The Impact of Catena-X on Digital Business Models in the Automotive Industry

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Dissertation submitted in partial fulfilment of requirements for the MSc in Management, at the Universidade Católica Portuguesa, 05.04.2023

Abstract

English version

Like many other manufacturing industries, the automotive industry is also affected by the consequences of the climate crisis and is required to ensure greater sustainability. Corresponding laws and standards are continuously coming into force and require new methods of implementation. A shared network that supports standardized verification and facilitates communication among participants is the industry's answer. Promoted by the German government, the expectation is to better equip the industry for an increasingly digital, global market. The emergence of open data ecosystems such as Catena-X in the automotive industry creates new opportunities for value creation by extending existing, or creating new Business Models. Catena-X is an open data ecosystem that connects the supply chain and creates value through increased transparency, which in turn leads to sustainability in the industry. Companies that are part of the automotive supply chain can thereby profitably contribute their data, creating benefits for the entire network. The research in this thesis is based on five semi-structured interviews with experts from the German automotive industry. The responses enable the identification of current developments, including the merging of production and service as a Business Model, but also a transformation of smaller companies that are adapting to the digital age in order to benefit from the new opportunities for value creation. This study places itself in a comparatively early phase of Catena-X and shows possible paths for further research, especially with regard to sustainability, which provides a solid basis for value creation on a social, environmental, and economic level.

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Title: “The Impact of Catena-X on Digital Business Models in the Automotive Industry”

Keywords: *Business Models, Sustainability, Catena-X, Automotive Industry*

Versão portuguesa

Tal como muitas outras indústrias transformadoras, a indústria automóvel também é afectada pelo impacto da crise climática e é necessária para assegurar uma maior sustentabilidade. As leis e normas correspondentes estão continuamente a entrar em vigor e exigem novos métodos de implementação. Uma rede partilhada que apoia a verificação normalizada e facilita a comunicação entre os participantes é a resposta da indústria, também promovida pelo governo alemão, com a expectativa de melhor equipar a indústria para um mercado cada vez mais digital e global. A emergência de ecossistemas de dados abertos, como o Catena-X na indústria automóvel, cria novas oportunidades para a criação de valor, alargando os modelos de negócio existentes ou criando novos modelos de negócio. Catena-X é um ecossistema de dados aberto que liga a cadeia de fornecimento e cria valor através de uma maior transparência, o que por sua vez conduz à sustentabilidade na indústria. As empresas que fazem parte da cadeia de abastecimento automóvel podem assim contribuir de forma rentável com os seus dados e criar benefícios para toda a rede. A investigação desta tese baseia-se em cinco entrevistas semi-estruturadas com peritos da indústria automóvel alemã. As respostas permitem uma identificação dos desenvolvimentos actuais, incluindo a fusão da produção e do serviço como modelo de negócio, mas também uma transformação das empresas mais pequenas que se estão a adaptar à era digital, de modo a beneficiar das novas oportunidades de criação de valor. Este estudo está localizado numa fase relativamente precoce de Catena-X e mostra possíveis caminhos para uma maior investigação, especialmente no que diz respeito à sustentabilidade, que fornece uma base sólida para a criação de valor a nível social, ecológico e económico.

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Título: "O Impacto da Catena-X nos Modelos de Negócios Digitais na Indústria Automóvel"
Palavras-chave: *Modelos de Negócio, Sustentabilidade, Catena-X, Indústria Automóvel*

Acknowledgments

The author is grateful for the support of supervisors Cláudia Antunes Marante and Professor René Bohnsack. Furthermore, high appreciation goes to Mrs. Ute Burkhardt, Mr. Ralf Neubauer, Dr. Jürgen Padberg, Mr. Patrick Strauß and Mr. Peter Weichsel, for their great support in the research by participating in the interviews.

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CO_2 – Carbon Dioxide

EU – European Union

EV – Electric Vehicle

IoT – Internet of Things

IT – Information Technology

SDGs – Sustainable Development Goals

WCED – World Commission on Environment and Development

1. Introduction

The automotive industry is in the midst of an unprecedented transformation that is leaving hardly any area untouched. Starting with new drive concepts, which seem inevitable due to political pressure with regard to climate change. For reference, the European Environment Agency found in 2019 that transport is responsible for around a quarter of CO_2 emissions in the EU. More than two-thirds of these were generated by road transport (European Parliament, 2019). New requirements and regulations on environmental protection are gradually coming into force, leading to a rethink within the industry. Manufacturers are gradually expanding their product portfolios to include electrically powered vehicles, which, unlike internal combustion engines, emit no CO_2 while driving. Beyond driving, the production of cars also does not contribute positively to the climate (German Environment Agency, 2022). Rare raw materials are mined from remote locations under extremely poor working conditions, only to be transported long distances, toxic substances are released when batteries are disposed of, and the energy needed to produce the vehicles is not necessarily renewable. According to the Federal Environment Agency, these ecological threats also lead to negative social impacts, for example through contamination of drinking water. The German automotive industry is aware of these problems and has long recognized the importance of sustainability. Manufacturers are responding both on an individual level and collectively. In 2021, Catena-X was founded by the largest German automakers such as BMW and Mercedes-Benz and German companies from other sectors such as consulting or chemical that have a stake in the automotive industry (Catena-X, 2023c). The goal is to unite all participants of the automotive value chain through an open data ecosystem and to create a data space that is characterized by transparency and standardization and can contribute significantly to a more sustainable production. Sustainability in this work is significantly determined by the following three components, social, environmental and economic (Elkington, 1997). His concept seems is highly respected in both research and practice and offers the most profound basis for value creation. Beyond sustainability, such an ecosystem can also offer potential for new business models. The concept of business models is primarily based on mechanisms for value creation and its capture (Teece, 2010). With the input of data by all participants along the value chain, there is great interest in the opportunities that this data can offer. The central question of this thesis deals with exactly how Catena-X, as an open, decentralized data ecosystem, enables potential for new, predominantly digital, Business Models. For this purpose, experts who are directly or indirectly

related to Catena-X will be interviewed. First, the necessary concepts of Business Models, sustainability, value creation in the context of data, and the characteristics of the automotive industry are explained in the theoretical part. In the practical part, the results of the five semi-structured interviews are presented and interpreted in the discussion part. Subsequently, this work points out new avenues for future research on the topic of Business Models and data ecosystems and then outlines approaches for practitioners to consider.

2. Theoretical Background

In this theoretical part, sustainability as such and sustainability in the business context will be examined. Furthermore, digital business models are the main focus of this research, accordingly, their importance is discussed, as the possibilities for value creation and the connection between value creation and data. The last part of this section discusses the current developments in the automotive industry with a focus on Europe and provides information about the data ecosystem Catena-X and its structure.

2.1 Sustainability

The concept of sustainability is nothing new to humankind. In fact, the term has been around for over two centuries (Geissdoerfer et al., 2017). Today, with the rise of climate change, sustainability is becoming omnipresent and likely indispensable in modern business affairs. Both practitioners and researchers have examined the true meaning of the term and its impact on society, economics, and the environment. Although over the years researchers have come up with a great number of definitions it seems that the following approach has found high acceptance across the board.

The "Brundtland Report" (United Nations, 1987) was published by the World Commission on Environment and Development (WCED) which is appointed by the United Nations (Martins and Pato, 2019). They defined sustainability as the

> "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (United Nations, 1987).

