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Investigating a manufacturing ecosystem in transition toward electric vehicles – a business model perspective

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Abstract

Purpose – Business Model Innovation is increasingly created by an ecosystem of related companies. This paper aims to investigate the transition of a manufacturing ecosystem toward electric vehicles from a business model perspective.

Design/methodology/approach – The authors investigate an automotive manufacturing ecosystem that is in transition toward electric and electrified vehicles, conducting semi-structured interviews with 46 informants from 27 ecosystem members.

Findings – The results reveal that the actions of several ecosystem members are driven by regulations relating to emissions. Novel requirements regarding components and complementary offers necessitate the entry of actors from other industries and the formation of new ecosystem members. While the newly emerged ecosystem has roots in an established ecosystem, it relies on new value offers. Further, the findings highlight the importance of ecosystem governance, while the necessary degree of change in the members' business models depends on their roles and positions in the ecosystem. Therefore, upstream suppliers of components must perform business model adaptation, whereas downstream providers must perform more complex business model innovation.

Originality/value – The paper is among the first to investigate an entire manufacturing ecosystem and analyze its transition toward electric vehicles and the implications for business model innovation.

Keywords Manufacturing ecosystem, Electric vehicles, Electrification, Business model innovation, Case study, Automotive industry

Paper type Research paper

Quick value overview

Interesting because: The automotive industry is in a phase of transition toward electric and electrified vehicles (xEVs) due to legislation, especially in the form of environmental and emission regulations. Driven by new technologies required, automotive ecosystems have to adapt their business models. Extant literature has investigated business model innovation (BMI) of single actors of an ecosystem, but not of an entire ecosystem.

Theoretical value: The ability and incentive to change business models depends on the actor's specific type, role and ecosystem position. Upstream actors, i.e. suppliers tend to

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perform more evolutionary or adaptive approaches in changing their business models. Automotive original equipment manufacturers (OEMs) and downstream ecosystem actors closer to the customer rather perform more focused or complex forms of BMI.

Practical value: Automotive OEMs act as central orchestrators of xEV ecosystems and thus new business models. They cooperate with an increasing number of new partners, e.g. energy companies to establish charging infrastructure solutions. Thereupon, they offer new forms of value capture business models, i.e. not only selling an xEV to the customer, but a charging and energy storage solution integrated into a smart grid. Further, xEVs act as a means of meeting emission regulations or generating value by selling CO_2 certificates, thus offering new business models. For these new business models, automotive OEMs must better integrate ecosystem members with disadvantages due to the shift to xEVs, e.g. traditional suppliers.

1. Introduction

Successful BMI increasingly relies on actors and their interaction in an ecosystem of companies, including other industry sectors (Adner and Kapoor, 2010). At the same time, BMI often results from technological discontinuities or policy changes (Massa and Tucci, 2014; Saebi *et al.*, 2017).

Electric and electrified vehicles (xEVs) and their respective ecosystems represent a technological discontinuity leading to BMI driven by policies and regulations (Massa and Tucci, 2014). Recent developments regarding governmental policies will require ecosystem actors to align BMI toward an xEV-centered value proposition (Bohnsack and Pinkse, 2017; Monios and Bergqvist, 2020; Secinaro *et al.*, 2020). Further, shifting technologies for vehicle propulsion are predicted to influence the structure of ecosystems in the automotive industry substantially (Abdelkafi *et al.*, 2013) and their interaction (Aaldering *et al.*, 2019).

Another argument for analyzing an entire ecosystem is that it allows the investigation of the evolution of ecosystem actors and their interaction (Granstrand and Holgersson, 2020). In particular, for BMI in ecosystems, multiple actors must find adequate forms of governance (Hoch and Brad, 2020; Palmié *et al.*, 2022). The corresponding research gap addressed is that literature on ecosystems centered on a specific innovation has only recently emerged (Burström *et al.*, 2021; Snihur and Bocken, 2022). BMI literature has tended to focus on single actors, neglecting a broader context, while empirical studies on entire ecosystems and their interrelations are scarce (Amit and Zott, 2015). Further, the topic of manufacturing ecosystems has only recently emerged (e.g. Ates *et al.*, 2023; Kazantsev *et al.*, 2023).

We thus aim to shed light on understanding an ecosystem involved in manufacturing automobiles in transition toward xEVs with a BMI lens, contributing to a better understanding of the emerging concept of manufacturing ecosystems. To achieve this, we investigate 27 ecosystem members with semi-structured interviews, collecting data from 46 respondents addressing the following research questions:

RQ1. What are the influences on individual actors, their interactions and corresponding changes in ecosystem architecture in an ecosystem centered on a novel technology?

RQ2. How do individual ecosystem actors change their business models when participating in an ecosystem centered on a novel technology?

