

Product-service systems in large automotive OEMs: characterising the decision-making process when developing and introducing vehicle sharing/pooling schemes

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Abstract

Automotive OEM introduced Product-Service Systems in the past 20 years, challenging their traditional business model. A qualitative study was developed to characterise the decision-making process across 6 case studies, and similar patterns across different enabled the identification of lessons learned and possible future implications. All PSS initiatives were introduced following an Agile/Lean experimental approach, but the opportunistic nature of trials casts doubts in future validity. New testing methods that generate more robust conclusions need to be developed.

Keywords: *product-service systems (PSS), decision making, business models, agile management*

1. Introduction

Over the past 20 years, incumbent Original Equipment Manufacturers of vehicles (OEMs) have tried to find new business models that enable them to remain profitable and relevant in the context of higher environmental concerns related to production, use and disposal of vehicles (Williams 2007). Many OEMs responded by introducing Product/Service Systems (PSS), such as car share or vehicle pooling. As defined by Mont (2002), a PSS is a combination of products, services, infrastructure and supporting networks that interact in a way that can satisfy the needs of customers while questioning principles like ownership of assets. In doing so, environmental impact tends to be lower than traditional business models. The link between product service systems as a potential for environmental impact reduction has been widely researched (Neramballi *et al.* 2020; Goffetti *et al.* 2022; Kurpiela and Teuteberg 2022), even in the automotive sector (Williams 2006; Ceschin and Vezzoli 2010; Smania *et al.* 2023).

The introduction of such systems by OEMs involves the development of a model that can challenge not only how vehicles are used, but also how they are designed for the sharing function, and how this value proposition interacts with their core business of selling vehicles as they have done for decades. This paper aims to characterise the processes by which established OEMs decide to instigate the design and introduction of Product Service Systems as part of their offering, even though it may be perceived as opposite to their core business models.

Where other studies have proposed tools to support decision-making in a normative approach (Wall *et al.* 2020; Sarancic *et al.* 2022; Mahl *et al.* 2023), the focus of the research is on describing the decision-making process *as it is* and not as it should be (Brunsson 1982; March 2002). The lessons learned from this study can be of use for automotive manufacturers aiming to incorporate business models with higher environmental ambitions, and designers seeking to initiate PSS developments in other types of large OEMs.

1.1. Product Service Systems as decision outcomes for innovative business models

The automotive industry is known for being strongly anchored in the production and sale of commercial and passenger vehicles. Consequentially, product-oriented PSS such as maintenance and vehicle finance schemes have been part of the offering portfolio for a long time. In the last two decades, however, new PSSs generated by OEMs or by newcomers such as Uber, Zipcar or Lyft started challenging the product-centred notion, as seen in Figure 1. These changes have not gone unnoticed by researchers, with numerous studies exploring the reasons (Firkorn and Müller 2012) and consequences (Gaiardelli *et al.* 2014; Mahut *et al.* 2017; Genzlinger *et al.* 2020) to the introduction of PSS by OEMs, especially regarding their implementation and management (Zapata and Nieuwenhuis 2010; Mocker and Fonstad 2017; Smania *et al.* 2023). Successful cases have also been examined, such as Rolls Royce Power-by-the hour (Harrison 2017; Smith-Gillespie *et al.* 2018).

Yet, the literature to date has not included a cross-case analysis, and it is valuable to explore what happens when looking at a range of initiatives within their context. The focus of this study is on use-oriented services (vehicle renting, sharing or pooling) and result-oriented services (pay per mile-minute) as defined by Williams (2007).

RQ1: What lessons can be extracted from the initiatives of OEMs to introduce PSS to the European market in the past two decades? What are the implications for lowering the environmental impacts of the automotive industry?