At that time, establishing such a definition on a global stage may have risen awareness in society, however, it does not define measures to act accordingly as an individual or a business. 30 years later, the public attitude seems to have changed. Businesses are progressively regarded as responsible for the environmental, social, and economic impact that their internal and supplier operations are causing (Hartmann and Moeller, 2014). Bansal (2005) has found similar developments regarding a firm's increasing commitment to sustainability and identified two perspectives on the subject, resource-based and institutional. The first aspect argues that a firm's performance is enhanced through the accumulation of valuable resources and capabilities (Barney, 1991). The second one states that firms often change to receive social approval (Meyer and Rowan, 1977). As the above-mentioned WCED's definition is rather universal, the concept of the "triple bottom line" (Elkington, 1997) has gained prevalence from a business point of view. His proposal is based on a 3P designation for people, the planet, and profits. The first bottom line is about the incumbent firm's social responsibility, the second bottom line refers to the firm's environmental impact and the last bottom line is about the financial profit or loss of a firm. The three bottom lines are based on the principles of social equity, environmental integrity, and economic prosperity (Elkington, 1997). Together these three principles are a more comprehensive approach to sustainable business (Martins and Pato, 2019), however, singularly they merely pose a necessary but not sufficient condition to sustainable business (Bansal, 2005).

2.1.1 Sustainable Business

The 17 "Sustainable Development Goals" (SDGs) are at the core of the United Nations' "2030 Agenda for Sustainable Development", which is in place since 2015. These Goals describe the foundation for a better planet regarding improved health and education, less poverty, and more equality (United Nations, 2022). In acknowledging and pursuing the SDGs, companies can contribute to more sustainable global development. It has already been established that businesses are increasingly adopting sustainability practices into their operations, driven by a range of motives including regulatory requirements, stakeholder pressures, and the potential for economic gains (Hartmann and Moeller, 2014; Bansal, 2005). Indeed, not having a reputation for sustainability could lead to significant operational risk for the company (Murray 2013). The "triple bottom line" (Elkington, 1997) encompassing planet, people, and profit has been acknowledged as a fundamental principle for establishing a competitive edge in the marketplace (Schulz and Flanigan, 2016). Therefore, it is crucial for companies to incorporate sustainability into their operational and marketing strategies for achieving success (Förstl et al. 2015). Engaging in sustainable behavior has the potential to enhance firms' profits by boosting revenue

and employee productivity, as well as decreasing expenses related to energy, water, waste, and other materials (Willard, 2012). Beyond that, he claims that it can also help reduce turnover rates and minimize strategic and operational risks.

Tackling the challenges associated with sustainable business, the new approach is based on the concept of "circular economy" (Lukin et al., 2022). In a business context that means incorporating this concept into the strategy and thus reducing the negative effects of production on the environment. Geissendörfer et al. (2017) have thoroughly examined the meaning of the circular economy and based on the existing research body and defined it

> "*as a regenerative system in which resource input and waste, emission and energy leakage are minimized by slowing, closing and narrowing material and energy loops*" (Geissendörfer et al. 2017).

Now that the importance of sustainability in business has been established (Förstl et al. 2015), the next step is to identify the challenges involved.

2.1.2 Challenges of implementing Sustainability

Firms that are in the process of implementing sustainability into their strategy are facing the challenge of finding the right balance between the three aspects of sustainability, that are *social*, *ecological*, and *economic* (Mota et al., 2015) Unlike innovation, which aims to create new products and processes that can ultimately increase profits in the long run, sustainability goals are more multifaceted, as managers are expected to meet social, environmental, and financial objectives simultaneously. Being intangible, measuring the social and environmental impact of such actions presents more significant difficulties compared to measuring financial performance (Epstein and Buhovac., 2010).

Research has provided evidence that an increasing number of companies are adopting the triple bottom line approach to performance evaluation (Svensson and Wagner, 2015). As a result, numerous indexes and frameworks have been developed to measure the sustainability performance of both private and public organizations (Nyberg, 2017). One example for such measurements is the *Global Reporting Initiative index* (Adams et al., 2014).

Further, academic literature has emphasized the importance of developing a strong and integrated framework for successful sustainability assessment (Correia, 2019). For instance, an "Integrated Sustainability Assessment" can be established to define and evaluate the relationships between the three dimensions of the triple bottom line. Such an approach has the

potential to help enhance interactive outcomes while considering the constraints faced by organizations (Farsi et al. 2017). They define sustainability assessment as

> *"a process to identify and evaluate the effects of possible initiatives on sustainability"* (Farsi et al., 2017).

As such, sustainability assessment can be an essential tool for organizations that are considering innovating their business models while remaining dedicated to their commitment to sustainability.

2.2 Business Models

2.2.1 Definition and Concept of Business Models

The advent of the internet brought about digitalization, resulting in traditional products and services being provided through online platforms with increased levels of customer satisfaction and reduced costs (Collis, 2021). As a result of this advancement, new companies with novel business concepts emerged, including prominent corporations such as Apple, Microsoft, Amazon, Alphabet, and Facebook. Today they make up some of the most valuable companies in terms of market capitalization (Menz et al. 2021). Although product innovation, especially in the case of Apple with the launch of innovative products such as the iPhone or iPad might have contributed to a large extent to their success, Business Model Innovation played a critical role as well (Sorescu, 2017).

As opposed to Sustainability, the concept of Business Models is fairly young in research terms as it gained attention through the extensive introduction of the internet in the 1990s (Menz et al. 2021). Scholars started using this very concept as "a holistic description of a firm's key business processes and how they are linked (Zott et al., 2011)." Especially in the early 2000s, scholars have attempted numerous times to define the term Business Model (Table 1). Most recent definition approaches circle around three key aspects which are a firm's value creation, value delivery, and value appropriation (Sorescu, 2017). Similar observations were made by Foss and Saebi (2017) who claim that many scholars refer to the definition of a Business Model as a firm's

> "*design or architecture of the value creation, delivery, and capture mechanisms*" (Teece, 2010).

Firstly, value creation describes how resources and processes are applied for developing and manufacturing products and services. Secondly, value delivery is about the environment of these products and services. Finally, value appropriation concerns the cost and revenue functions of the incumbent firm (Sorescu, 2017). Alternative definitions can be found in Table 1, "*Definitions of the Business Model*".

Table 1. Definitions of the Business Model

Author/s	Definition
Shafer et al. (2005)	*"Representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network."*
Teece (2010)	*"Design or architecture of the value creation, delivery, and capture mechanisms."*
Casadesus-Masanell & Ricart (2010)	*"Business Model refers to the logic of the firm, the way it operates and how it creates value for its stakeholders."*
Osterwalder & Pigneur (2010)	*"A business model describes the rationale of how an organization creates, delivers, and captures value."*
Zott & Amit (2011)	*"A business model can be viewed as a template of how a firm conducts business, how it delivers value to stakeholders (…) and how it links factor and product markets."*

As a logical consequence of the expanding research on business models, the research body of business model innovation soon began to grow as well (Foss and Saebi, 2017).

This effective and efficient form of innovation (Wirtz et al., 2016) is a firm's approach to managing a dynamic market and competitive business environment and adapting accordingly with the overarching goal of economic success (Kastalli and van Looy, 2013). It is considered a complement to conventional forms of innovation such as process, product, and organizational innovation (Zott et al., 2011). Business model innovation can include both the refining of a present business model or the implementation of an entirely new one into a firm's business (Massa and Tucci, 2014). As the urgency of sustainable development in society grows, research

on sustainability becomes increasingly important as well (Bansal, 2019). The concept of sustainable business models is thus continuously evolving, leading to research results, that are yet preliminary (Li et al., 2023).

In short, the process of business model innovation can be described as an adjustment or refinement of the aforementioned three elements which are value creation, value delivery, and value appropriation with the aim of "significant change to the firm's value proposition" (Sorescu, 2017).

2.2.2 Data and Digital Business Models

The key difference between a business model and a digital business model is the transformation of physical objects, processes, and other content into predominantly or completely digital formats (Trischler and Li-Ying, 2023). Through digitalization, businesses and society foster the rapid extension of available data, which seems to have the potential for adopting and developing new, digital business models (Aangaard, 2019). The data created in this process is referred to as "big data", a prevailing topic of high significance to scholars, who have recently examined the organizational impact of big data predominantly in terms of value creation (Kaiser et al. 2021). Big data offers as yet untapped potential for companies to achieve and maintain a competitive advantage (Wiener et al., 2020). Despite the high interest in the concept of big data, definitions differ and thus pose a threat to a structured evolution of its true meaning (DeMauro et al. 2015). For that reason, they have compared the contemporary definition approaches with the aim to find a viable one, based on key similarities, resulting in the following definition:

> "*Big data represents the information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value*" (DeMauro et al. 2015).