2. Background

2.1 BMI in ecosystems

While comprising different definitions, a business model can be subsumed in value offer, value creation and value capture (Foss and Saebi, 2017). Afuah and Tucci (2003) define a business model as a “method by which a firm builds and uses its resources (value creation) to offer its customers better value than its competitors (value offer) and to make money doing so (value capture).” BMI describes a significant change in multiple elements of an extant business model. Further, the value created by a given technology largely depends on the business model within which it is used, such as in the digital transformation of manufacturing or Industry 4.0 (Müller, 2019; Rachinger *et al.*, 2018).

So far, empirical studies have primarily investigated business models as a company-centric construct (Hoch and Brad, 2020; Palmié *et al.*, 2022; Yi *et al.*, 2022). However, from early on, business models were conceptualized in the context of business environments (Amit and Zott, 2015) due to the boundary-spanning nature and dependence on external actors (Adner, 2017; Talmar *et al.*, 2018).

As individual companies typically control different sets of resources and pursue specific activities, ecosystems are likely to emerge in situations where actors do not yield total control over their operations (Hoch and Brad, 2020; Palmié *et al.*, 2022; Yi *et al.*, 2022). Granstrand and Holgersson (2020) define an ecosystem as an “evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.”

In manufacturing literature, the topic of manufacturing ecosystems has only recently emerged (Ates *et al.*, 2023; Kazantsev *et al.*, 2023). Several authors describe the formation of manufacturing ecosystems due to Industry 4.0 or post Covid-19 (e.g. Das and Dey, 2021; Schmidt *et al.*, 2023). While other industries have seen developments toward ecosystems earlier, the automotive industry is characterized by traditional standards and is organized centrally by the automobile original equipment manufacturers (OEMs) (Kazantsev *et al.*, 2023; Riasanow *et al.*, 2021; Suuronen *et al.*, 2022).

The research gap addressed is that there is little empirical evidence on entire ecosystems and detailed interactions of actors and their governance (Amit and Zott, 2015). xEV ecosystems represent a novel research context for an entire production ecosystem. Conclusively, the purpose of this study is to gain a better understanding of BMI in manufacturing ecosystems due to the transition of automotive manufacturing toward xEVs. In particular, the paper investigates *Strategic Influences on Business Model Design* (Abdelkafi *et al.*, 2013; Aaldering *et al.*, 2019). Further, how *Business Model Design* is manifested in the elements of a business model, *Value Creation, Value Proposition and Delivery,* and *Value Capture,* is investigated (Foss and Saebi, 2017).

2.2 Interaction and governance of BMI in ecosystems

Actors in an ecosystem require a vision for the overall ecosystem and appropriate governance to ensure their alignment (Adner, 2017; Iansiti and Levien, 2004; Moore, 1996) and the ecosystem’s overall health (Dattee *et al.*, 2018). Subsequently, ecosystem actors must know their resources and respective business models and understand how ecosystems are governed. Then, they can align their business models to create BMI as an ecosystem (Adner, 2017). Ecosystem actors can be divided into (1) central ecosystem actors, in our case, automotive OEMs, (2) upstream actors, e.g. suppliers and (3) downstream actors, e.g. retailers (Dedehayir *et al.*, 2018).

Several authors refer to a form of governance or orchestration of BMI in ecosystems to describe the interactions within ecosystems. Iansiti and Levien (2004) highlight the importance of keystone actors who create and share ecosystem value to attract and retain other actors, increasing stability and predictability. Thus, BMI in ecosystems requires the alignment of customer needs, technologies and infrastructures (Wang *et al.*, 2022). In addition, as proposed by Russell and Smorodinskaya (2018), ecosystems typically emerge from collaboration by the actors. Hence, technological shifts require specific governance by actors and their interactions (Spieth and Meissner, 2018). We therefore investigate the *Governance of*

Interactions and the *Types of Interactions*. The latter also reflects Spieth and Meissner (2018), who find incumbent companies increasingly relying on partners for additional resources, resulting in new forms of interactions and a *Change of Ecosystem Value Creation Architecture* as a further target of our investigation. The required integration, however, proves especially difficult (Baccarella *et al.*, 2023).

Spieth and Meissner (2018) further indicate that taking an ecosystem-based approach to BMI can be a delicate prospect because it requires a thorough understanding of the entire company environment and external influences. Hence, we further investigate *Strategic Influences on Interactions.*

3. Method

3.1 Choice of method

Case study research represents an appropriate research method for gaining insights into contemporary phenomena in their real-life setting. Further, "How and Why" questions that do not require control of behavioral events should be answered (Yin, 2017). Swanborn (2010) adds that case studies are an appropriate research method to investigate phenomena that are not isolatable. Thus, we regard the interactions within an ecosystem to create BMI as appropriate for conducting a case study. Further, the transition toward xEVs represents a contemporary phenomenon. The automotive industry is in transition toward xEV due to legislation, especially in the form of environmental and emission regulations (Abdelkafi *et al.*, 2013; Bohnsack and Pinkse, 2017; Monios and Bergqvist, 2020). Due to geographic and cultural proximity, we chose an automotive manufacturing ecosystem in transition toward xEV in Germany and Austria as our case study. Germany represents the most important manufacturing country within the European Union and is also leading in patents and technologies toward xEVs (European Commission, 2020). Austria was included due to its essential roles in the automotive manufacturing ecosystem and geographical proximity, e.g. the majority of BMW's engines are manufactured in Steyr, Austria (BMW, 2023).