Figure 1. Twenty years of PSS: selected events in the European automotive sector

1.2. Strategic decision-making to introduce Product Service Systems in the automotive sector

Incumbent automotive OEMs are organisations with well-established rules, policies, and procedures to deliver key functions (such as Research and Development, R&D). Design teams are usually part of the process of generating innovations that can be commercialised later. Some of those innovations, such as PSS, demand more than design decisions: they require changes in strategy, operations, and business models. The literature on strategic decision-making suggests that the process of choosing between alternatives is rational and often depicted as linear (Citroen 2011; Enström and Frendin 2023) but recognise the existence of uncertainty surrounding future consequences of present actions. Uncertainty is incorporated in the model as “risk,” with alternatives attached to different levels of risk (March 1994). Key information reduces uncertainty. Figure 2 from Citroen (2011, p.496) represents a depiction of this decision-making process as linear, including some possibility for iterative feedback. Rounded boxes indicate the five phases in the decision process; square boxes contain parameters that provide input for the indicated actions. Arrows indicate the main direction of interactions.

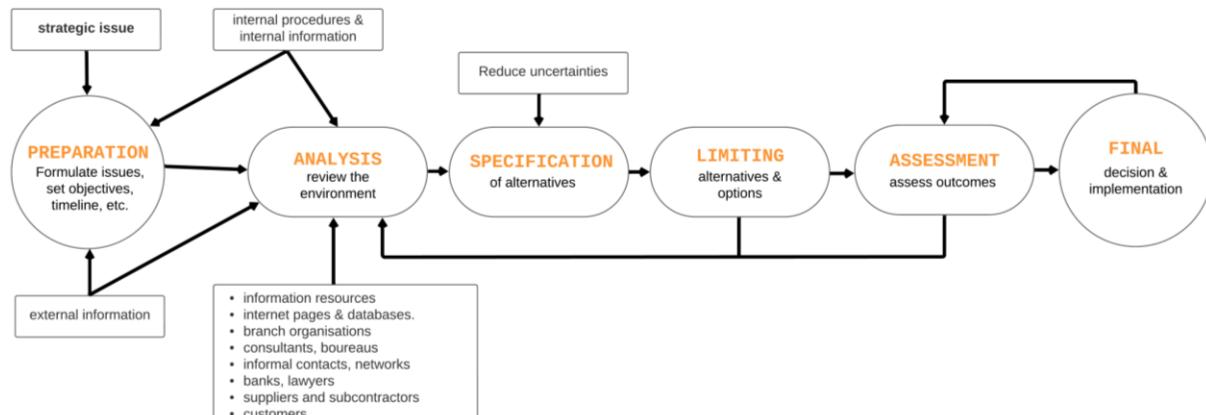


Figure 2. Model from the phases of rational decision-making process adapted from Citroen (2011, p.496)

Management theory suggests that firms use some form of capital rationing when formulating new product development plans, establishing fixed R&D budgets and then use a rank system to determine which will be funded (Schilling 2013), as well as a myriad of quantitative, qualitative, and mixed methods used to evaluate alternatives for R&D. But the criteria for limiting alternatives can be more diverse: in a recent study, Enström and Frendin (2023) explored the incorporation of sustainability criteria as part of the decision-making process of three automotive companies from Sweden. They found that goals, outlined at the start of the project, get divided into sub-goals when delegated to specific business functions. Each function focuses on the sub-goal and collects information that will enable them to understand the interactions between alternatives and the effective ways of delegating work (Enström and Frendin 2023). However, there is very limited research on strategic decision-making in the automotive sector regarding the incorporation of Product/Service systems as part of their core business offering, so the second proposed research question is:

RQ2: What was the decision-making process in established OEMs introducing PSS into their offering thereby challenging their traditional business model?

2. Methodology

As the literature review revealed a lack of studies describing the decision-making process in the automotive sector concerning the introduction of Product Service Systems, the chosen design is exploratory, aiming to build hypotheses from the data gathered. A qualitative research design

exploring patterns across cases was chosen due to its capacity to depict processes connected to the subjects' experience of it (Merriam and Tisdell 2015).

