumption in the circular economy: A literature review. *Sustainability, 10*(8), 1-25. https://doi.org/10.3390/su10082758

Ceschin, F. (2010). How to facilitate the implementation and diffusion of sustainable Product-Service Systems? Sustainability in Design: Now! Challenges and Opportunities for Design Research, Education and Practice in the XXI Century, 1, 440-454.

de Jesus Pacheco, D. A., ten Caten, C. S., Jung, C. F., Sassanelli, C., & Terzi, S. (2019). Overcoming barriers towards Sustainable Product-Service Systems in Small and Medium-sized enterprises: State of the art and a novel Decision Matrix. *Journal of Cleaner Production, 222,* 903-921. https://doi.org/10.1016/j.jclepro.2019.01.152

Doyle, C. (2016). *A dictionary of marketing*. Oxford University Press.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research policy, 33(6-7), 897-920.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24-40. https://doi.org/10.1016/j.eist.2011.02.002

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy, 36*(3), 399-417. https://doi.org/10.1016/j.respol.2007.01.003

Geels, F. W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2017). The Socio-Technical Dynamics of Low-Carbon Transitions. *Joule, 1*(3), 463-479. https://doi.org/10.1016/j.joule.2017.09.018

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757–768.

Goedkoop, M. J., van Halen, C. J. G., te Riele, H. R. M., & Rommens, P. J. M. (1999). Product Service Systems, ecological and economic basics. *Report for Dutch Ministries of Environment and Economic Affairs*.

Goodall, W., Fishman, T. D., Bornstein, J. & Bonthron, B. (2017). The rise of mobility as a service. *Deloitte Review, 20,* 112-130.

Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., ... & Anderson, P. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575*(7781), 75-86.

Hidalgo-Carvajal, D., Carrasco-Gallego, R., & Morales-Alonso, G. (2021). From Goods to Services and from Linear to Circular: The Role of Servitization's Challenges and Drivers in the Shifting Process. *Sustainability, 13*(8), 4539.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221–232.

Kjaer, L. L., Pigosso, D. C. A., McAloone, T. C., & Birkved, M. (2018). Guidelines for evaluating the environmental performance of Product/Service-Systems through life cycle assessment. *Journal of Cleaner Production, 190,* 666-678. https://doi.org/10.1016/j.jclepro.2018.04.108

Kuo, T. C., Ma, H. Y., Huang, S. H., Hu, A. H., & Huang, C. S. (2010). Barrier analysis for product service system using interpretive structural model. *The International Journal of Advanced Manufacturing Technology, 49*(1-4), 407-417.

Lozano, R. (2015). A holistic perspective on Corporate sustainability drivers. *Corporate Social Responsibility and Environmental Management, 22*(1), 32-44. https://doi.org/10.1002/csr.1325

Mahut, F., Daaboul, J., Bricogne, M. & Eynard, B. (2016). Product-Service Systems for servitization of the automotive industry: a literature review. *International Journal of Production Research, 55*(7), 2102-2120

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research policy, 41*(6), 955-967.

Maxwell, D., & Van der Vorst, R. (2003). Developing sustainable products and services. *Journal of Cleaner production, 11*(8), 883-895.

Meulenkamp, E., van Bree, T. & Geurts, A. (2019). Verkenning batterijen 2: Positie NL in waardeketen. TNO Rapport.

Michalik, A., Besenfelder, C., & Henke, M. (2019). Servitization of Small-and Medium-Sized Manufacturing Enterprises: Facing Barriers through the Dortmund Management Model. IFAC-PapersOnLine, 52(13), 2326-2331.

Mont, O. K. (2002). Clarifying the concept of product-service system. *Journal of Cleaner Production, 10*(3), 237- 245. https://doi.org/10.1016/S0959-6526(01)00039-7

Moro, S., Cauchick-Miguel, P. A., & Mendes, G. D. S. (2020). Product-service systems benefits and barriers: an overview of literature review papers. *International Journal of Industrial Engineering and Management, 11*(1), 61-70.

Mylan, J. (2015). Understanding the diffusion of Sustainable Product-Service Systems: Insights from the sociology of consumption and practice theory. *Journal of Cleaner Production, 97*, 13-20. https://doi.org/10.1016/j.jclepro.2014.01.065

Natuur & Milieu (2019). Van autovol naar autovrij: over de toekomst van gebiedsontwikkeling en stedelijke mobiliteit. Accessed from: https://www.natuurenmilieu.nl/wp-content/uploads/2019/02/Van-autovol-naar-autovrij-februari-2019.pdf

Osterwalder, A. & Pigneur, Y. (2010). Business Model Generation: a Handbook for Visionaries, Game Changers, and Challengers. Wiley, Hoboken, NJ.

Phillips (n.d.). LaaS. Accessed from: https://images.philips.com/is/content/PhilipsConsumer/PDFDownloads/Global/PDFs/ODLI20180105-UPD_en_AA-LaaS_Brochure_Office1.pdf

Pigosso, D. C. A., & McAloone, T. C. (2016). Maturity-based approach for the development of environmentally sustainable product/service-systems. *CIRP Journal of Manufacturing Science and Technology, 15*, 33-41. https://doi.org/10.1016/j.cirpj.2016.04.003

Pigosso, D. C. A., S. R. Souza, A. G. Filho, A. R. Ometto & H. Rozenfeld (2010). Is the industrial product-service system really sustainable? In *Proceedings of the 2nd CIRP IPS2 Conference*, 59–65.

Richter, A., Schoblik, J., Kölmel, B., & Bulander, R. (2018). Un bilan des facteurs déterminants de la mise en œuvre de systèmes produits-services. *Revue Européenne d'Économie et Management des Services, 2018*(5), 65- 95.

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: new or refurbished as CE 3.0?—exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling, 135*, 246-264.

Reim, W., Parida, V., & Örtqvist, D. (2015). Product–Service Systems (PSS) business models and tactics–a systematic literature review. *Journal of Cleaner Production, 97*, 61-75.

Rexfelt, O., & af Ornäs, V. H. (2009). Consumer acceptance of product - service systems: Designing for relative advantages and uncertainty reductions. *Journal of Manufacturing Technology Management, 20*(5), 674-699.

Rijksoverheid (n.d.-a). Fiets van de zaak. Accessed from: https://www.rijksoverheid.nl/onderwerpen/fiets/fiets-van-de-zaak#:~:text=De%20bijtelling%20is%207%25%20over,bedrag%20op%20bij%20het%20salaris.

Rijksoverheid (n.d.-b). Mobility as a service (MaaS): Multimodaal reisadvies op maat. Accessed from: https://www.rijksoverheid.nl/onderwerpen/mobiliteit-nu-en-in-de-toekomst/mobility-as-a-service-maas

Ritchie, J., Spencer, L., & O'Connor, W. (2003). Carrying out qualitative analysis. Qualitative research practice: A guide for social science students and researchers, 2003, 219-62.