3.2 Participants' selection

We chose four automotive OEMs as a starting point to investigate the ecosystem since Eisenhardt (1989) suggested four as a minimum number for a case study. As Strang (2015) noted, the final number of participants cannot be stated at the outset of the research but develops during the course of it. Following the recommendation of Yin (2017), this study was designed to include at least two participants for each ecosystem actor type in addition to the four OEMs representing central ecosystem actors. Considering the insight into relevant ecosystem roles provided by Dedehayir *et al.* (2018), both upstream and downstream actors were included. In addition to the participant selection procedure described above, participants had to fulfill the following selection criteria: (1) companies needed to be either actors in the xEV ecosystem or directly affected by actors in the xEV ecosystem, (2) data collection focused on organizational units providing value toward the xEV ecosystem value proposition and (3) only data from companies with a headquarter in Germany or Austria was collected for the reason of geographical and cultural ecosystem proximity to ensure comparability.

For selecting participants, we started by including four major automotive OEMs, as described above. We continued with their most important automotive suppliers, which are among the largest worldwide. The participants were identified using professional networking platforms (i.e. LinkedIn and Xing). Additional participants like Tier 2 suppliers as well as engineering and technology providers, partnering research institutions (RI), automotive retail companies and corporate vehicle fleet operators were either recommended by participants or identified through desk research. A similar approach was taken to identify further participants such as energy and infrastructure companies. While this selection of informants potentially bears some bias since participants were partially recommended by each other, we were able to identify those who actually cooperate directly. This is especially important for the intended ecosystem perspective, which is further strengthened by the fact that several cross-relationships exist, such as Tier 1 suppliers providing products and services to several of the four OEMs, as well as others such as engineering and technology providers, infrastructure companies or RI.

We stopped data collection for the empirical study if additional insights from each actor type did not occur, i.e. when saturation was reached. Since we do not aim to derive importance from a number of occurrences and mainly analyze each actor type individually, we argue that it is acceptable to include different numbers of participants for each actor type. We stopped data collection after gathering data on 27 ecosystem members and insight from 46 interview respondents.

Potential informants were contacted and provided with a short research project summary. The main requirement was their knowledge about and interaction with further ecosystem actors. In addition, we aimed for at least a team leader level to ensure some level of involvement in strategic considerations. While this approach did not aim for completeness regarding the representation of all actor types equally, we aimed to gain an overview of as many actors as possible.

3.3 Participants' description

Table 1 summarizes the case study participants. In addition, Appendix 1 gives more details on the individual participants, their roles and interview types and lengths. Due to demands for anonymity, we had to generalize several roles while others are stated with more details.

Figure 1 further illustrates the ecosystem investigated.

3.4 Data collection and analysis

We conducted semi-structured interviews based on an interview guideline asking for *Strategic Influences on Interactions, Governance of Interactions, Change of Ecosystem Value Creation Architecture* and the *Types of Interactions* relating to Research Question 1. For Research Question 2, the questions related to *Strategic Influences on Business Model Design,*

Ecosystem actor role	Abbreviation	Ecosystem position	Companies/ institutions	Participants
Original equipment manufacturers	OEM	Central	4	6
Engineering and technology providers	ETP	Upstream	2	9
Research institutions	RI	Upstream	2	2
Suppliers (established automotive)	SUP(e)	Upstream	4	12
Suppliers (focused technology)	SUP(f)	Upstream	2	3
Automotive retail	RET	Downstream	2	2
Corporate vehicle fleet operators	FO	Downstream	2	2
Energy companies (electric)	EC(e)	Downstream	3	4
Energy companies (petrol)	EC(p)	Downstream	2	2
Infrastructure companies	INF	Downstream	4	4
Total			27	46