This description of big data refers to its characteristics as such and its potential to create value. However, value creation is not necessarily and exclusively limited to a financial value, thus the monetization of a Business Model (Zott and Amit, 2011). As described above it includes economic, social, and environmental aspects (Elkington, 1997). Sustainable Business Models take into account the aforementioned triple bottom line approach and extend the Business Model by including stakeholder interests from society and the environment in line with financial interests (Bocken et al. 2014). Beyond that, the utilization of data holds potential for practical value as well. In the case of supply chain activities, it can contribute to higher

resilience through standardized data and real-time access to information (Catena-X, 2023a). As more business models emerge that attempt monetizing data, it seems the value of big data is of high interest (Coyle and Manly, 2022). However, converting these large amounts of unspecified data successfully into an actual value is yet to be further examined by scholars and practitioners (Günther et al. 2017).

Although building a digitally enabled business seems lucrative, it is believed to be associated with certain disadvantages, very similar to the characteristics of unattractive industries (Porter, 1980). These are lower entry barriers for competitors, higher buyer and supplier power, and finally more substitutes given the assumption that new business models may disrupt the old. The initiative of digitalizing a business or a business model on the other hand appears to potentially create higher customer retention, enables winner-take-all scenarios, and supports building a sustainable competitive advantage (Menz et al. 2021). With new technologies occurring, there is room for more insights on this.

2.2.3 Emergent Technologies

According to Kiel et al. (2016), the internet of things, or short "IoT", is part of these latest developments and connects intelligent devices which are reflected in digital business models as well. They further claim that IoT can provide key leverage and relevant data for developing digital business models, thus the interconnection between data and the internet of things becomes even more evident. Defining the internet of things in the context of digital business models, which are at the core of this paper, appears most reasonable. The International Telecommunications Union defines IoT as

> "*a global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies*" (ITU, 2012).

This approach describes the value creation ability of servicing and fulfilling specific tasks by connecting physical and virtual objects with little or no human interaction at all (ITU, 2012). With current advancements in the development of artificial intelligence, machine learning, and natural language processing, the interest in the practical and theoretical implications of IoT is seemingly growing (Ghaffar et al., 2021). In a report, McKinsey Global Institute (2015) estimated the financial impact of IoT to be between $3.9 trillion to $11.1 trillion a year by 2025 (Manyika, 2015). Six years later, McKinsey (2021) has concluded that the IoT market has not

met the growth expectations. They have identified obstacles such as change management, cost, and cybersecurity. In their latest report, "*IoT value set to accelerate through 2030: Where and how to capture it*", new estimates range between $5.5 trillion to $12.6 trillion in global value by 2030, which includes the value obtained by consumers and customers of IoT products and services (Chui et al., 2021).

Artificial intelligence is considered among the main drivers of economic development (Samoili et al. 2020) and should hence not go unmentioned when discussing future digital business models. As there is no common definition of intelligence itself and different approaches how to quantify it, defining artificial intelligence seems demanding (Warner, 2001). However, the research body of artificial intelligence provides numerous attempts which often share four similarities, these are the perception of the environment, information processing, decision-making, and achieving specific goals (Samoili et al. 2020). As artificial intelligence is only a concomitant in this dissertation, a simplified definition as provided by the European Commission (2018) is sufficient to explain its general concept.

Their understanding of artificial intelligence denotes systems that demonstrate intelligent behavior through the analysis of their surroundings and act by achieving particular goals while maintaining a certain level of autonomy (European Commission, 2018).

Within the automotive industry, there are many use cases of artificial intelligence already in place or being introduced. The application of this technology enables analyzing road conditions using multiple sensors integrated into the vehicle with the goal of higher road safety; in automotive manufacturing, the combination of IoT and artificial intelligence allows for manufacturing process optimization; probably the most prominent and complex use case right now is using artificial intelligence alongside other technologies for operating autonomous vehicles in road traffic (Singhal et al. 2022). In addition to that, data storage is critical for big data applications in smart manufacturing. As the manufacturing industry increasingly benefits from the use of Big Data, it is important to store it in file systems or data spaces (Cui et al., 2020).

2.2.4 Digital Ecosystems

Digital Ecosystems go beyond the ability of data storage and provide more possibilities (Cui et al., 2020). As Catena-X is a digital ecosystem for the automotive industry. When looking into Catena-X, it turned out that there is virtually no research on this topic yet. This is the key motivation for this dissertation, to make an initial contribution to this topic. Recently, the effects of the COVID-19 pandemic have emphasized the need for digital interactions in the future and

even strengthened the interest in the adoption of digital-ecosystem business models (Dietz et al., 2020). The value-generation potential of such ecosystems, which are for instance growing the core business, expanding the network, or generating new revenue streams, has caused global organizations to consider the ecosystem Business Model (Dietz et al., 2020). So-called "*platform-ecosystems*" are becoming more predominant due to the associated network effects and switching costs of digital economy products (Menz et al., 2021).

Li et al. (2023) found that especially for manufacturing companies, digital platform ecosystems have developed into a great foundation for shifting to innovation. They further claim that five characteristics of digital platform ecosystems positively impact five elements of sustainable business models. Their focus was on manufacturing companies, which are in the process of sustainable transformation.

Nischak et al., (2017) have conducted a thorough literature review on digital ecosystems with the aim of finding a universal definition. They further state the ecosystem concept originates from the biological research body and has found its way into the information system context. According to the authors, it is based on three key pillars. First, a heterogeneous and flexible member base (Yoo et al., 2010). Second, connections between participants through virtually co-opetitive relationships (Yoo et al. 2012). And third, a combination of digital and non-digital resources in order to fulfill individual (survival-) tasks (Tilson, 2010). These three key components materialize to the following definition of digital business ecosystems:

> "*A digital business ecosystem is a flexible combination of heterogeneous actors, interacting co- opetitively by fundamentally drawing on a shared set of digital resources in conjunction with non-digital resources driven by the underlying perception that engaging in joint value creation increases individual chances of survival and growth*" (Nischak et al., 2017).

This definition is based on a large number of contributions within ecosystem research and therefore provides a good understanding for this literature review. A more recent approach simplifies the meaning of the digital ecosystem and outlines it as a system that provides mutual benefits by connecting several, usually independent asset providers and consumers (Koch et al., 2022).To provide a more practical example, they claim that a typical activity within digital ecosystems is the exchange of assets over a digital platform between a broker and a consumer. To align this approach with the characteristics of the automotive industry, it can be further adapted to describe digital automotive ecosystems (Kaiser et al., 2021). In this case, the

participants are represented by manufacturers, data intermediaries, or data service providers. Through leveraging resources such as data and infrastructure and by providing and consuming data, they participate in value exchanges.

Beyond that, the automotive ecosystem expands through vehicles, drivers, and other road users. As vehicles become more digital, they offer space for new types of data-driven services and therefore enable new players from outside the industry to become part of a generally inaccessible ecosystem (Athanasopoulou, Bouwman, Nikayin, & de Reuver, 2016).

2.3 Automotive Industry

2.3.1 Current Developments

As part of the EU's "Fit for 55" program, which pursues to reduce net greenhouse emissions by at least 55% until 2030, the European Parliament is planning to prohibit car manufacturers from selling vehicles with an internal combustion engine within the EU from 2035 onwards (German Government, 2022). Road transport is causing a significant number of emissions and through this ban, electric vehicles (EVs) shall replace diesel and gasoline-powered vehicles in the long run and thus reduce the overall carbon footprint. German automakers as well as their competition around the globe have acted accordingly and are well within the process of electrifying their portfolio of vehicles (Del Pero et al., 2018).