The first research action was mapping events occurring in time following the introduction of PSS. Some elements from narrative analysis have been used as part of the process of "sense-making" of events, and the resulting evidence was organised in a timeline in Figure 1, a data representation method that organised events in a chronological arrangement, with a visual indication of the significance attached to the events (Kolar *et al.* 2015).

The initial timeline enabled the selection of cases to be considered in the study. A non-probabilistic sample was built with the goal of discovering, understanding, and gaining the **most** insights (Merriam and Tisdell 2015). The inclusion criteria guided the selection of large established automotive OEM's active in the European market, who deployed well-documented use-oriented or result-oriented PSS initiatives in Western Europe between 2002 and 2022. Six OEMs filled the criteria: BMW, Mercedes Benz (then Daimler), Audi, Volkswagen, Ford and Stellantis (then PSA).

All data has been analysed following a framework based on decision making theory (Brunsson 1982; March 1994; March 2002; Citroen 2011; Bertoni 2019; Wall *et al.* 2020) centred in a) the way problems or opportunities are outlined, b) who is involved in the process and what are their goals and preferences, c) which alternative solutions are being considered, and d) the decision-making rules and procedures. A short narrative was then built for each case study, and a table summary was created to aid the identification of patterns between the case studies in the sample.

2.1. Data sources and collection methods

The nature of decisions makes their study notoriously difficult. Interviews are often applied to get details of what happened, but people's memories and the subjectivity creates some validation issues (Merriam and Tisdell 2015). This research takes a different approach, embracing the exploratory nature of the design and attempting to draw a high-level description of the decision-making process. To that effect, the data used comes from grey literature such as: public records (including legislation, press releases from OEMs and Annual Reports) and popular culture documents (newspaper articles, magazine articles, interviews of key stakeholders performed by journalists), accessed through the Business Source Complete database, published by Ebsco. Occasionally an additional search would be run to find complementary pieces of news on the same event using Google News. These sources are less obtrusive than interviews but result in some limitations to the depth of understanding of the decision-making processes. This is because strategic decision-making processes tend to be highly confidential interpersonal affairs. Such limitations will be addressed later. To complement the understanding, some secondary data from previous case studies on related topics (Dremel *et al.* 2017; Mocker and Fonstad 2017; Genzlinger *et al.* 2020; Enström and Frendin 2023; Smania *et al.* 2023) were also included.

A complete list of sources as well as the narratives for the cases studied can be found in the Zenodo repository accessible here: <https://doi.org/10.5281/zenodo.10138671>.

3. Findings

The historic review of PSS related initiatives from established OEMs enabled the identification of six case studies. Information on the societal, economic, and political context was added, as seen in Figure 1, to aid the understanding of the motivations expressed by the decision-making participants identified in the case studies. Table 1 outlines the selected case studies organised in chronological order.