Source(s): Own elaboration

Table 1.
Participant overview

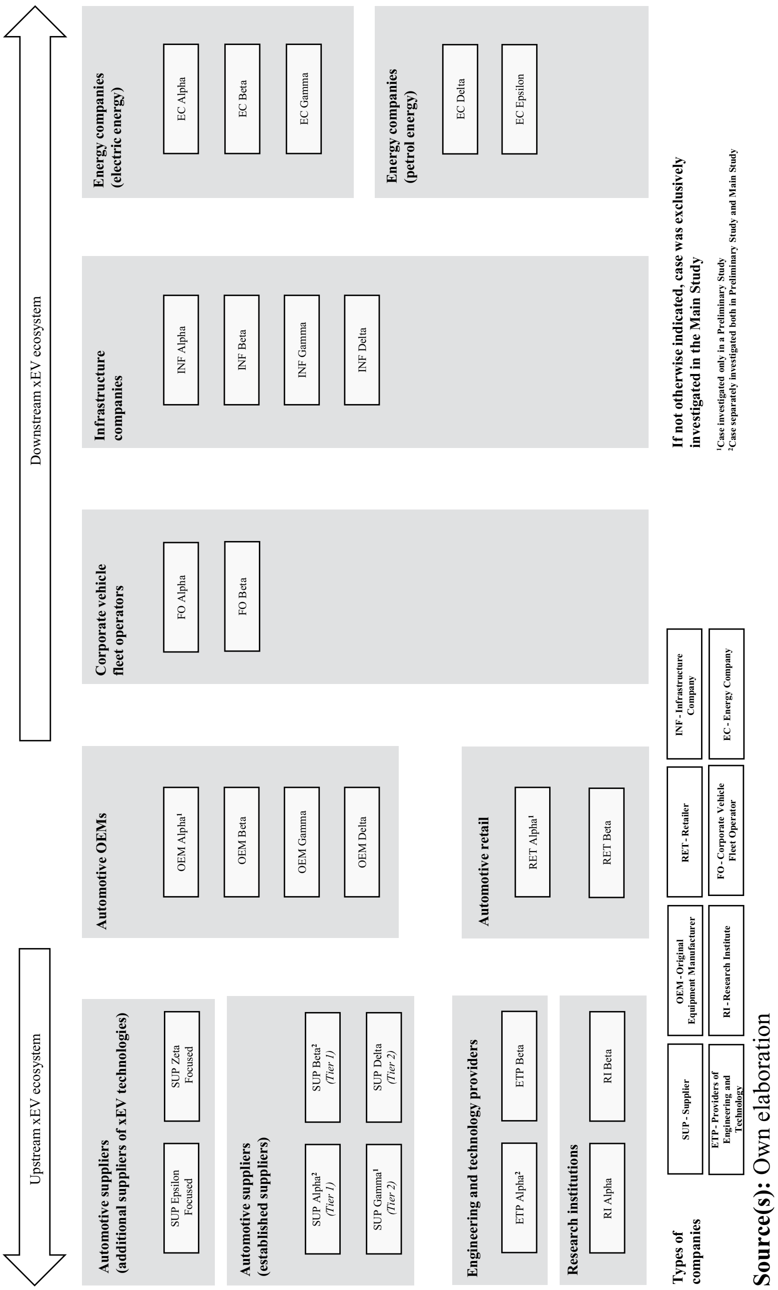


Figure 1.
Overview of the ecosystem investigated

Value Creation, Value Proposition and Delivery, and *Value Capture*. Appendix 2 shows the detailed interview guideline.

The data for the main study were collected from December 2018 to September 2019. All interviews were recorded and transcribed in full to establish a solid basis for further analysis. The collected transcripts were used to perform a qualitative content analysis (Gioia *et al.*, 2013). The coding procedure was performed considering individual sense-bearing phrases using the software MAXQDA2018. A structuring logic proposed by Gioia *et al.* (2013) was employed to evaluate and structure relevant findings into categories. A category was considered saturated when no new properties, dimensions, conditions, actions/interactions or consequences emerged from the data.

After analyzing data from 46 respondents, a workshop with industry professionals was held to verify and extend the results. Hence, Figures 2 and 3 attempt to show overarching themes across categories and across actors. Further, Figures 2 and 3 show the most important interrelations regarding both research question 1 and research question 2. The figures do not aim for completeness but to get an overview of the most important aspects, their interrelations and the ecosystem structure. Tables 2 and 3 summarize the interview data for each actor type, as explained in the following section. Since we do not aim for a cross-actor analysis but rather interrelationships of the entire ecosystem, we do not display the detailed constructs according to Gioia *et al.* (2013).

4. Results

4.1 Influences and governance on interactions, change of ecosystem architecture (RQ 1)

Table 2 gives an overview of *Strategic Influences on Interactions, Governance of Interactions, Change of Ecosystem Value Creation Architecture* and the *Types of Interactions* relating to Research Question 1. The results are separated for the different ecosystem roles (abbreviations can be found in Table 1) and show the condensed categories for each actor type. Below, we briefly summarize the findings for each actor type.