Rogers, E. M. (2003). *Diffusion of Innovations,* 5th ed., New York: New Press.

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field methods, 15*(1), 85-109.

Schallehn, H., Seuring, S., Strähle, J., & Freise, M. (2019). Customer experience creation for after-use products: A product–service systems-based review. In *Journal of Cleaner Production, 210,* 929-944. https://doi.org/10.1016/j.jclepro.2018.10.292

Schoonover, H. A., Mont, O., & Lehner, M. (2021). Exploring barriers to implementing product-service systems for home furnishings. *Journal of Cleaner Production, 295*, 126286.

Sun, Q., Feng, T., Kemperman, A. & Spahn, A. (2020). Modal shift implications of e-bike use in the Netherlands: Moving towards sustainability? *Transportation Research pat D*: *Transport and the Environment, 78,* 102202.

Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning, 43*(2-3), 172-194. https://doi.org/10.1016/j.lrp.2009.07.003

Teece, D. J. (2018). Business models and dynamic capabilities. *Long Range Planning, 51*(1), 40-49. https://doi.org/10.1016/j.lrp.2017.06.007

Termaat, G. (2020). Aantal diefstallen e-bikes stijgt explosief: 'statussymbool voor de jeugd'. Accessed from: https://www.telegraaf.nl/nieuws/1943188722/aantal-diefstallen-e-bikes-stijgt-explosief-statussymbool- voor-jeugd

Tijm, J., Dimitropoulos, A. & in 't Veld, D. (2021). Extended producer responsibility: case studies on batteries, end-of-life vehicles and medicine in the Netherlands. Den Haag: PBL

Tour de Force (2017). Kopgroep huur- en deelfietsinitiatieven rapportage. Accessed from: https://www.fietsberaad.nl/CROWFietsberaad/media/Kennis/Bestanden/201708_13_Rapportage_Fietsdelen_V13.pdf?ext=.pdf

Tukker, A. (2004). Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet. *Business Strategy and the Environment, 13*(4), 246-260. https://doi.org/10.1002/bse.414

Tukker, A., & Tischner, U. (2006). Product-services as a research field: past, present and future. Reflections from a decade of research. *Journal of Cleaner Production, 14*(17), 1552-1556. https://doi.org/10.1016/j.jclepro.2006.01.022

United Nations (n.d.). The Paris Agreement. Accessed from: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Van der Linden, M. & de Geeter, S. (2021). Verbieden, verplichten of verleiden? Een onderzoek naar maatregelen om reisgedrag te beïnvloeden. Accessed from: https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2021/04/30/verbieden-verplichten-of-verleiden-een-onderzoek-naar-maatregelen-om-reisgedrag-te-beinvloeden/verbieden+verplichten+of+verleiden+-+onderzoek+naar+maatregelen+om+reisgedrag+te+beinvloeden.pdf

Vezzoli, C., Ceschin, F., Diehl, J. C., & Kohtala, C. (2015). New design challenges to widely implement 'Sustainable Product–Service Systems'. *Journal of Cleaner Production, 97*, 1-12.

Wells, P., & Nieuwenhuis, P. (2018). Over the hill? Exploring the other side of the Rogers' innovation diffusion model from a consumer and business model perspective. *Journal of Cleaner Production, 194*, 444-451.

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning, 49*(1), 36-54. https://doi.org/10.1016/j.lrp.2015.04.001

Yin, R. K. (2003). Case study research: Design and methods. London: Sage.

9. Appendices

Appendix I – List of drivers and barriers

See external Excel called 'List of drivers and barriers.'

Appendix II - Interview guide

English version

Thank you so much for helping me with my research by doing this interview. To briefly tell you something about myself and this research; I study at the University of Utrecht and do my graduation research on behalf of TNO. Both I and TNO are interested in sustainable business models. TNO itself is involved in developments in making batteries more sustainable and a focus area in this is on mobility, which includes the electric bicycle.

With this interview I try to gain more insight into the vision of companies on a specific type of business model, namely the product-as-a-service business models. What is different from the sales model is that in such a product-as-a-service business model, a mix of tangible products and intangible services are designed and combined in such a way that they are collectively able to meet the needs of the end consumer. The customer generally pays for the desired result instead of owning a product. With the interviews I want to find out which barriers and drivers are actually relevant for companies to offer such a business model, what it takes to stimulate the growth of these types of models and to what extent sustainability plays a role. within such a model.

This interview will only be used for research purposes and all data will also be made anonymous. The research results will be announced to TNO and Utrecht University and my thesis itself will be stored in the UU database that is accessible to everyone. Do you give permission for this? And can I record the interview so that I can listen to it again afterwards?

Introduction

1.1 Could you tell me a bit about yourself and your job?

PSS business model

1.2 Could you describe the business model of your company?

1.3 How are services integrated in the business model of the company?

1.4 Why was there an interest in developing this type of business model?

1.5 What were the main drivers for implementing this business model? What opportunities did you see?

1.6 What were the main barriers to overcome?

1.7 What new capabilities were needed for managing the use phase and end of life phase of the product?

1.8 How did you acquire these new capabilities?

1.9 What aspects would companies who want to switch to a servitization model need help with? What capacities would they need to develop?

Diffusion

1.10 What are currently the biggest barriers for PaaS models to grow?

1.11 What are the opportunities for growth?

Circularity

1.12 Where do the products that you offer come from? Do you buy them from a producer or is there a more elaborate partnership with these firms?

1.13 How do you decide what materials are used in the e-bikes?

1.14 Why are these materials deemed suitable?

1.15 What happens to the e-bikes and the battery when the subscription is cancelled or the product breaks?

1.16 How are the e-bike batteries reused/refurbished/recycled?

1.17 Who is managing the end-of-life processes? Do you have any partners for this?

1.18 If yes, in what way does this partnership increase the circularity of the product?

1.19 Could the circularity at the end-of-life be increased? How? What stands in the way of this decision?

Consumers

1.20 What type of people does your customer base for the e-bike exist of? (think of age, occupation, wealth)

1.21 What are the consumers main reasons for choosing to lease an e-bike through your company? What makes your offer attractive to (potential) customers?

1.22 What are the benefits of choosing this type of subscription model for consumers versus buying the e-bike?

1.23 What are barriers for consumers to choose this type of model?

1.24 What are motivations?

1.25 What would be necessary to increase the demand for these types of models?

1.26 In what way does consumer behavior affect the sustainability/circularity of the product?

1.27 How can this be improved?

End

1.28 Are there are any remaining topics you would like to discuss?

1.29 Do you have any suggestions for other people that might be interesting for interviewing about this topic?

Dutch version

Heel erg bedankt dat je mij wil helpen met mijn onderzoek door dit interview te doen. Om even kort iets over mijzelf en dit onderzoek te vertellen; ik studeer aan de Universiteit van Utrecht en doe mijn afstudeeronderzoek in opdracht van TNO. Zowel ik als TNO zijn geïnteresseerd in duurzame businessmodellen. TNO zelf houdt zich bezig met de ontwikkelingen binnen het verduurzamen van onder andere batterijen en een focusgebied daarin ligt op mobiliteit waar de elektrische fiets onder valt.