Still, producing electric cars is not necessarily better for the environment. In operation, they consume a lot of electricity, which is often not generated from renewable energy sources (Karczewski et al., 2019). The COVID-19 pandemic has further contributed to the turbulent situation within the automotive industry, after sales had gone down another fundamental issue has arisen. Though the demand for vehicles has stabilized, car manufacturers are struggling with a severe semiconductor shortage, resulting in closed production lines and reductions in product diversity (Burkacky et al., 2022).

As a reaction, the automotive industry is optimizing its manufacturing processes to reduce energy consumption and waste generation for instance. By using environmental management systems, firms can not only obtain a reduction of the aforementioned but also enhance customer relations and market acceptance (Martín-Peña et al. 2014). Once a car is built it can be shipped to virtually any place in the world, which again requires significant energy input. For that reason, BMW and Daimler are switching to rail transport and electric trucks to get vehicles from the factory to the dealerships (BMW Group, 2017).

2.3.2 Digital Transformation in the Automotive Industry

Apart from the challenges associated with sustainability and production, yet another fundamental development is shaking up the entire industry; the effects of digital transformation are ubiquitous across most industries (Iansiti and Lakhani, 2014). Unlocking the full potential economic value of consumer data is not only expected to impact current Business Models in the industry but might as well open up new consumer service markets (Hemphill et al., 2022). For decades, car manufacturers have built physical products, and their strategy was formulated accordingly. Nowadays, with the sheer amounts of data generated by connected vehicles, companies are turning from manufacturing businesses to digital ones (Pop, 2020).

Servitization

The business model based on simply selling a tangible asset, in this case a vehicle, is being overhauled (Wells, 2013). Nowadays, consumer interaction is a central element and value creation results from intangible services such as specialized skills, knowledge, and processes (Coreynen, Matthyssens, & Van Bockhaven, 2017). This shift is often referred to as "servitization" and demands developing business models which leverage new technologies to effectively provide "customer knowledge-based services" that cover the whole lifespan of the manufacturing process (Bustinza et al., 2018).

Confirming this view, new technologies enable progressive digitalization throughout all industries, facilitating new services and innovative business models (Gallouj, Weber, Stare, & Rubalcaba, 2015). As car manufacturers are shifting towards becoming mobility service providers, Genzlinger et al. (2020), have examined the opportunities and challenges involved in creating and capturing value associated with the "servitization" process.

Sustainability in the Automotive Industry

As a reaction to environmental concerns, firms within the automotive industry are in the process of redefining their strategies and operations by integrating the concept of sustainability (Lukin et al., 2022). As concrete measures, the authors have identified an expansion of the product portfolio through environmentally friendly cars, and the installation of sustainability requirements for business partners along the supply chain with the goal of minimizing negative effects on the environment. Finally, with regard to production, automotive brands are reducing resource consumption in the production process and are switching to renewable power supplies.

The digital transformation also provides a foundation for moving away from traditional production systems to intelligent data-based systems, resulting in higher quality and increased productivity. As competitive pressure in the automotive industry is high, managers are incorporating "Industry 4.0" into their strategy for digitalizing their production systems accordingly. Such systems are capable of optimal decision-making and communicating for instance (Pop, 2020).

It seems parts of the industry do acknowledge the value of sustainable business practices. Lukin et al. (2022) concluded that the observed set of automotive manufacturers meets at least 12 of the 17 United Nations Social Development Goals.

The most commonly fulfilled goal in the automotive industry is SDG 8 "Decent work and economic growth" (Lenort et al., 2023). They identified a relationship between these results with the fact that over half of the examined participants originate from developed European economies. Companies operating in economically less developed areas, show significant differences in comparison.

To conclude, the research body on the automotive industry suggests that digitalization affects the industry in two fundamental ways. First, firms are acknowledging sustainability as essential and adapting their Business Models accordingly (Lukin et al., 2022). Consequently, this affects both the production in becoming more eco-friendly as the vehicles themselves, caused by the electrification of powertrains. Second, in the course of "servitization" car manufacturers are moving away from solely producing cars to becoming mobility providers (Coreynen, Matthyssens, & Van Bockhaven, 2017). Business models are refined in order to utilize the data from connected cars and eventually create value from them.

2.3.3 The Concept of Catena-X

On the 7th of May 2021, the BMW AG, Mercedes-Benz AG, Deutsche Telekom AG, Siemens AG and SAP SE and more relevant companies within the European automotive industry, have founded the "Catena-X Automotive Network e.V." (Catena-X, 2023a). The abbreviation "e.V." is German and stands for "eingetragener Verein", which means registered association in English. In January 2023, the members of the association founded an operating company, called "Cofinity-X" which is in charge of the onboarding process carbon footprint calculation for example (Cofinity-X, 2023).

The founders describe Catena-X as a collaborative and open data ecosystem with the goal of a uniform standard for global data and information exchange along the entire automotive value chain. Data sovereignty is at the core of this concept. Desired outcomes of the initiative are

benefits such as higher competitiveness, more efficient collaborations, and faster business processes in the automotive industry (ISTOS, 2021; Mercedes-Benz Group AG, 2021). Moreover, Catena-X shall contribute to sustainability by offering higher transparency regarding CO_2 emissions through digital twins of vehicle components for example. Currently, companies calculate their carbon footprint in their own, unique ways leading to different outcomes. Standardized measurement methods as defined in the "Catena-X Product Carbon Footprint Rulebook" are supposed to tackle that issue and enable real CO_2 data comparisons between the participants of this open data ecosystem (Catena-X, 2023b).

At the 2021 "Digital Mobility Conference", Oliver Ganser, Chairman of the Catena-X e.V. Board, states that new value chains are going to replace or add existing peer-to-peer networks for cocreating a foundation for new methods of value creation based on use cases rather than monetization. Further, this open ecosystem is being designed in a way that small and medium-sized businesses can easily participate as well.

Figure 1 shows how activities within the Catena-X network are organized. The Association itself acts as a foundation, composed of all member companies and organizations. Respective activities include standardization, certification, neutral data space governance, and finally transfer and activation. The Development Area includes the early-stage members, referred to as the "Kick-Starters", software developers, and service providers, which collectively oversee developing applications and services for the Data Space. The operating area, including the data space manages member onboarding as well as value creation.

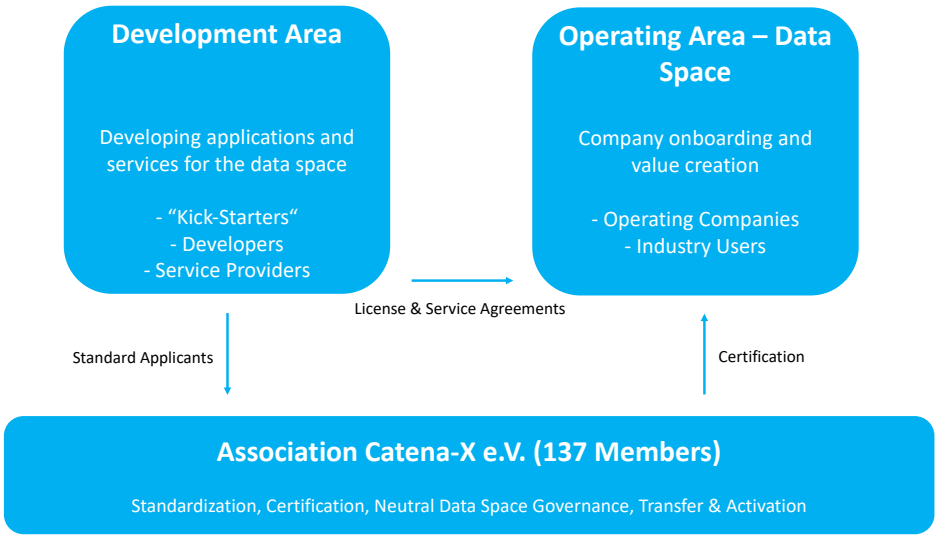

Figure 1. Activity Organization of Catena-X (Based on Catena-X, 2023c)

In the case of Catena-X, the participants have agreed upon the International Data Spaces standard for data sovereignty as an essential infrastructure foundation in practical use cases (Mercedes-Benz Group AG, 2021). The association has defined five application areas for enhancing productivity and strengthening sustainability along the automotive value chains. Pilot projects are focusing on quality management, logistics, maintenance, supply chain management, and sustainability, all supported by a networked data infrastructure. This network will be designed in a way, that participating companies benefit from new opportunities the digital transformation has to offer. As mentioned before, data sovereignty is at the core of Catena-X. However, the success of this open data space is dependent on highly sensitive data inputs from all participants, it is crucial that all data is protected and is not going to be used for unintended purposes.