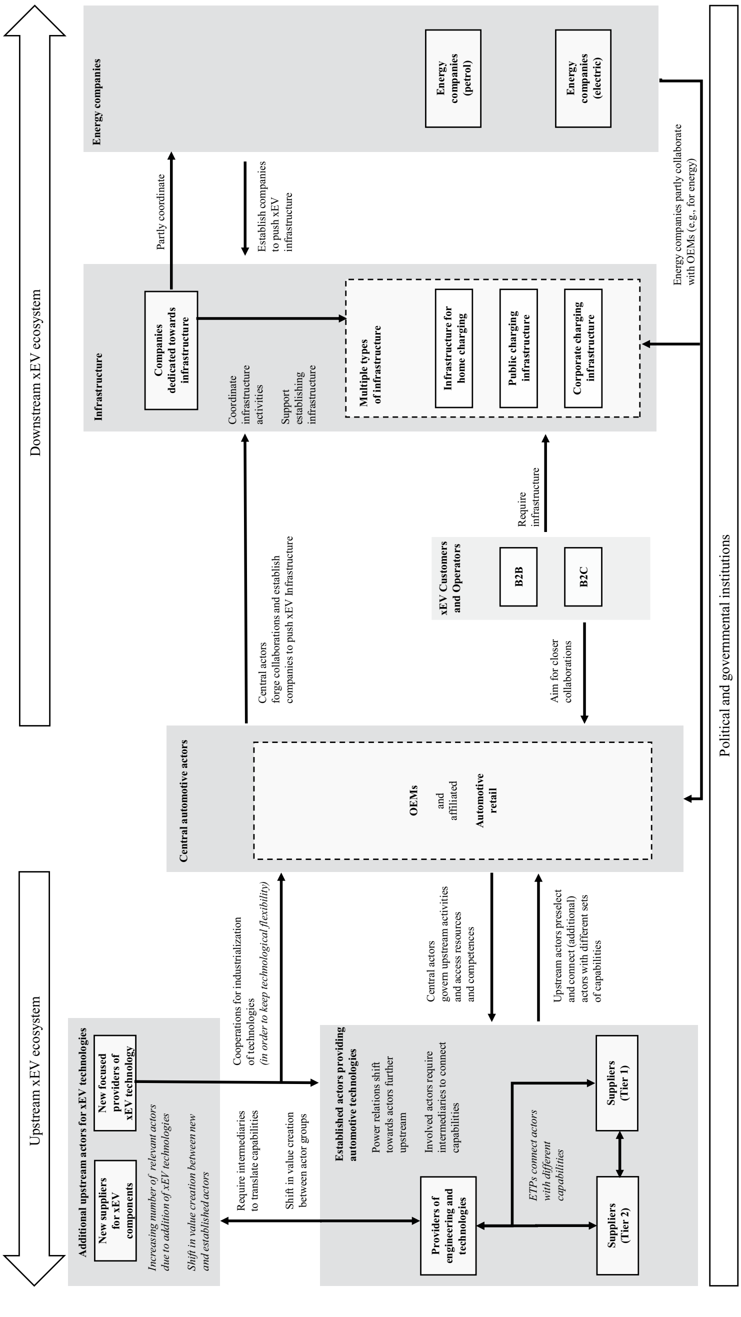
OEMs as central actors rely on collaboration with other ecosystem actors and reorient their strategies both upstream and downstream in the ecosystem.

Engineering and Technology Providers (ETPs) face the challenge of establishing themselves as integral ecosystem members. While they possess crucial technological expertise, they find themselves in a position of limited influence compared to OEMs. Still, their experience with xEV-related technologies positions them as valuable partners in the ecosystem.

Established automotive suppliers (SUP(e)) are capitalizing on the growing demand for sustainability-driven solutions. They collaborate closely with OEMs, albeit with an eye on the emergence of new competitors in the xEV market. Meanwhile, focused technology suppliers (SUP(f)) pursue market leadership in xEV components, collaborating with large customers to influence OEMs and aiming for cooperation via technology licensing and partnerships. RI report increased regulations and shifting competencies required for xEVs.