Met dit interview probeer ik meer inzicht te krijgen in de visie van bedrijven op een specifiek soort businessmodel, namelijk de product-as-a-service businessmodellen. En wat er nou anders is dan het verkoopmodel is dat in zo'n product-as-a-service businessmodel een mix van materiële producten en immateriële diensten zodanig worden ontworpen en gecombineerd dat zij gezamenlijk in staat zijn om aan de behoeften van de eindverbruiker te voldoen. Hierbij betaalt de klant over het algemeen voor het gewenste resultaat in plaats het bezit van een **product**. Met de interviews wil ik erachter komen welke barrières en drijfveren er nou eigenlijk relevant zijn voor bedrijven om zo'n soort business model aan te gaan bieden, wat er voor nodig is om een groei van dit soort modellen te stimuleren en hoeverre duurzaamheid een rol speelt binnen zo'n model.

Dit interview zal uitsluitend gebruikt worden voor onderzoeksdoeleinden en uiteraard wordt alle data ook anoniem gemaakt. De onderzoeksresultaten zullen aan TNO en de UU bekend worden gemaakt en mijn scriptie zelf worden opgeslagen in de UU database die voor iedereen toegankelijk is. Aan jou de vraag of jij hier toestemming voor geeft? En of ik het interview zou mogen opnemen zodat ik het terug kan luisteren?

Introductie

1.1 Kunt u iets over uzelf en uw baan vertellen?

A) Businessmodel drivers & barrières (voor bedrijven die al een Product als een service (PaaS)-businessmodel hanteren)

1.2 Hoe zou u het businessmodel van [bedrijf] omschrijven? / Wat doen jullie als bedrijf?

1.3 Hoe zijn services geïntegreerd in dit businessmodel? (slijtage onderdelen, accu)

1.4 Wat zijn belangrijke partners in de keten waar jullie mee samen werken? (zoektocht naar een beschrijving van de bestaande ketenpartners) Zijn relaties met bestaande partners in de keten veranderd n.a.v. PaaS businessmodel?

1.5 Wat waren de grootste drijfveren achter het implementeren van dit businessmodel? Welke kansen zag u?

1.6 Wat waren de belangrijkste obstakels die moesten worden overwonnen? Hoe is dit uiteindelijk gelukt?

1.7 Welke nieuwe vaardigheden waren nodig voor het beheer van de gebruiksfase? En welke voor het eind van de levensfase van de e-bike?

1.8 Hoe heeft u deze vaardigheden verkregen?

1.9 Waarbij zouden bedrijven die over zouden willen stappen naar een product-als-een-service-businessmodel hulp nodig hebben? Welke capaciteiten zouden zij moeten ontwikkelen? Welke grootste barrières zouden zij moeten overwinnen?

Diffusie

1.10 Wat zijn de grootste barrières die de groei van deze businessmodellen tegen gaan?

1.11 Wat zijn de grootste kansen?

Circulariteit en duurzaamheid

1.12 Waar komen de e-bikes en de batterijen vandaan? Worden deze gekocht bij een producent of is er sprake van een meer nauwe samenwerking?

1.13 Wat gebeurt er met de e-bike wanneer deze kapotgaat?

1.14 Wat gebeurt er met de batterijen aan het eind van de levensfase?

1.15 Wie beheert de eindfase van de e-bike? Werkt u hiervoor samen met partners?

1.16 Zo ja, op wat voor manier zorgt deze samenwerking voor een verhoogde circulariteit van het product?

1.17 Kan de circulariteit aan het eind van de levensfase van de e-bike en de batterij verhoogd worden? Hoe? Wat staat deze beslissing in de weg?

1.18 Zijn er nieuwe partijen nodig om mee samen te werken om meer duurzamer te worden? Zo ja, welke?

1.19 Waar valt volgens u nog winst te behalen op het gebied van duurzaamheid?

Consumenten

1.20 Uit wat voor type mensen/bedrijven bestaat uw klantenbestand (denk aan: leeftijd, beroep, rijkdom).

1.21 Wat zijn de grootste redenen voor klanten om te kiezen voor een e-bike lease-abonnement via uw bedrijf? / Wat maakt uw aanbod aantrekkelijk voor (potentiele) klanten?

1.22 Wat zijn de voordelen van het kiezen van een abonnement versus het kopen van een e-bike? Welke overwegingen spelen bij de klant een rol?

1.23 Wat zijn de barrières voor consumenten om dit soort abonnementen af te sluiten? (denk aan bezit)

1.24 Wat zijn drijfveren?

1.25 Verwacht u dat de vraag naar dit soort abonnementen zal groeien? Hoezo?

1.26 Op wat voor manier beïnvloedt consumentengedrag de duurzaamheid/circulariteit van de e-bike? En wat is specifiek de invloed op de batterij?

1.27 Hoe kan dit verbeterd worden?

Einde

1.28 Heeft u nog onderwerpen die u graag zou willen bespreken?

1.29 Heeft u nog suggesties over wie ik nog meer zou kunnen interviewen over dit onderwerp?

Appendix III – Insights CIRCO-Track

Challenges to make the battery more circular:

In principle, the battery of an e-bike is leading. When the battery breaks, the whole bike will be thrown away. This is unnecessary. Thus the main challenge for the e-bike is ensuring a long life for the battery. At the moment, the lifespan of the battery is not at an optimal level yet. It has been mentioned that a battery sometimes can only last up to three years. This partly has to do with the use phase (non-exhaustive list):

- Very extensive use (biking every day for X hours) will result in more wear and tear of the battery.
- Whether the battery is taken inside when it's freezing outside
- Charging of the battery → allowing the battery to only charge up to 80% is actually better for the battery
- Using a fast charger instead of a normal charger

But also with the design (non-exhaustive):

- There is a trend in the industry to build an increasingly bigger battery that has a large capacity (e.g. can last longer without charging). This means more cells will be included in the battery, which heightends environmental impact (more critical materials / resources needed), but can also mean that it breaks more easily (the battery stops working due to safety issues the moment one cell malfunctions). What is interesting here is that this bigger capacity probably isn't necessary from a consumer perspective.
- In line with the above point, batteries are made in such a way that the user can 'squeeze out' all of the capacity within a battery, which results in unnecessary wear and tear of the battery.
- One common design problem Heskon (refurbishing company of batteries) faces is water leakage. The battery housing often isn't built 'water proof' enough (or the other way around: a possibility for water to get out when it gets inside), so water still gets inside. This results in rust.

Interesting trade-offs:

Smart technology can overcome some of the above mentioned challenges, especially those in the use-phase. For example, by actively influencing consumer behaviour by sending push notifications to phones, but also making the user unable to charge the battery to 100% capacity. However, these smart technologies make the battery more 'complicated'. This could mean that even more strain is put on the battery (because it requires more capabilities) and thus it can also break more easily than if the battery was more 'simple'.