Table 1. Summary of the selected OEM case studies

PSS	OEM's context prior to the decision	Outcome of the decision
2008 – Daimler's Car2Go	2008 financial crisis looming. Large investments in R&D after company restructuring (2007). A business innovation team formed to develop new growth opportunities (2007).	A free-floating carsharing pilot was launched in Ulm, which would later become Car2Go GmbH – a subsidiary brand for mobility.
2011 – BMW's DriveNow	BMW Group launches Strategy Number ONE (2007) stating the mission of becoming “the world’s leading provider of premium products and premium services for individual mobility”. A group called “Project i” is created (2007) within the company to focus on sustainable and electric mobility.	After a traditional product development process that included the launch of the Mega City Vehicle concept, DriveNow was launched in April 2011 as a 50-50b joint venture with Sixt and offered under BMW i. DriveNow services were available first in Munich and then Berlin.
2015: Audi on-demand	Audi AG reports increases in revenues and unit sales since 2005 thanks to new markets opening. In 2009, the company launches the Audi Urban Future Initiative to explore innovative ideas and concepts addressing gridlock, lack of space and pollution. In 2013, Audi Business Innovation (ABI) GmbH is launched to work on innovation challenges.	Between 2014 and 2015 ABI run 4 PSS trials with their own business models and targeting different markets. Audi on Demand, launched in April 2015 in San Francisco and Munich) worked with a concierge pick up system, and it was incorporated as an offer through the dealership in selected locations in USA and Europe.
2016: VW's MOIA	The achievement of the company’s goal to become the world’s largest car manufacturer by volume in 2015 gets overshadowed with the Diesel scandal and major PR crisis that followed. Senior leadership was replaced and a new strategy, TOGETHER 2025 was released by mid-2016.	MOIA was launched in 2016 as a wholly owned subsidiary focused on shared mobility on ride hailing services (acquired and fully developed in-house). The shared tailor-made carpooling vehicles would launch in Hamburg in 2017.
2017: Ford's Chariot	Having avoided bankruptcy in 2010, and improving sales figures up to 2015, Ford Motor Company creates the Ford Smart Mobility LLC and appointing Jim Hackett as CEO in May 2017. The new company aims to design and build mobility services on its own, collaborating with start-ups and tech companies.	A vehicle pooling service known as Chariot was trialled in London in 2017, in partnership with Transport for London. A Smart Mobility Innovation Office opened in London in October 2017.
2022: Stellantis Free2move acquires ShareNow	PSA Group introduce their PSS initiative Free2move in 2016. PSA and FCA form Stellantis in 2019. A strategy is generated for the new group. BMW and Daimler merge their PSS companies into a joint venture known as ShareNow but registered as YourNow (offering a variety of mobility services).	Stellantis’ Free2move acquired ShareNow, expanding their offering of free-floating car sharing services to 21 cities and 5.4 million users.

3.1. Problems/opportunities across cases

The research focuses on OEMs whose core business is to manufacture and sell vehicles to customers. Throughout the 20 years studied it became apparent that OEMs identified challenges to the long-term sustainability of their core business, such as: a) the increases in urban population paired with the trend of major cities imposing tougher measures to control the circulation of Internal Combustion Engine (ICE) vehicles to reduce congestion and harmful emissions; b) the financial instability caused by the 2008 financial crisis; c) the increased digitalisation of mobility, marked by the emergence of competitors such as Uber, Lyft, Gett and Zipcar; and the possibility of big new players such as Google or Apple entering the world of mobility; d) the trend of younger people “preferring not to own a vehicle”.

Trends exist beyond the influence of the OEMs, but only became problems or opportunities when participants (the senior leadership members, individuals on the research departments, external consultants, or specialised research unit members) identified a potential challenge to their future business. The trends were articulated as problems, and the level of uncertainty was high: senior leaders openly stating they “did not know” what the world of future mobility would look like. Data to inform the formulation of the problem/opportunity was often collected through established research processes and mechanisms within OEMs to gain insights into these trends and reduce uncertainty. By 2016 all

major OEMs had trialled some sort of PSS in an attempt to reduce the uncertainty regarding the future of mobility. Profit was seldom mentioned in the early days: the problems/opportunities were characterised with high levels of uncertainty and solutions tended to be localised.

3.2. Participants, preferences, and goals

Due to the nature of the decision of introducing PSS for automotive companies, which affects the core business of the OEMs, the top senior management (C-suite) participated in this decision for all cases studied. CEOs, CIOs and board members are often mentioned as having taken part in the process, either as initiators, supporters or detractors. A specialised, diverse team (members tended to have backgrounds in IT, Marketing, Engineering, Policy, etc.) was created in every case analysed, often incorporating user-centred design methods and agile methodologies common to software development organisations. Given the limitations of the sources used in this research, underlying drivers/motivations are not known for most of the participants. Expressed goals are used as a proxy to understand what guided the participants and the OEM throughout the process.

For several of the decision-making processes studied, the goals were set following a strategy defined earlier in their process. A distinction can be made between the teams who had periods of time between the definition of the strategy and the formal launch of the PSS brands of more than 2 years (Daimler, BMW), and those who had instructions to launch within a year of the strategy being defined (VW MOIA, Stellantis Free2move acquisition of ShareNow). Given the limitations of the data used it is not possible to establish how those goals were established, however it is possible to organise them into four categories: a) To develop a new business model or to redefine the company, b) To respond to environmental and urban concerns, c) to attract new customers, and d) to keep up with competitors.