Data sovereignty can be described as a form of control, ownership, or alternative interests in data. Predominantly, the concept is of high interest in IT architecture and legislation concerning the processing of such data (Hummel et al., 2021). A thorough review of the existing research body further concludes that data sovereignty usually refers to control and power over data. A decade ago, DeFilippi and McCarthy (2012) have already uttered concerns over data privacy in the subject of cloud computing, which has similarities with a data ecosystem, where users give away their data and consequently lose control over it to the cloud providers. Back then, lawmakers were expected to actively protect the users and their personal data. Consequently, in 2018, the European Union acted and introduced the “General Data Protection Regulation” (GDPR), which is designed to enforce legal obligations for organizations that target or collect data from people within the EU (Proton AG, 2020).

3. Methodology

This study aims to investigate the impact of Catena-X on Business Models within the automotive industry. For this purpose, a qualitative approach is taken and semi-structured interviews are conducted with experts from the industry. Semi-structured interviews fall between predetermined questionnaires and open conversations and thus offer a predefined structure in which follow-up questions about unanticipated or particularly significant statements are possible (Blandford, 2013). Such a qualitative approach is suitable for descriptions, interpretations, and precise explanations (Lee, 1999). The goal is to gather information that is as accurate and substantive as possible.

Sample

The selection process of participants for this survey is based on their expertise regarding Catena-X. Inquiries were sent exclusively to candidates who are directly or indirectly related to this topic. This concerns in the case of this specific study, representatives of two automotive manufacturers and consultants with several years of experience in the automotive industry. These different perspectives allow for a diversified and holistic answer to the question. Fortunately, one female candidate in this otherwise male-dominated domain also agreed to participate. This and the different professional backgrounds of the interviewees, positively contribute to diversity and heterogeneity, which can generally increase the applicability of the results. Nevertheless, the claimed degree of applicability should always be viewed with a certain level of caution. Researchers in the field also note that not heterogeneity but homogeneity can lead to generalizability and replicability (Möller et al., 2022). Generalizability is often hastily stated because many researchers do not pay enough attention to certain variables such as stimuli, tasks, or scientific sources (Yarkoni, 2022). The risk of disregarding such effects can lead to strong deviations, but in the specific context of this study, it can be considered low, as the questions do not aim at absolute answers. The study is designed to be rather open-ended, allowing a glimpse into future developments within the industry related to Catena-X. Generously, the five participants in the study agreed to disclose names and companies, which positively underpins the authenticity of the results. The risk of not being able to speak openly can also be considered low, as the study does not target sensitive data from the companies.

Data Collection

After agreeing to participate in the questionnaire, the candidates were contacted by video call in four out of five cases. In one case, it was a simple phone call. This enables a more personal culture of conversation and creates a basis of trust on which it is easier to go into depth about the content. Facial expressions additionally helped to better emotionally classify what is said. On average, the interviews lasted 40 to 50 minutes and were only recorded after obtaining the consent of the interviewees. The interviews were based on a set consisting of 16 questions that tended to be open-ended; follow-up questions were asked individually according to the conversation. The core topics of the protocol are Business Models related to data and sustainability in the automotive industry, and how Catena-X can influence these subjects. To be in line with the core theme of this paper, the questions are phrased more in terms of the future, for example, current developments in the industry, and less on the past. Catena-X is a

particularly new topic for the automotive industry, and it is necessary to work with assessments of the current situation and selectively with forecasts, as the data situation is accordingly sparse.

Data Analysis

After the recordings were thoroughly reviewed and manually transcribed, they were bundled into tabular form and divided according to the following four categories. *Business Models, Data Ecosystems, Competition,* and *Sustainability*. This division stems from the focus of the research question and helps to facilitate the convergence of high-quality results. The next step was to then filter the responses according to relevance in relation to the four categories. A particularly careful manual review of the results ensured that only the scientifically significant content was included in this paper. Since not all responses could always be assigned to a single category and in specific cases there was overlap, further manual separation was necessary. Once a sound representation of the research findings was achieved, the next step was to identify commonalities and differences in the responses. A certain variance in terms of content can be justified by the fact that the selection of respondents is characterized by heterogeneity and that, accordingly, there are different levels of expertise in different focus areas.

4. Findings

The results show that the interviewees on an individual basis, as well as the companies they are working for, are concerned with this research topic's focal points. It becomes particularly noticeable by the fact that in addition to their subject-specific, theoretical knowledge, many practical examples from the industry are also mentioned. This helps to make industry-specific processes more tangible and to be able to better classify them. In the presentation of the results, special attention is paid to the similarities within the statements and examples that the interviewees perceive from different perspectives. Thus, a certain degree of validity can be underlined. These similarities were further analyzed in an effort to reveal potential patterns or dynamics in the industry.

Business Models

Current Business Models in the automotive industry

The first part of this section focuses on business models that currently exist in the industry or are in the process of being developed. The second part then discusses how a data ecosystem can be used to create opportunities to develop new models or enhance existing ones.

When asked about current business models, the answers vary. On the one hand, car manufacturers are increasingly offering alternative services beyond the traditional sale of cars. These include, for example, mobility services such as car-sharing, but also rental and subscription models for vehicles, right through to online trading of new and used cars (Peter Weichsel). This expansion of the core product to include such services creates a certain fusion of processes. In addition, more functions within the car are offered as add-on options, such as heated seats (Patrick Strauß). Data is also a key element in the development of automotive business models; the networking of vehicles means that they collect a lot of data, for example on traffic conditions or on the vehicle itself. Catena-X can help to make better use of this data in the future (Dr. Jürgen Padberg).

Benefits through Catena-X

In the question of how Catena-X can contribute to the formation and further development of business models, then this is on the one hand the extension of previous ranges, currently not all parts of the supply chain are networked with each other. A lot of data is already being collected, but it is only through Catena-X that it can be used profitably (Patrick Strauß). You can think of the construct as a kind of decentralized platform that offers new opportunities for exchange (Dr. Jürgen Padberg). Here, the focus is primarily on trust, as the basis for a credulous exchange of data among specific participants. Everyone can individually determine which participant has access to which data, so that data sovereignty is guaranteed. This creates transparency, which is also a key element of the initiative, that it is less arbitrary and more targeted. This transparency also relates to supply structures and availability within the supply chain, giving automakers a better overview of available capacities. One possible consequence of this would be more flexible supplier contracts, which in the future could potentially also offer scope for manufacturing as a service, i.e. production on demand, so that certain parts can be ordered at shorter notice with the option of individual adaptation (Ute Burkhardt).

Disruption

Creating and changing business models is mostly about associated value creation. Respondents agree that Catena-X will provide new opportunities for value creation, through circular economies for example. In this scenario, recycling of certain parts would also be financially worthwhile, but for this, multi-level data exchange is elementary, which is precisely made possible by this network (Patrick Strauß). Battery production is currently increasing enormously due to the electrification of drives; with the help of a functioning circular economy, disposal could then be made profitable (Dr. Jürgen Padberg). Not all the interviewees see a direct disruption through Catena-X. It depends on what the involved parties do with it, depending on what value the companies involved derive from the new possibilities. In the automotive industry, supply structures are outdated and hardened; these need to be softened, or disrupted. Only then can a holistic transformation be implemented (Ute Burkhardt).