Other notes:

- Currently, it's quite hard to recycle the battery, which makes it relatively expensive (now: producers have to pay to recycle it, so this is a big obstacle for circularity). Simply burning it is a lot cheaper.
- In line with the above, there are no standard (design) rules for the e-bike batteries, which makes recycling on a large scale harder (battery has different sizes, forms, etc., they have to be sorted before the start of the recycling process). It's not yet possible to separate materials in an automatic process, it's all manual work (thus expensive).
- Hard to recycle the materials of the battery.
- Financial incentives for the recycling companies are becoming less and less, because recycling requires high investment costs, but value gained from recycling is becoming increasingly less. Scale is thus very important. Combined with the fact that batteries are always developing, including different compositions, recycling companies run the risk of investing in the wrong technology.
- A lot of cells in the battery are still usable for other applications. Being able to somehow measure how 'bad' individual cells have become, could be useful when thinking of second life
- A lot of companies are reluctant about allowing repair/changing/refurbishing their batteries. They see a lot of risks, because the battery can explode if it is done incorrectly. However, something like certified refurbishing could solve this problem (and furthermore create more value for the battery and the supply chain).
- The logistics of the return of old batteries remains an issue at the moment. Financial triggers are probably a must.

Appendix IV – Summary consumer interviews

Can be obtained upon request.

Appendix V – Matrices of drivers and barriers

See external Excel sheets named:

1. Results – barriers external
2. Results – barriers internal
3. Results – drivers external
4. Results – drivers internal

Appendix VI – Unique factors

The following table shows the list of unique factors identified in this case study that was not yet previously found during the literature review.

Factor	Type	Theme
Organizational fit	Driver - internal	Organizational
demand for e-bikes	Driver - external	Consumer
Corona	Driver - external	Context
Complexity of designing service components	Barriers – internal	Design
Differences in battery sizes	Barriers – internal	Design
Discrepancy between the durability of different components	Barriers – internal	Design
Fast growth impeding good development	Barriers – internal	Design
Expensive to relocate used products	Barriers – internal	Economic
Low residual value	Barriers – internal	Economic
Complexity of reuse	Barriers – internal	Economic
Lack of knowledge due to novelty	Barriers – internal	Knowledge
Feeling no urgency	Barriers – internal	Organizational
Not interesting for older people	Barriers – external	Consumer
Corona	Barriers – external	Context
Differences in geographical locations	Barriers – external	Context
Slow rate of innovation	Barrier – external	Economic
Dependence on one partner	Barrier – external	Value chain
No insurance for reused/refurbished products	Barrier – external	Value chain

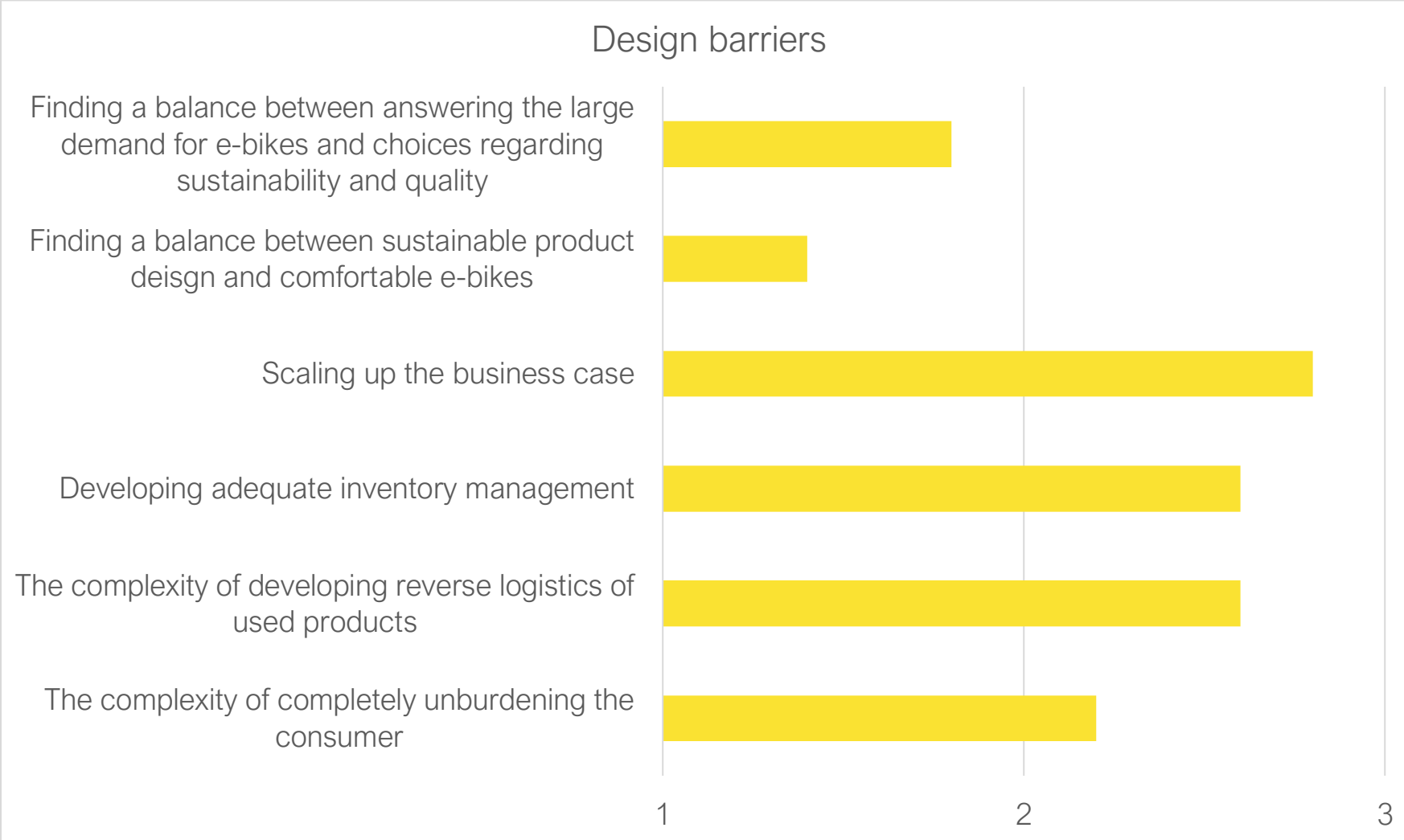
Appendix VII – Factors included in the survey