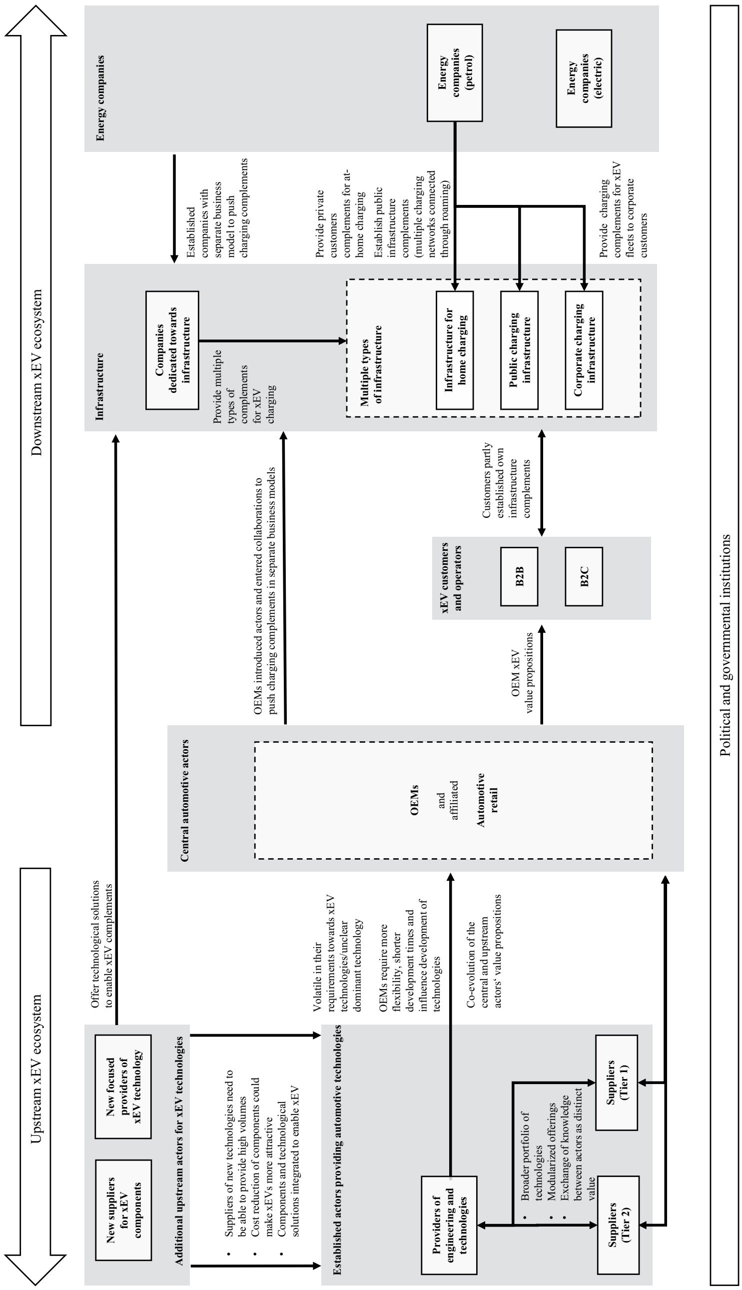
Retailers (RET) are focusing on complementary solutions to support the xEV ecosystem, such as charging infrastructure, while reporting dependencies on OEMs and energy providers. Fleet Operators (FO) are leveraging governmental incentives and forming partnerships to integrate xEVs into their vehicle fleets. However, they face challenges related to infrastructure availability and are dependent on OEMs for supply.

Electric energy companies (EC(e)) monitor the environment to align activities with other ecosystem actors and collaborate to offer seamless charging infrastructure coverage. However, they face challenges in exerting significant influence on central ecosystem actors like OEMs. Petrol energy companies (EC(p)) face technological and financial risks alongside the low availability of xEVs, hindering investment in the charging infrastructure.



Source(s): Own elaboration

Figure 2.
Identified interactions and dependencies in the xEV ecosystem



Source(s): Own elaboration

Figure 3.
Alignment of business models in the xEV ecosystem

Table 2. Influences and governance on interactions, change of ecosystem architecture

	Strategic influences on interactions	Governance of interactions	Changes of ecosystem value creation architecture	Types of interactions
OEM	• The investigated OEMs introduced xEVs in the past. The profitability of these undertakings was limited • OEMs view technological requirements toward xEVs as volatile and perceive the need to increase cooperation with ecosystem actors to improve the profit of new technologies	• OEMs can influence the technological directions of partners in the ecosystem. OEMs relay regulatory influences (e.g. emission regulations) to their partners • Regarding their relations, OEMs generally mention a tendency to avoid strong dependencies on other ecosystem actors	• OEMs state that energy companies lacked the initiative to establish electric charging infrastructure. To be able to sell xEVs, they needed to provide charging infrastructure solutions • OEMs reorientate their focus upstream (supporting suppliers to establish economies of scale with new technologies) and downstream (acting as infrastructure providers)	• Due to their initiatives toward xEVs, OEMs` overall number of ecosystem partners has recently increased • OEMs cooperate with energy companies and establish joint ventures to offer charging infrastructure solutions
ETP	• Report that environmental regulations emerge and new automotive OEMs are entering the market of xEVs • OEMs outsource competencies to ETPs	• Act as mediator to provide information and advice between several ecosystem members • Only limited influence on technological developments in the ecosystem	• Non-automotive actors enter automotive ecosystems ETPs facilitate interactions between established and newly entered ecosystem members	• Aim for coopetition with suppliers due to complementary but also redundant competencies
SUP(e)	• Benefit from Increased attractiveness of technologies due to sustainability requirements, political funding and maturity of technologies • Driven by OEMs, but suppliers are more flexible in shifting to xEV technologies	• OEMs drive their behavior, while suppliers coordinate upstream supplier networks	• Report of lower entry barriers for new competitors into xEVs than for petrol-based vehicles • New suppliers enter the market • SUPs directly interact with other ecosystem members that were coordinated by OEMs before	• Aim for cooperation with the entire ecosystem and new players simultaneously
SUP(f)	• Pursue a market leadership strategy of xEV components driven by OEM requirements	• Cooperate with large customers (e.g. FOs) to influence OEMs, such as exclusive partnerships	• Aim for cooperation via licensing of technologies	• Seek contractors for high-volume manufacturing, which are scarce