The value of data

Digitization in the industry creates a lot of data the potential of which is not always fully exploited. Both the Catena-X association and the companies themselves are involved in the use of this data. The interest in earning money with it today is great, but in reality, the question must be asked, what opportunities will arise with it in the future, through which monetization will then be possible (Ralf Neubauer). A great added value, which also affects already existing business models, is the increase in efficiency that is promoted by agreeing on a standard within the network (Dr. Jürgen Padberg). A new feature is the ability to standardize processes, which means they only have to be defined and implemented once. An example of this is a supplier who has to manually provide proof of carbon footprint for several customers and now only has to do this once. While data is a central element of Catena-X, it is not because it is simply stored there, but because it creates a platform for profitable transactions (Peter Weichsel). Central to this is the bilateral transfer of data according to the principle of "one up, one down", which describes an even exchange between the two sides (Ute Burkhardt).

Monetization

Catena-X is still in a very early phase and currently, the goal is to tend to short-term benefits, so more aspirants can be attracted. Monetization would then come in the next step, but is not the goal of Catena-X. For data-based, financial value creation, asymmetrical data exchange is more conceivable. This means that one party gives data and the other pays for it. Currently,

however, the principle is "*you share - we share*" (Dr. Jürgen Padberg), meaning a party gives their data to the dataspace and in total this results in advantages for the entire network. Suppliers positioned at the lower end of the supply chain usually have more data to share than manufacturers at the upper end of the chain. Through this discrepancy, there could be potential for financial compensation. Smaller companies in particular can benefit by making their data available to the ecosystem in exchange for payment (Ute Burkhardt). Added value is generated primarily through use cases by providing an open platform that enables users to implement practical use cases. Investments flow into the development of services that support specific use cases and, because they are open source, are accessible to everyone. How value is thereby created is then at the discretion of the user himself (Peter Weichsel). In the future, Cofinity-X, the operating company of Catena-X, will be responsible, for example, for the licensing and distribution of this open-source software.

Consulting

Management consultancies are also involved in the development process and some of them are part of the association as well. On the one hand, they can support the development of the data ecosystem, but also later in the ongoing process, there are opportunities for new business. This mainly concerns technology and its application, Ralf Neubauer assumes. The network is based on common applications such as Python, but the conceptual part of the decentralized network is new. Neubauer sees this as a possible starting point for consulting services. For consulting services of this kind, it is essential that the necessary quality is offered, which is why the Catena-X association is already looking into corresponding certifications (Dr. Jürgen Padberg). He adds that an important element here will be the onboarding of companies. It is a question of whether it is worthwhile getting started and how this is done. The basis for this is provided by their own data and how they can be meaningfully incorporated into Catena-X. Peter Weichsel does not necessarily see the implementation as a business in its own right, but rather as a partial result of digitalizing a company and making it competitive. However, this is already one of the core tasks of digital consultancies and therefore does not necessarily offer a new business model.

Data Ecosystem

General objectives of Catena-X

As noted, the focus of the initiative is not monetization, but standardized data exchange based on European values that prioritize transparency and data sovereignty. Sometimes it is an effort

to drive the digitalization of the automotive value chain, which goes beyond the supply chain. The German Federal Ministry for Economics and Climate Action is funding the initiative with a low triple-digit million-euro amount. By enabling certain use cases, it is possible to use the Catena-X data ecosystem to contribute to sustainability, among other things. Through this investment, the German government is expecting that companies will develop digital capabilities and be able to compete in an increasingly digitalized global marketplace (Dr. Jürgen Padberg). In terms of efficiency, companies are brought together without prior points of contact; this is also referred to as a network of networks (Peter Weichsel).

Advantages through participation

The supply chain problems during the COVID-19 pandemic in particular have shown that structures and requirements in the market are becoming more dynamic. To cope with such dynamics, it requires, among other things, networks that offer the necessary flexibility. For example, if interface contracts have not been negotiated in time. In this way, small and medium-sized companies in particular gain better access to the market (Ralf Neubauer). Since the possibilities of such a data ecosystem are manifold, there is a variance in the answers here. Dr. Jürgen Padberg sees above all, three decisive purposes of Catena-X. First, increasing efficiency in data preparation and transfer, resulting in effort and cost savings. The second purpose is compliance, describing the fulfillment of corresponding regulations, which includes, for example, CO_2 monitoring and the Battery Pass (a digital twin of the battery for the traceability of the individual components). The third purpose is to generate new business.

Transferability to other industries

While there are some similar projects in other industries, in dimension Catena-X is a pilot project, also called a Kickstarter ecosystem. In essence, the goal is to achieve applicability for other manufacturing industries as well. The network is being designed accordingly. The focus is primarily on the supplier network, while other comparable initiatives are more concerned with development and production, which entails other tasks and challenges. In the medium term, however, these networks should grow together (Patrick Strauß). Because many companies in the automotive industry are also active in other industries, a transfer is obvious and should be relatively easy (Dr. Jürgen Padberg).

Sustainability

How Catena-X contributes to sustainability

When asked how Catena-X and sustainability are related, there certainly seems to be evidence pointing to a positive influence. Sustainability plays a major role in development, the answers reflect. The German supply chain law, obliges the participants in the supply chain to comply with standards that also directly contribute to sustainability. In this case, Catena-X takes the role of enabler and supports the implementation of the related obligations. The newly created transparency enables full traceability of the individual components (Ralf Neubauer). On the ecological level, an accurate calculation of the carbon footprint allows going beyond the consumption of the cars in operation. For example, one can better calculate the parity value between electric cars and internal combustion engines (Dr. Jürgen Padberg). The economic advantages have already been sufficiently presented, but the network can also support on the social level. Ute Burkhardt sees this as a kind of job engine that can create new jobs in this area. Also, aspects like child labor or corruption can be better identified and fought (Peter Weichsel). In summary, Catena-X does not contribute to sustainability itself, but simplifies many of the measures necessary for it. Not least through the already mentioned possibilities to promote circular economies.

Circular economies

Approximately 70-80 percent of the value added in the automotive industry is generated by suppliers. In order to promote a functioning circular economy, it is them who must act (Patrick Strauß). Especially digital marketplaces for a "Secondary Life" of vehicle parts offer themselves here, since scrap dealers can use new ranges through Catena-X. This increases the proportion of recycled materials, which are thus fed back into the cycle. The interviewees agree that Catena-X acts as an "enabler" for such processes by enabling more transparency about the individual components.

Economic Implications

Competitive advantage

Currently, the development of Catena-X takes place mainly in Germany in the association of German companies. However, due to the fact that automotive supply chains are global, the impact is ultimately global as well. Patrick Strauß sees the decisive parameters for a competitive

advantage in data exchange through digitalization, efficiency gains and sustainability. The latter represents a selling point for the most environmentally friendly car. Because of the increased transparency, this can also be proven based on CO_2 data, the proportion of recycled materials, and compliance with corresponding environmental standards. Currently, the German automotive industry would have a first-mover advantage over international competitors. For a sustainable competitive advantage, however, this must be supplemented by technological progress, for example in battery development (Dr. Jürgen Padberg). Through the overlaps with other manufacturing industries, Peter Weichsel sees an overall advantage for the German manufacturing sector beyond the automotive industry itself. These effects are not yet measurable, but the goal is to see the first successes from the end of 2024 onwards (Ute Burkhardt).

Economic dependencies

The emergence of an economic dependency on Catena-X is so far a very theoretical concept, but it should not come to an obligation. Rather, dependencies could arise in practice when it comes to compliance with certain standards. Currently, the companies at the top of the supply chain can put pressure on those further down the chain (Ute Burkhardt). This means automakers have buyer power over suppliers. Despite everything, the association wants to avoid potential lock-in effects. A decentralized approach is intended to counteract this, through the installation more than one operating company, for instance (Patrick Strauß).