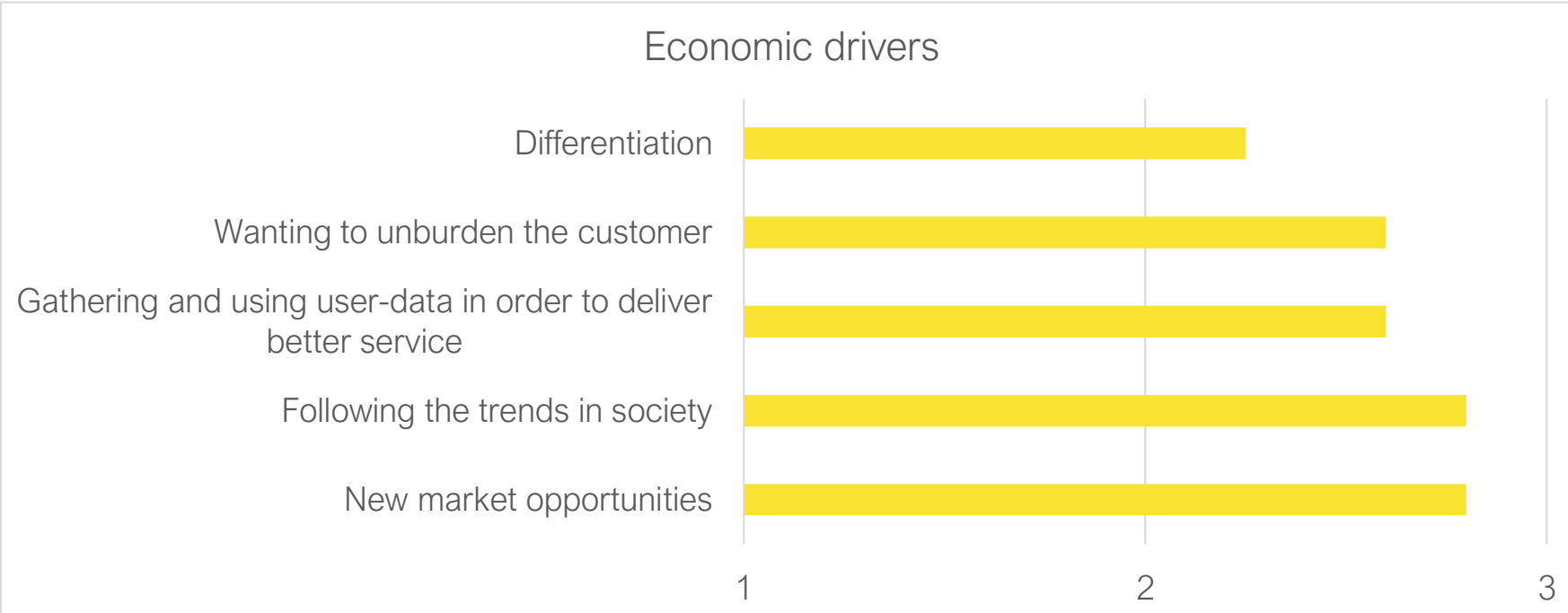
Raw data

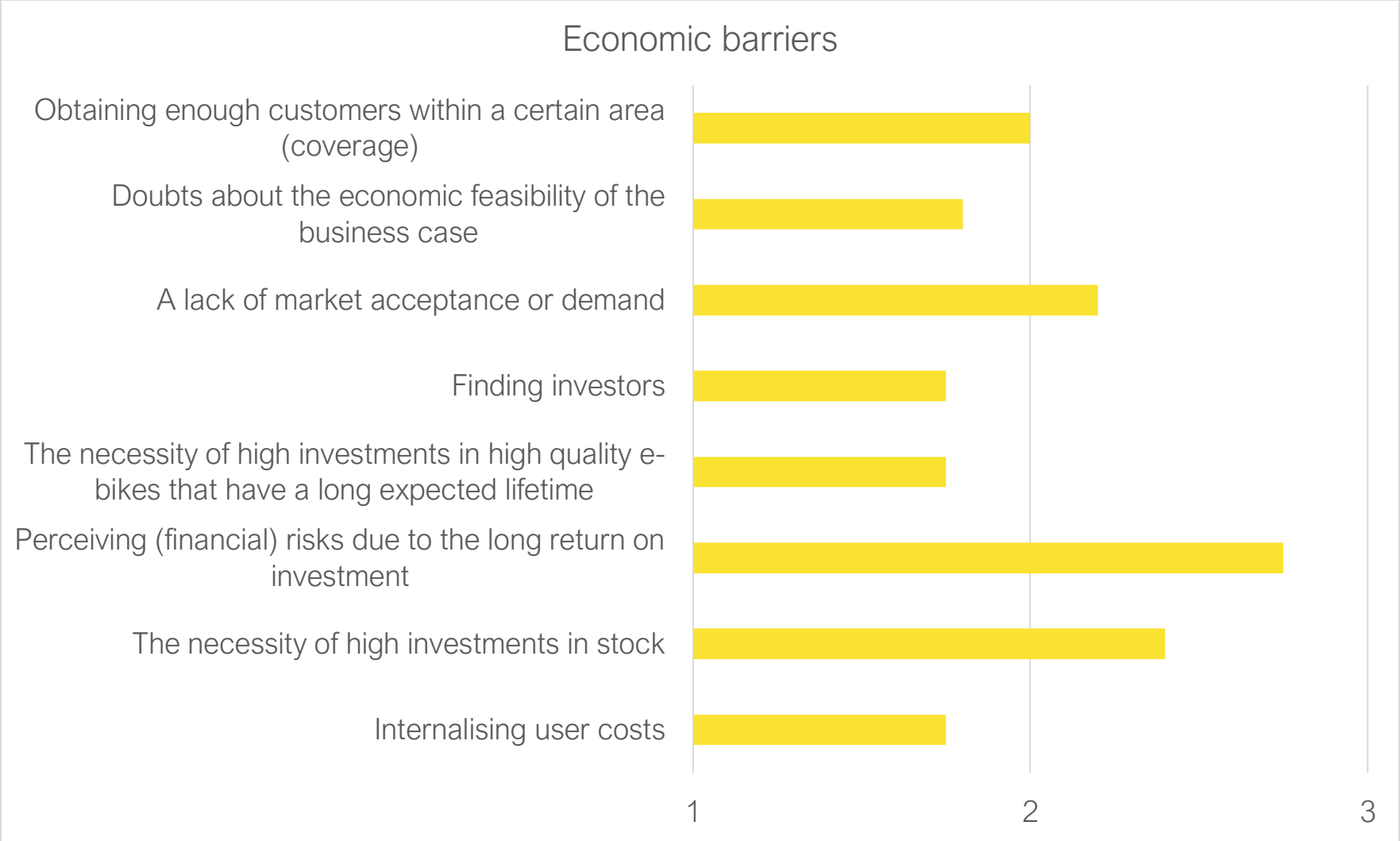
	Variable English	Mean	Std. Deviation
barrier - design	The complexity of completely unburdening the consumer	2,2	0,447
	The complexity of developing reverse logistics of used products	2,6	0,548
	Developing adequate inventory management	2,6	0,548
	Scaling up the business case	2,8	0,447
	Finding a balance between sustainable product deisgn and comfortable e-bikes	1,4	0,548
	Finding a balance between answering the large demand for e-bikes and choices regarding sustainability and quality	1,8	0,447
barrier - economic	Internalising user costs	1,75	0,5
	The necessity of high investments in stock	2,4	0,894
	Perceiving (financial) risks due to the long return on investment	2,75	0,5
	The necessity of high investments in high quality e-bikes that have a long expected lifetime	1,75	0,957
	Finding investors	1,75	0,957
	A lack of market acceptance or demand	2,2	0,837
	Doubts about the economic feasibility of the business case	1,8	0,447
	Obtaining enough customers within a certain area (coverage)	2	1,155
barrier - know & org	Risks of over-diversification	1,5	0,577
	Resistance to change employees	2	1
	A lack of commitment of higher management	1,75	0,957
	Focus on short term goals	2,2	0,837
	The necessity to develop new skills & competences	2	0,707
barrier - context	Conflicting interests within the value chain	2,4	0,548
	Missing infrastructure at strategic locations	2,2	0,447
	Lack of regulations that stimulate PaaS models	2	0,707
driver - economic	New market opportunities	2,8	0,447
	Following the trends in society	2,8	0,447
	Gathering and using user-data in order to deliver better service	2,6	0,548
	Wanting to unburden the customer	2,6	0,548
	Differentiation	2,25	0,5
driver - know/org/cont	Wanting to offer a sustainable business model	2,8	0,447
	Being able to use sustainability for marketing purposes	2,4	0,548
	Increase position in the value chain	2,5	0,577
	The existence of supportive laws and regulations	2	0
driver - consumer	High degree of flexibility	2,6	0,548
	Insurance of always having a working e-bike	2,8	0,447
	Losing the responsibilities of ownership	2,4	0,894
	Preference for the use of the product instead of owning it	2,4	0,548
	Preference for monthly payments instead of making one large investment	2	0,707