(*continued*)

	Strategic influences on interactions	Governance of interactions	Changes of ecosystem value creation architecture	Types of interactions
RET	• Availability of complementary solutions (electric charging infrastructure, charging technology) and vehicle batteries (range, costs) • Strict regulations regarding the charging infrastructure, technology-market fit	• Largely dependent of affiliated OEMs	• Growing importance of energy providers and charging infrastructure	• Try to balance the disadvantages of xEVs through collaborations with rental companies • Coopetition relation with energy providers, seen as thread but also cooperation
FO	• Governmental funding and incentives lead to increased use of xEVs • Corporate fleet operators are placed under political pressure to adopt more sustainable technologies. However, high initial investments and the need for external partners to maintain xEVs are still cited as concerns • Corporate fleet operators would rather not depend on public infrastructure providers	• They are upscaling xEVs in their vehicle fleets as a means to satisfy the requirements of stakeholders and customers • Corporate fleet operators depend on OEMs for their xEVs and are limited by the overall low availability of xEVs • Energy companies currently play only a minor role for corporate fleet operators	• Establishing sophisticated solutions for xEVs is perceived as challenging due to their current low availability and small market shares • Corporate operators of vehicle fleets rely on ecosystem actors to establish their own proprietary charging infrastructure	• Due to the low number of xEVs on the market, corporate operators of vehicle fleets are currently limited in their xEV initiatives • Value long-term co-creation relations, where they use their expertise in operating xEVs to support OEMs in their development efforts • Rely on collaborations with external actors (e.g. booking software, physical infrastructure) to establish their own charging solutions. Collaborations with energy companies are seen as attractive in the long run

(*continued*)

Table 2.

Table 2.

	Strategic influences on interactions	Governance of interactions	Changes of ecosystem value creation architecture	Types of interactions
EC(e)	• Monitor their environment to (1) time their technologies and (2) align their activities with other ecosystem actors (e.g. OEMs)	• Have little influence on central ecosystem actors (e.g. OEMs). The technological development of xEV charging stations is primarily defined by OEMs • ECs increased collaboration to offer seamless coverage for electric charging infrastructure	• The energy sector and the automotive sector are perceived to converge. OEMs and energy suppliers are beginning to offer their customers integrated energy solutions (including xEV charging) • Energy suppliers have begun to start to offer complementary digital solutions to customers	• Experience potential competition from OEMs in selected areas (predominately xEV charging and xEV car sharing) • Simultaneously, ECs often rely on the same ecosystem actors for new technologies • ECs see themselves as enabling to use charging infrastructure for B2B–and B2C customers
EC(p)	• Technological and financial risks and the low availability of xEVs are hindrances to investing in the energy grid or in charging infrastructure	• *No significant changes*	• *No significant changes*	• *No significant changes*
INF	• The dominant role of OEMs for xEV charging (e.g. through influencing standards and industry norms) • Aim to provide easy-to-use charging solutions for a broader audience • Monitoring of environment for technologies	• They are affiliated with companies in the energy sector – Governance via personal relations and joint research projects • Have tried to introduce charging solutions without involving OEMs to support rapid innovation • Infrastructure company Beta is affiliated with an automotive OEM which helped the company influence its suppliers	• Cooperation with suppliers of automotive OEMs • OEMs tend to insource complementary activities (e.g. charging of vehicles) to act as complete solution providers for xEVs • As the xEV market grows, companies in the ecosystem need to specialize and differentiate • Need to integrate solutions from multiple industries	• Coopetition as OEMs are moving into the charging infrastructure area • Predominantly cooperate with research institutions and energy companies