The majority of the goals can be labelled as 'ambiguous' as done by [Levinthal \(2012\)](#), with the extreme examples of Daimler's "To revolutionise transport" or Audi's "To rethink the automotive core business". It is worth noting that 'profit' is not mentioned as a goal for earlier initiatives, while 'revenue' and 'numbers of users' were introduced as goals when the OEMs gained more understanding of how the product service systems work.

3.3. Alternatives and solutions

The consideration of different alternatives and their consequences was conducted by teams specialised in "mobility" in all cases. These teams would identify and trial different alternatives of PSSs. The goal was to generate knowledge about desirability, feasibility, and viability, and present those back to the Senior leadership team of the Parent company in all cases. Alternatives involved either developing a PSS from scratch with time-consuming development in a very small-scale trial or acquiring a functioning PSS and expanding to new markets (usually more costly but faster). The selection of the location of trials was opportunistic in all cases: alternatives were tested first in the same city where the new team was based, sometimes with enough commercial viability to enable an expansion, and then introduced to other locations prior to negotiation with local authorities.

For some companies (Daimler, BMW, Audi) the alternatives were generated in response to a goal established by the company's new strategy. Trials were used as tools to gather more information that could facilitate the implementation of the new business units through the lens of traditional corporate criteria (profitability). For other companies (Ford, Stellantis), the alternatives had been explored, developed, and trialled before- or in parallel to- senior management defining the goal of the new PSS, so when the time for decision-making emerged, it was possible to move forward with implementation. Existing alternatives were loosely coupled with problems and implemented to quickly respond to the market opportunities. In some cases (Ford, BMW, Daimler), alternatives were explored to generate awareness among the Senior Leadership team about the need to initiate a goal-setting process for new mobility opportunities.

Capital rationing was crucial to define how many alternatives could be tested. In many cases there was no alternative chosen at one point, but rather several alternatives implemented in parallel as short-term experiments (1 year, 2 years), after which budgets were not renewed for the alternatives that did not accomplish the goal of revenue. It is safe to assume that the financial criteria, controlled by the finance function, was the ultimate decision-maker for the length of the trial and/or continuation of the PSSs.

3.4. Decision-making technology: rules and knowledge

Only two cases provided rich information about how decisions were made. Detailed evidence on which rules of decision were used is otherwise scarce, even more so when looking at how aware of such rules the actors were. Nevertheless, it was observed that all OEMs opted to create a specialised business unit to ponder the available alternatives and manage the implementation of their PSS. Most of these groups evolved to become independent business units with budgets of their own and different degrees of integration with the parent company. Evidence from Ford Smart Mobility and Audi Business Innovation, available on the published case studies in Zenodo, suggests that these units had ways of working that were considerably different from the parent companies, and decision-making rules that enabled them to have shorter and faster innovation and learning cycles. Words like "agile," "experiments," "smart" or "innovative" were often mentioned while describing these groups. In such methods decision-makers tend to be more pragmatic and act based on information from trials gathered in short cycles, focused on reducing the uncertainties; rather than extensive reports evaluating consequences of all available/conceivable alternatives, presented in large board meetings.