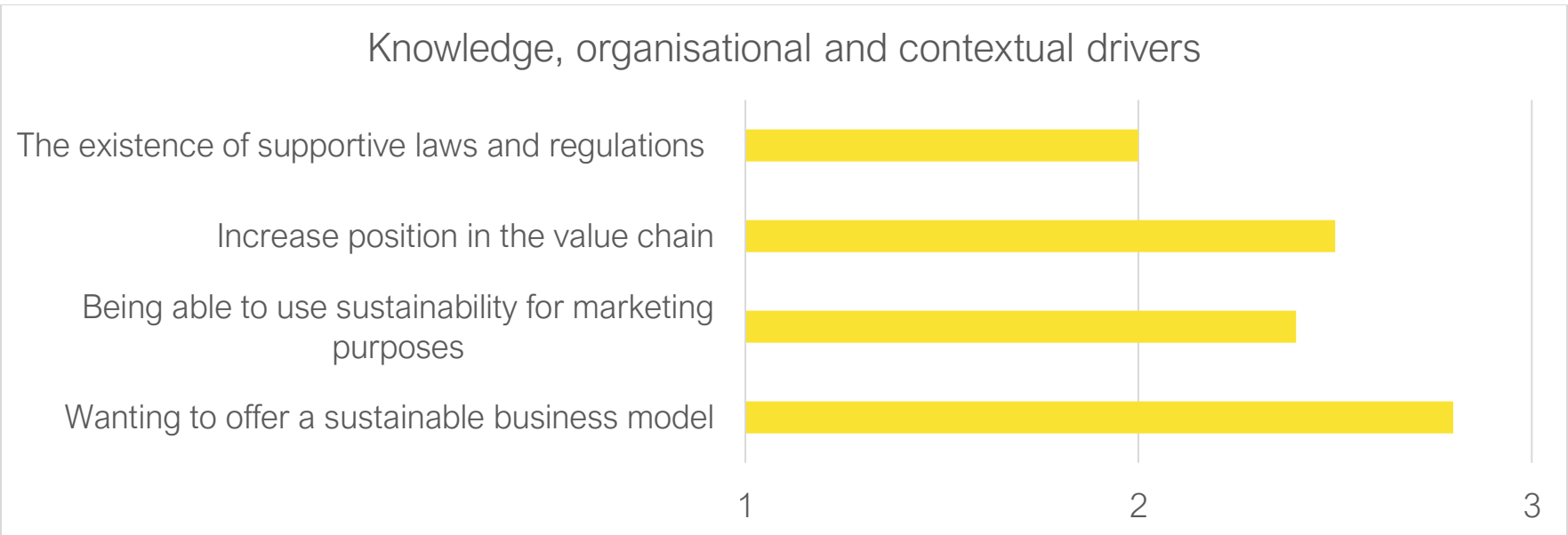
barrier - consumer	Too expensive	2,6	0,548
	Being stuck with a subscription	2,2	0,447
	No product choice	1,8	0,837
	Unable to estimate the life cycle costs	1,8	0,447
	No perspective of eventually owning the product	1,6	0,548
	Perceiving owning an e-bike as a statussymbol	2	0,816
barriers - sust. Dev.	Innovations in battery EoL are still in the development phase	2	0,707
	New batteries are cheaper than second hand batteries	1,75	0,957
	Repairing batteries requires new skills and competences	2	1
	The various components of the e-bike have a different lifespans	2	0,707
	Repair of batteries by third parties is not accepted by respective suppliers	2,4	0,894
	Little to no actors offer second hand batteries	1,6	0,894
	No insurance is provided for second-hand components	1,8	0,837
	Lack of laws and regulations regarding electrical components of the e-bike at the end of its life	1,75	0,5
	Lack of laws and regulations regarding standardized battery design rules	1,8	0,447
	As a company, there is little influence in the value chain to bring about change	1,5	1
	There is little to no urgency to change at the moment	2,25	0,957
	Unfair competition from Asian countries	1,5	0,577