Catena-X as an industry standard

The intended transparency and the fact that competitors will soon share a network with sensitive data raise competition law questions. Responsible offices and authorities have examined the conditions in detail and found no evidence of unfair competition (Dr. Jürgen Padberg, Peter Weichsel). The joint exchange of data is elementary for the functioning of the network, according to the principle that one gets far on their own, but together they get even further (Ute Burkhardt). This means that everyone in the network benefits from sharing data. In addition, the participants retain data sovereignty and can determine exactly which data is shared and which is not.

Entry barriers

It is undeniable that being part of a data ecosystem requires certain technological skills. A functioning IT infrastructure is needed, which costs money. This may present new challenges

for smaller companies. While one wants to keep barriers as low as possible, one cannot eliminate them entirely. Ralf Neubauer puts forward the following thesis in this regard:

> *"The more intensive the data exchange in Catena-X, the higher the value creation, but also the investment" (Ralf Neubauer).*

Company sizes along the supply chain fluctuate, and so it happens that not everyone has their own independent IT. Peter Weichsel speaks of a kind of "*digital illiteracy*", or a lack of understanding of digital processes. He therefore sees the barriers more as an intrinsic obstacle and less as a universal barrier.

5. Discussion

To better process the results, key terms were identified and are discussed below. There is overlap in the four defined focus areas of *business models*, *data ecosystems*, *sustainability* and *economic implications*. The identification of these key terms thus allows for a clear designation of commonalities among the respondents and allows for a degree of validation. These will be discussed in the following section.

In the key area of business models, the candidates agree that there is a transformation of the industry in which manufacturers in particular are expanding the pure production of vehicles to include services related to mobility. These findings are in line with current observations on this development made by scholars, who state that servitization promotes new business models which offer innovative services to the customer (Genzlinger et al., 2020). This is also having an impact on production, but more so on the stages of the supply chain below the automakers themselves. There is a majority observation among respondents that "manufacturing as a service" is emerging as a new development and could be facilitated by Catena-X. Manufacturers are digitalizing their production systems to benefit from new possibilities and increase overall quality (Pop, 2020). The business model based on production is not obsolete as a result, but it is being changed and extended by other business models. Peter Weichsel spoke of a merging of processes which summarizes the statements of the interviewees well. When discussing business models in the automotive industry with the respondents, there was unity in the sense that the extension of existing business models can be observed. Entirely new business models are only just evolving or have yet to be developed entirely. Therefore, the results contribute to research

on business model innovation, which can include both the refining of present business models and the creation of new ones as well (Massa and Tucci, 2014).

A term that came up several times when describing the concept of Catena-X is "enabler". Across all four focus areas, this term comes up repeatedly with all candidates. This is where there is the greatest overlap in the answers. The newly created, open data ecosystem does not directly offer value creation and is rather to be understood as a kind of tool for it. Several characteristics of digital ecosystems can have a positive impact on value creation for instance, shareability supports the value network by bringing together the participants (Li et al., 2023). There is possibly a connection between the terms "enabler" and transparency, as they are very often associated in the interviews. However, that is an observation resulting from the questionnaire and cannot be backed up sufficiently by the research body on digital ecosystems. Instead, this dissertation attempts to illustrate the value creation process thaking the aforementioned into consideration. The model is illustrated by figure 2, "*Value Creation through Catena-X as Enabler*", below and provides a contribution to the research body on value creation through digital business models in digital data ecosystems. In the model, a kind of causal chain can be identified that starts with the Catena-X data ecosystem as an "enabler" for transparency, thus offering potential for value creation. This value creation can be divided into three further categories, *social*, *environmental* and *economic* (Elkington, 1997), as mentioned earlier. Data sovereignty based on European values, forms a kind of foundation in this structure.

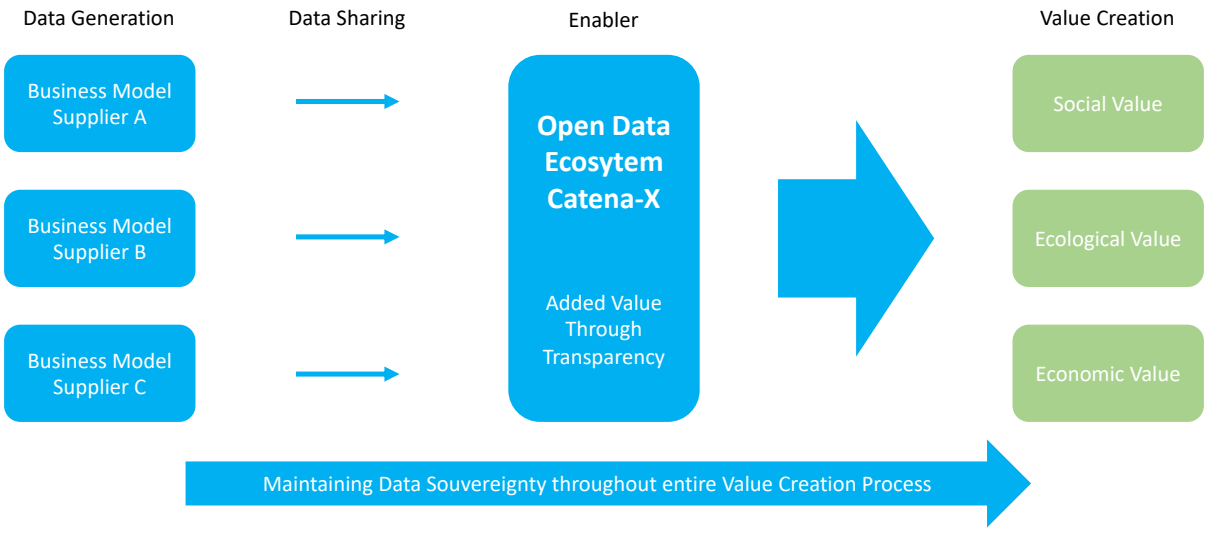

Figure 2: Value Creation through Catena-X as Enabler

In this course, the "one up, one down" principle was also mentioned several times and overlapped across the interviewees' statements, implying a kind of democratic data exchange, which is in line with European values and does not place monetization as a top priority. Therefore, the claim that business models do not necessarily pursue a purely financial value cration (Zott and Amit, 2011), is supported by these findings. In the case of Catena-X, social value creation is promoted primarily through the creation of new jobs, but this was mentioned only sporadically by the interviewees, so it can be classified as less strong. Furthermore, compliance with guidelines relating to human rights is mentioned in this context. Here there is more overlap in the candidates' statements. The elimination of corruption and child labor were mentioned as examples.

With regard to ecological added values, the frequent mention of the German Supply Chain Act, the battery pass, and the carbon footprint are particularly noticeable in the responses. These aspects were mentioned several times by almost all the interviewees. Third, the economic added values stand out strongly in the answers, potentially indicating high interest by the industry, and are at the same time the most difficult to predict.

How social and ecological added value is achieved can be described in great detail by the respondents, which is partly due to the prioritization of the use cases defined by Catena-X, in which sustainability plays an overriding role. Economic value creation is currently based primarily on speculation, especially regarding the emergence of new business models. Excluded from this is the increase in efficiency made possible by the network. Here, there is a great deal of agreement among the experts. The increase in transparency enhances the influence by being able to reach all parts of the supply chain via the network. But the standardization of processes also reduces the amount of work involved in repetitive tasks and can lead to cost savings while taking up less time.

Generally, it can be stated that an exact separation of these three axes of sustainable value creation is not always possible. They are partly interdependent or have side effects. One example of this are circular economies. When certain components are recycled, this has direct ecological and economic effects, allowing for incentives to do so (van Beukering et al., 2014). The same applies to better utilization of production and supply capacities. With total utilization, empty runs or additional means of transport can be avoided, which saves costs and benefits the environment.