4. Discussion

4.1. Characterising the decision-making process across the cases

Some patterns were identified from the selected case studies, which enabled the characterisation of a generic decision-making process behind the introduction of PSSs by established automotive OEMs. Figure 3 visually represents the patterns identified, organised as interacting elements in a decision-making process (building on [Citroen, 2011](#)), which involved different teams and goals. The black arrows represent the flow of the process, whilst green arrows represent influence. The process starts with 1) The analysis of the environment, done continuously by specialised teams, usually under R&D. They are the ones monitoring trends and identifying potential problems and opportunities, as well as potential solutions. 2) Problematic trends are dealt with in strategic plans by the senior team. The resulting Strategy establishes ambiguous goals to guide the work of newly created business innovation unit specialised in "future mobility". 3) The new specialised "mobility" team identifies or creates alternatives based on viability, desirability, and feasibility hypotheses. 4) Budget constraints (defined by Finance teams) are established to limit the number of alternatives to be tested, as well as the "tolerance" for testing without clear revenue. 5) Specialised mobility teams implement and manage tests of alternatives within a timeline in an opportunistic manner, with the goal to gain information on viability, feasibility, and desirability. Senior leadership tends to be involved. Some alternatives reach the end of their test without meeting profitability and "fit with the company" criteria and are discarded. Lessons learned are recorded to inform future decisions. 6) Surviving alternatives of implemented PSSs are subject to scrutiny on viability and desirability after implementation. These can then be considered successful PSSs, but discontinuation due to failure in commercial viability is common.

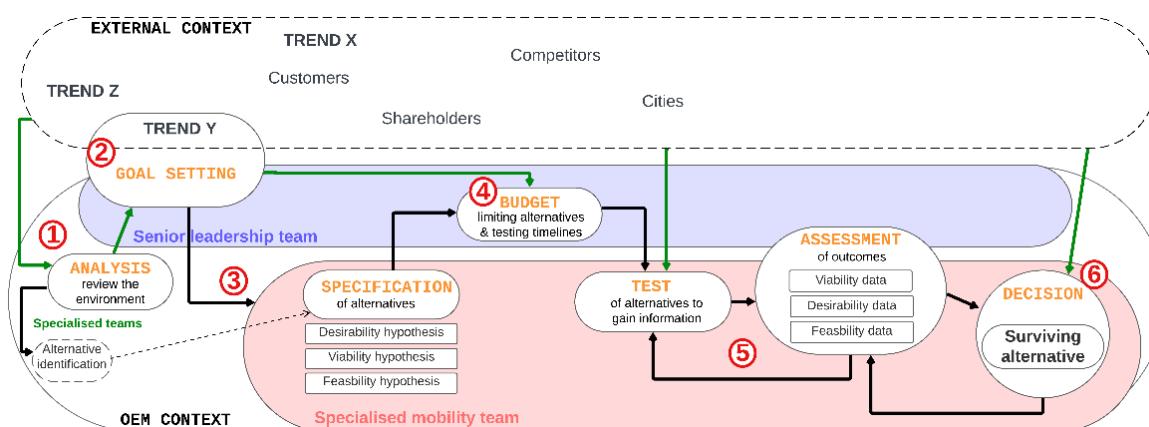


Figure 3. Characterisation of strategic decision making for the introduction of PSS by incumbent OEMs

The evidence suggests that participants perceived the process as rational. However, the ambiguity of goals, the relevance of timing for problem definition and goal setting, and the extreme uncertainty about consequences of existing and created alternatives, reveals the limits of such rationality. The decision to introduce PSSs as well as the success of mobility PSSs is highly dependent on contextual factors, including: regulations about parking, that change from city to city; consumer readiness; availability of vehicles; competition/collaboration with public transport, etc. Budget constraints imposed on the teams created a tendency for opportunistic testing, that generated data biased towards the specific context of implementation, which, in turn, had an influence on the survival of the PSSs studied.

4.2. Lessons learned

The introduction of PSS offerings by incumbent OEMs was presented by the decision-makers to pursue a business opportunity with lower environmental impact (lower congestion levels, lower emissions levels), while delivering value to their customers. The introduction of PSS implies the generation of a whole new business model as well as changes in a relationship with the customer when the ownership structure of the vehicle's changes (Williams 2007). The emergence of new players such as Zipcar and Uber based on such models, encouraged OEMs to explore these possibilities, but a critical mass of customers was not always present.