Tables per theme

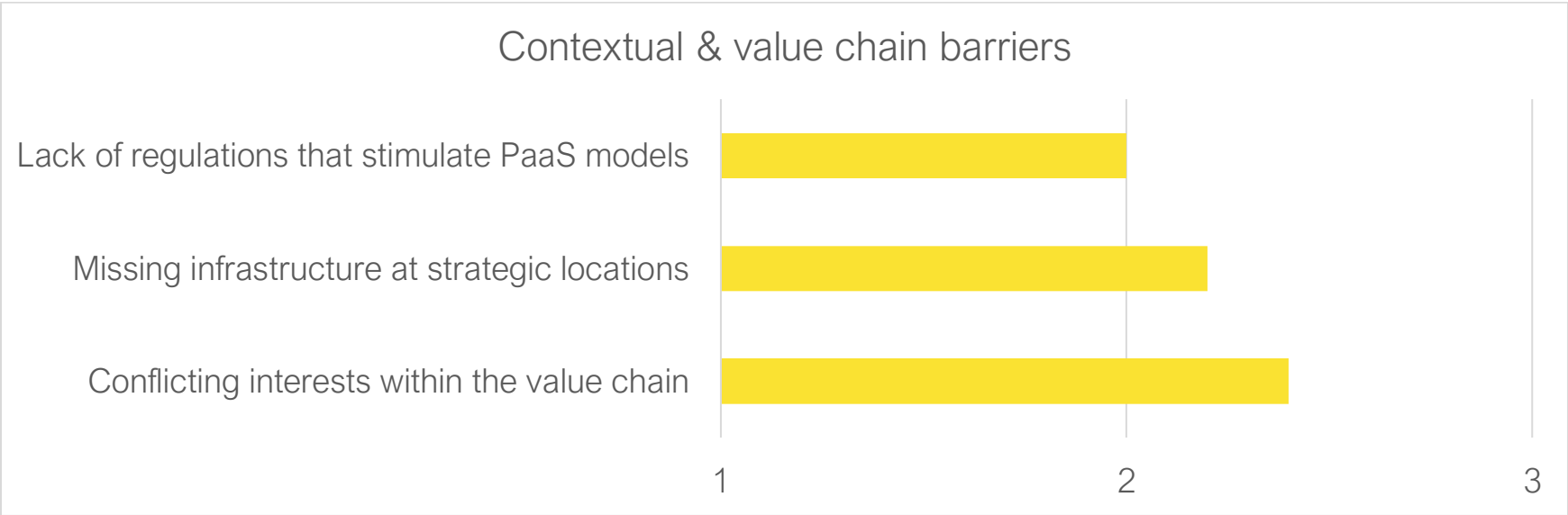


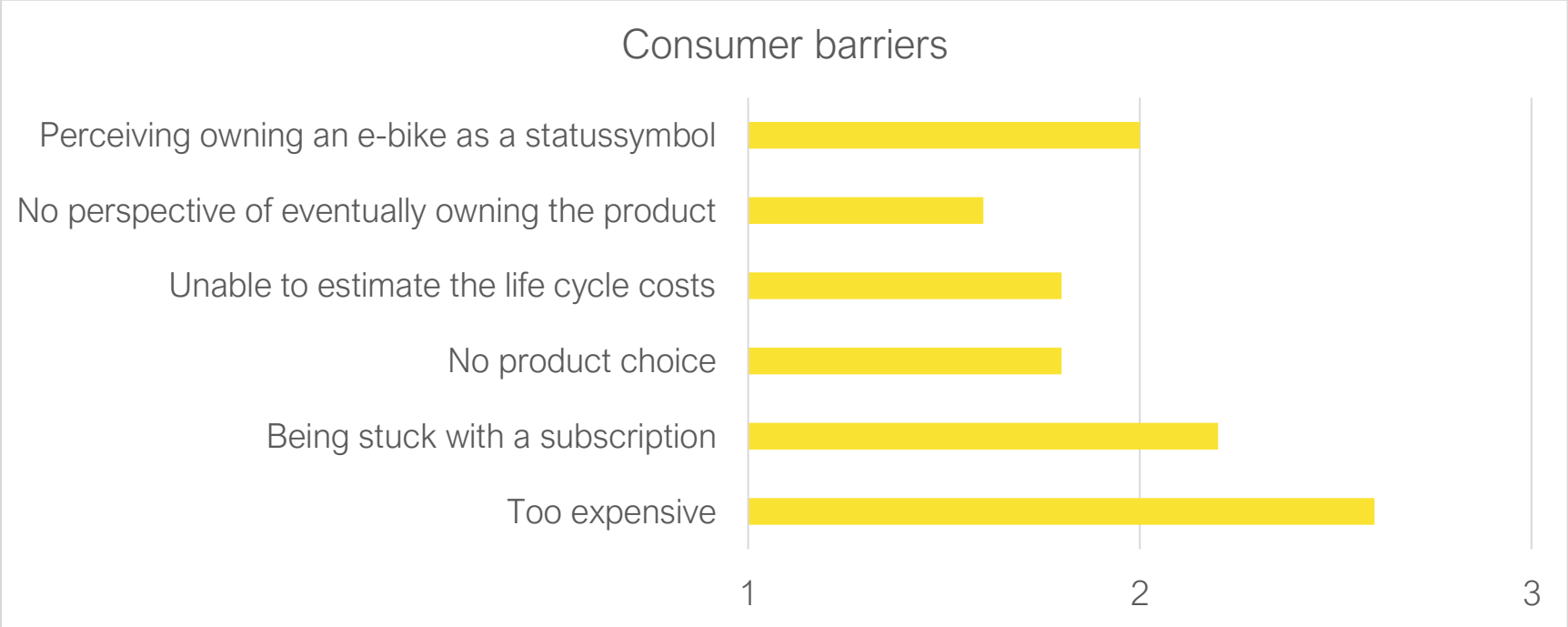


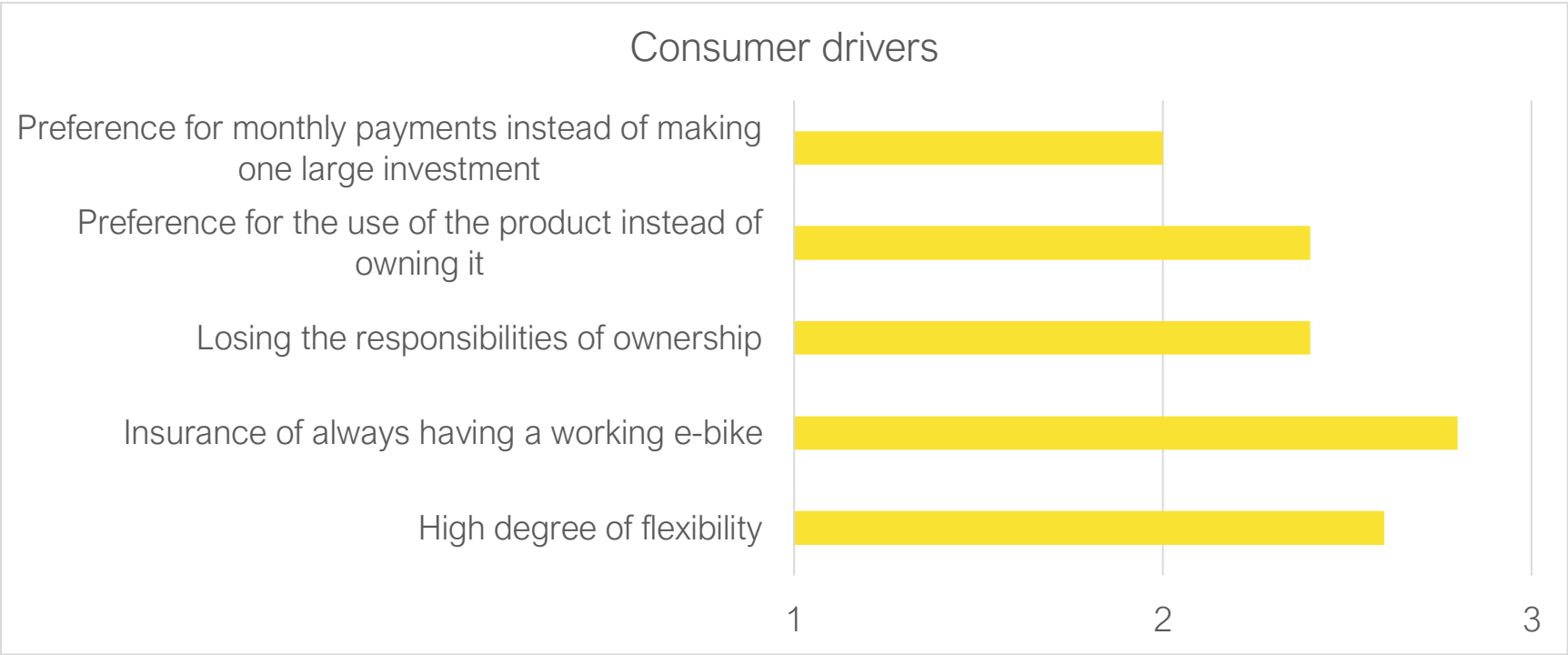

Economic barriers
Obtaining enough customers within a certain area (coverage)
Doubts about the economic feasibility of the business case
A lack of market acceptance or demand
Finding investors
The necessity of high investments in high quality e-bikes that have a long expected lifetime
Perceiving (financial) risks due to the long return on investment
The necessity of high investments in stock
Internalising user costs
1
2
3

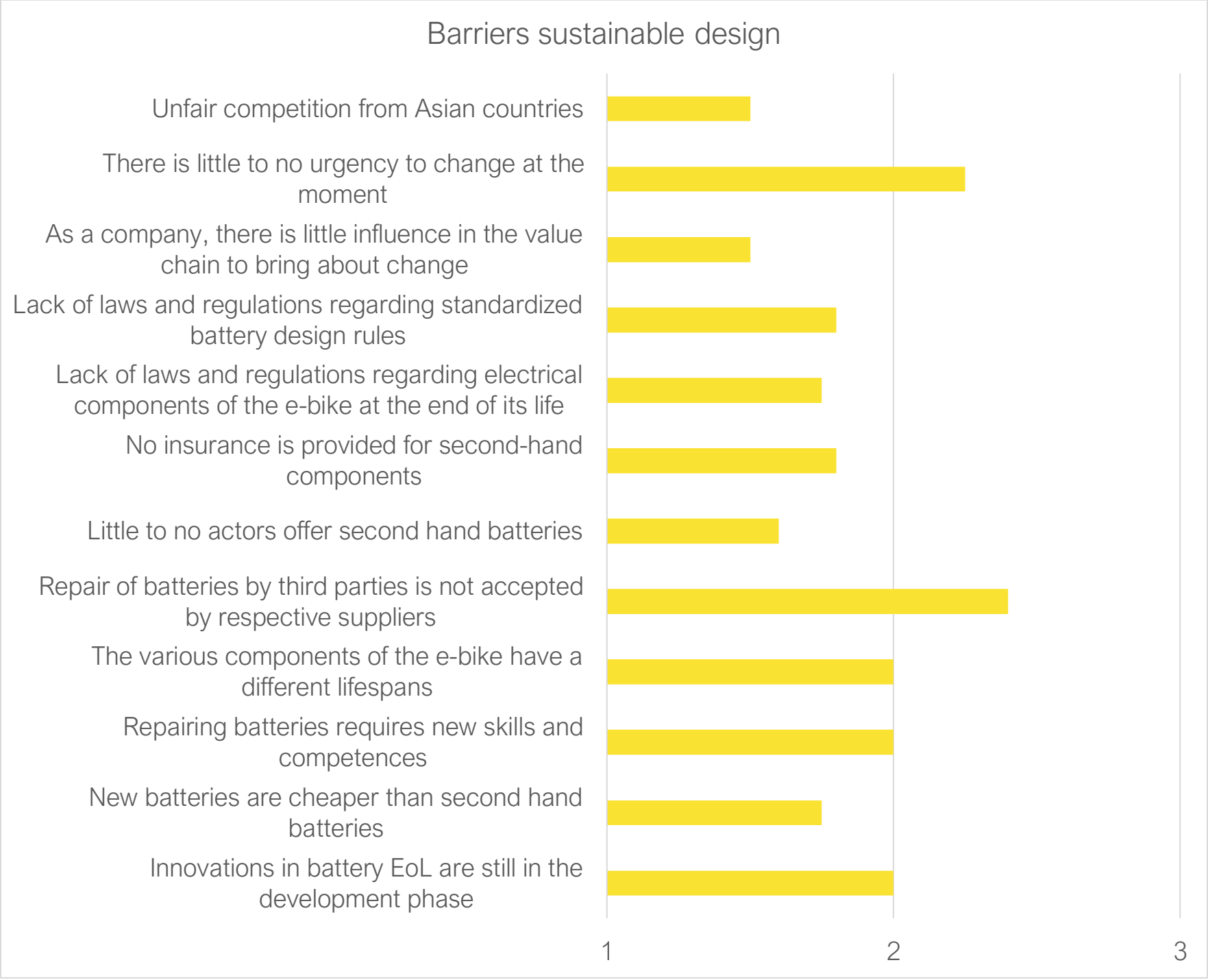

Knowledge, organisational and contextual drivers
The existence of supportive laws and regulations
Increase position in the value chain
Being able to use sustainability for marketing purposes
Wanting to offer a sustainable business model
1
2
3


Knowledge & organisational barriers
The necessity to develop new skills & competences
Focus on short term goals
A lack of commitment of higher management
Resistance to change employees
Risks of over-diversification
1
2
3


Contextual & value chain barriers
Lack of regulations that stimulate PaaS models
Missing infrastructure at strategic locations
Conflicting interests within the value chain
1
2
3


Consumer barriers
Perceiving owning an e-bike as a statussymbol
No perspective of eventually owning the product
Unable to estimate the life cycle costs
No product choice
Being stuck with a subscription
Too expensive
1
2
3


Consumer drivers
Preference for monthly payments instead of making one large investment
Preference for the use of the product instead of owning it
Losing the responsibilities of ownership
Insurance of always having a working e-bike
High degree of flexibility
1
2
3


Barriers sustainable design
Unfair competition from Asian countries
There is little to no urgency to change at the moment
As a company, there is little influence in the value chain to bring about change
Lack of laws and regulations regarding standardized battery design rules
Lack of laws and regulations regarding electrical components of the e-bike at the end of its life
No insurance is provided for second-hand components
Little to no actors offer second hand batteries
Repair of batteries by third parties is not accepted by respective suppliers
The various components of the e-bike have a different lifespans
Repairing batteries requires new skills and competences
New batteries are cheaper than second hand batteries
Innovations in battery EoL are still in the development phase
1
2
3