In conclusion, it can be said that predominantly positive effects are achieved; among the respondents, few to no disadvantages that could arise from Catena-X were named. However, this can also be explained by their proximity to the initiative. The newly created benefits offer

new opportunities not only to the automotive industry, as the theoretical learning effects and software building blocks are also made available to other, predominantly manufacturing, industries. Due to the digital nature of the ecosystem, companies are encouraged to implement this digital transformation internally as well, to be better prepared for the market globally (Dr. Jürgen Padberg). From these research results, further theoretical and practical implications on business models, data ecosystems and sustainability can be derived.

Research Implications and Limitations

Implications for Theory

When developing business models, value creation is the goal to be achieved. Most research in data, takes on the user perspective (Wiener et al., 2020). This dissertation contributes to the data ecosystems perspective which have the ability to can support value creation by extending reach and providing a space where data can be exploited, in bringing many participants together. Therefore, a contribution to the research on value creation through big data from a multi-actor perspective (Günther et al., 2017) is made. These network effects can also be observed in the case of Catena-X. Since the initiative has not been in existence long and the practical effects will not be fully realized until the end of 2024, there are several research opportunities here in the future. Especially the monetary value creation through the development of existent and creation of new business models enabled by Catena-X promises great potential. Both for research (Climent and Haftor, 2021) and for business. Initial developments, such as the emergence of new digital marketplaces, already sketch a rough picture of how these opportunities will be exploited. The aforementioned merging of automakers' business models from pure manufacturing and digital services (Wells, 2013) is only just taking place and provides a valid basis for further research. Sustainability is not only gaining importance in the automotive industry, both in industry and in research there is a high interest in how business models of the future can be designed to serve social and environmental interests in addition to financial values (Nosratabadi et al., 2019). It seems that Catena-X offers a very high potential for a more sustainable car industry. As a research approach, it is plausible to focus on the effects it has on recycling and disposal of materials, CO_2 emissions of the whole supply chain and not only of the vehicles in operation, and on the labor market, especially the creation of new jobs and improvement of working conditions.

Implications for Practice

The topic is also highly relevant for consultancies. Looking at the results in this thesis, it turns out that there is a high demand for consulting services. Smaller companies in particular need support in implementation and the digital skills required for this. Alternatively and complementarily, new opportunities could also arise for service providers. For example, they could offer an interface to Catena-X and provide smaller companies with the necessary IT infrastructure practically on demand. It will also be important to look more closely at the implications of data sharing. Data that is not currently being exploited could soon offer a new source of revenue, which is something that especially participants at the bottom of the supply chain need to focus on. With regard to sustainability, authorities and agencies impose new regulations that are legally binding. Since Catena-X offers a suitable platform to implement them, it is in the interest of companies to prepare themselves and take the necessary precautions. Other approaches will emerge once the network is fully up and running.

Limitations

Five experts were selected for the sample, two of whom work directly for German car manufacturers and the other three work in consultancies where they are responsible for digital topics often related to the automotive industry. Also, all of them have a direct relation to the Catena-X association. Thus, a high level of expertise and at the same time a differentiation of perspectives is provided. Due to the numerous overlaps in the statements of the interviewees, one can conclude that this is an adequate sample. Since the majority of the interviewees have more than 20 years of professional experience, it can be assumed that they have a particularly high level of knowledge. As Catena-X is an association of predominantly German companies, it seems appropriate to interview only experts from these companies. For this, semi-structured interviews have been chosen which inherently allow for a certain openness of responses, thus contributing to a richness in quality. However, it is more challenging in the analysis of the results to present them in an unbiased way, as they are more difficult to quantify. The classification into certain categories and the identification of overlaps should help to reduce bias as much as possible. Still, it cannot be entirely eliminated with this method. The same applies to the interview process itself. The questions and especially the follow-up questions were not always phrased the same way due to different interview dynamics and thus potentially lead to subtle differences in the answers. Certainly, the fact that Catena-X is still in an early phase presents research with certain challenges, as little insight and tangible data are yet available. This was countered by having the questions target current developments that are

already visible. In this way, the room for speculation and assumptions can be reduced to a minimum.

Conclusion

This thesis deals with value creation through the development and evolution of Business Models in the automotive industry under the influence of Catena-X, an open data ecosystem for the automotive supply chain. For this purpose, five experts from the German automotive industry were interviewed to uncover how data can be used profitably within supply chains, in relation to the three components of sustainability, *social*, *environmental,* and *economic*. This revealed that Catena-X, as a data ecosystem, primarily acts as an "*enabler*" for value creation by contributing to increased transparency in the supply chain. Currently, the influence on new business models is only moderate; rather, an expansion of existing business models can be observed, which primarily contributes to sustainability and generates value from it. Perspectives are offered for novel business models, such as being offered by new service providers of interfaces to Catena-X. It was also noted that the applicability to other industries is very close, as the participants are also present there. The theoretical research gap addressed here aims at the creation of value through Business Models in the concrete data ecosystem Catena-X, by utilizing data from the automotive supply chain. This data is diverse and complex and could be further explored by researchers in the future from a value creation perspective. In the concluding section, further relevant research paths were identified as well as the most important developments and challenges for practice. These consist mainly of the onboarding of new companies and how they need to be digitally transformed to be able to convey their data in a value-adding way. Catena-X will continue to develop rapidly in the coming years and it will be curious to see what new opportunities arise for the global automotive industry in particular, but also for the manufacturing sector in general.

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7. Appendix

Presentation of the Interview Candidates in chronological order

Patrick Strauß

Use Case Lead for Traceability at BMW AG. Part of the Catena-X association as Product Owner.

Dr. Jürgen Padberg

Global Head of Automotive Manufacturing Industries at Detecon International GmbH. Responsible for Customer Experience Management and Supply Chain Management, including Catena-X. Part of the Catena-X association.

Ralf Neubauer

Project Manager at msg systems AG. Responsible for operative and research projects in the field of data ecosystems. In charge of topics related to Catena-X among others.

Peter Weichsel

Managing Director at Strategy&, Part of the PWC Network, for Digitalization, Strategy and Business Transformation. Experienced in digital platform projects and previously worked as a consultant for the Catena-X association.

Ute Burkhardt

Logistics expert in Capacity Management at Volkswagen AG with a focus on data exchange between suppliers. Product Owner in the Catena-X association in the working area *networks*.

Interview Manuscript

1. *Intro: "What is your job position?" > follow up: "How is your work connected with Catena-X?"*

2. *“In short, what is the overall goal of Catena-X?”*

3. *"What are current Digital Business Models in the Automotive Industry?"*

4. *“How can (digital) business models benefit from Catena-X or similar networks?”*

5. *“Is Catena-X disruptive for the industry in the sense that current business models need to be adapted?”*

6. *"Would you agree data is a central element in Catena-X? If so, do you see potentially new business models emerging from this newly created data?"*

7. *“What are the advantages of Catena-X for the industry and for the participants/partners?”*

8. *"Based on the large amounts of data, is there a potential for monetary value creation through Catena-X as well?"*

9. *“In the future, does Catena-X provide a competitive advantage for the German Automotive Industry? If so, how?”*

10. *“Regarding the three key aspects of sustainability, which are social, economic and ecological, how does Catena-X contribute to sustainability and to what extent?”*

11. *"How can your company/institution be designed to achieve or nurture/embrace Circular Economies?"*

12. *"Do you think Catena-X creates economic dependencies within the industry?"*

13. *"Would you agree, that Catena-X will become a mandatory standard for the industry? If so, does Catena-X change the competitive landscape along the value chain?"*

14. *“What are possible entry barriers for prospective partners?”*

15. *“To what extent is Catena-X applicable to other industries?”*

16. *“How can Consulting firms benefit from Catena-X?”*