Despite OEMs mentioning goals related to lower environmental impact during the design process, alternatives were ultimately evaluated through the lens of revenue generation. Capital rationing, coupled with a shift in focus on emissions regulations (rather than on congestion) seems to be key in a decline in OEMs considering business models that require systems change, like PSS. Instead, the focus shifted to electrification of the powertrain and the development of autonomous technology: OEMs once again focused on their traditional core business model of selling cars.

All PSS initiatives were introduced following an Agile/Lean approach intending to create experiments to learn fast. But the experiments were opportunistic in location and timing. Evidence suggests that timing and context are especially important for customer adoption of these kinds of PSS. Opportunistic experiments may lead to the wrong conclusions that the model is non-viable when it just the case of it not working "then and there".

4.3. Implications for the achievement of lower environment impact in the automotive industry

Capital rationing forces R&D to focus resources. The period studied coincided with increased pressures for OEMs to also face other disruptions including Electrification, Automation and Connectivity. Most OEMs studied, opted to direct a sizeable proportion of their R&D efforts on electrification and automation, rather than changing their relationship with the consumer that would be required for shared mobility. Yet, there is an open question about how autonomous vehicles are going to be commercialised, given emerging trends focusing on robo-taxis instead of traditional sales. These robo-taxis will be shared vehicles and will therefore be part of new PSSs. It is possible that OEMs who intend to generate profitable business models for their autonomous vehicles, introduced as PSSs, will have to go back to lessons learned from these past trials and make decisions accordingly. But, as was mentioned above, opportunistic trials may produce information about alternatives that is biased towards the specific context of implementation. There is an opportunity for further research and collaboration between design teams from OEMs and academia on the design and implementation of testing new PSSs, seeking to build better experiments that can generate more robust conclusions to inform decision-making.

4.4. Limitations of this study

Conducting research on how decisions are made comes with challenges. Decision-making is an intra- and inter-personal process. Grey literature (published interviews, reports, letters to shareholders, etc.) provide some clues to that process, but the data has its limitations to show hidden goals that stakeholders may have had, or how aware of the rules of decision-making they were.

Moreover, this study identifies patterns from grey literature and proposes the influence of other factors such as global trends and policy requirements, but the confirmation of causality is beyond the scope of

this study because a different method with more comprehensive data would be needed. A trial interview to explore a change in methodology, which might address this limitation, was conducted.

5. Conclusion

The introduction of PSS initiatives by automotive OEMs in Europe in the past two decades have provided some lessons that can have real implications for future attempts of the automotive industry at producing products and services with lower environmental impact than current business models. This paper analysed six distinct case studies on product service systems initiated by incumbent automotive OEMs. The study led to the characterisation of the typical decision-making process in the initiation, design, development, and deployment of those PSSs, identifying crucial factors such as timing, context and budget constraints that had an effect on the speed in which decisions were made as well as on the possible longevity of the PSS initiative.

Incumbent automotive OEMs who have gone through this process have gained relevant knowledge that can inform future decisions in the pursuit of automotive products and services with lower environmental impact. Yet, the study of the decision-making process shows that the validity of past lessons can be questioned. The relevance of timing and context for the decision also opens the question: if the alternatives had been tested in different context or if stakeholders had other priorities, would alternatives have had better chances of viability? The implications of this question invite researchers to explore future collaborations to build better trials that can generate more robust conclusions to inform the decision-making process in futures where autonomous PSSs enter the market.

The decision-making process can be characterised as "less rational" than participants perceive it. This should not be treated as a quest for normative approaches, but rather a way of embracing the introduction of new ways of making decisions, usually following user-centric approaches, agile and lean methodologies focused on experimentation, in a context where the expected design needs to overcome high levels of uncertainty, and goals and success are ambiguous.

There is a remaining question about the role of OEMs in the future of mobility, given the evidence showing a turn back to their core business (R&D efforts focused on electrification and the development of autonomous vehicles with the aim of selling vehicles). New business model innovations with lower environmental impacts are yet to be fully explored. Learning how decisions are made and the factors influencing the outcome of the decision can help designers, managers, and decision-makers to better harness the process.

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