Source(s): Own elaboration

Table 3. Changes in business model design and strategic influences

	Strategic influences on BM design	Value creation	Value proposition and delivery	Value capture
OEM	• OEMs demonstrated the technological feasibility of xEVs early on. However, they consider the timing of when to scale up the technology and charging infrastructure as critical factors • OEMs are attempting to shorten vehicle development times to increase developmental flexibility	• They are attempting to maintain their current vehicle capabilities while adding additional ones for xEVs (e.g. capabilities for electric/electrified drivetrains) • OEMs rely on partners for new offers (e.g. electric charging solutions) to complement their own • Increased flexibility in the development processes will require more flexibility from suppliers	• Need for OEMs to provide holistic solutions for xEVs. Therefore, the attractivity of xEV technologies needs to be increased (e.g. through higher driving ranges) • Simultaneously, OEMs are beginning to offer complementing solutions (e.g. charging infrastructure, electrical energy, additional leasing of non-xEVs in specific circumstances) to satisfy customer requirements	• Currently, xEVs are primarily leased to business customers (e.g. operators of vehicle fleets) • Sales of high-end non-xEVs still drive OEM earnings • In order to avoid fees for not adhering to regulations (e.g. on emissions), they need to sell xEVs with low local emissions • Technology development (e.g. batteries) is expected to bring xEV costs down
ETP	• Describe the unclear role of multiple, potentially competing technologies leading to high uncertainty of investments • Profits from petrol-based technologies are required to finance an extensive portfolio of technologies required for xEVs	• The focus of R&D activities was initially on establishing the desired technological properties (e.g. efficiency, durability) and shifting toward integrating technologies into the customers' vehicle system • Training current employees as well as hiring employees skilled in new technologies • Acquire companies to expand their competencies • Participate in funded research projects with other actors (e.g. research institutions, start-ups) to increase capabilities • Coordinate an extensive network of suppliers and new partners	• Use prototypes to demonstrate and communicate its capabilities to customers • Support customers in (1) identifying and (2) developing new technologies as well as (3) industrializing related products and (to some degree) (4) increasing the customers' competencies concerning new technologies • Add value for customers by relaying information and requirements between actors in the ecosystem • Especially for xEVs, shortening development cycles (time to market) and more agile approaches (especially concerning new ecosystem actors) are required	• Revenues are generated through (1) engineering projects or (2) engineering services • Customers are increasingly demanding a higher degree of flexibility in their payment solutions • The profitability of technological areas is a criterion that should be used to revise the company's technological approaches

(*continued*)

Table 3.

	Strategic influences on BM design	Value creation	Value proposition and delivery	Value capture
SUP(e)	• Establish independent organizational units for xEV technologies due to high risks and currently low-profit margins • Aim for modularization of components to be used on xEVs and petrol-based vehicles	• M&A activities to extend competencies for xEVs • Tier 1 suppliers relay flexibility requirements to their suppliers further upstream • Acquire new technology components while increasing their capabilities in selected areas (e.g. electric motors) • New technologies for xEVs reduce the value-added share • Training and recruiting employees toward xEV technologies is challenging • They integrate technologies into vehicle systems and ensure the overall system properties during development • Describe increasing cooperation with RIs, ETPs and many partners	• The archetypical business model of developing and selling products to customers (primarily OEMs) did not change in the case of xEVs • Sharing risks when developing technologies and subsequent products for xEVs provided additional value to their customers • They emphasized the need to deliver their products to customers worldwide with customer-specific solutions	• In Tier 1 suppliers, profits are achieved by direct product sales • Development capabilities were used to justify the sale prices and improve cost efficiency in development efforts • Furthermore, revenues from after-sales business (e.g. product maintenance) were predicted as lower with xEV technologies
SUP(f)	• Suppliers relying on a focused area of technologies (SUP Epsilon, SUP Zeta) stated they avoided manufacturing high volumes of their products independently- - driver for establishing manufacturing partnerships	• Bring technology to the market largely in-house • Alternatively, both companies took on the role of a technological enabler	• The energy sector and the automotive sector converge their value proposition. OEMs and energy suppliers are beginning to offer their customers integrated energy solutions (including xEV charging) • Rely on specialized ecosystem actors for these solutions, often forming co-creation partnerships	• Focused suppliers generate revenues by licensing their technologies, conducting development projects with customers and obtaining research grants

(*continued*)

Table 3.

	Strategic influences on BM design	Value creation	Value proposition and delivery	Value capture
RET	• Technological and financial feasibility • In addition to OEMs, they depend on energy providers	• Collaborate with subsidies of the affiliated OEMs that provide charging solutions • Cooperate with start-ups to reduce dependence	• Offer charging infrastructure and equipment	• Yet unclear, not profitable so far
FO	• xEVs as a means to satisfy the requirements of customers, shareholders, and stake-holders regarding ecological sustainability • Integrating xEVs into vehicle fleets requires commitment from upper management. However, initial investments (e.g. vehicle costs, rapid devaluation of vehicles, infrastructure) and the reliability of xEVs are still concerns	• They are establishing their own proprietary charging infrastructure to include a substantial percentage of xEVs in their fleets. A supporting factor for this is the predictability of driving distances and routes • The shift toward xEVs was made gradually to gain experience with the new technology. Activities outside the companies' areas of expertise are handled by ecosystem partners (e.g. xEV maintenance)	• Use xEVs to provide more sustainable mobility solutions for their company operations • Through resilient and readily available proprietary charging infrastructure and customized solutions for booking and billing charging operations, the ease of use of xEVs is ensured	• Handling electric charging purely through charging infrastructure providers was considered too expensive compared to having proprietary charging infrastructure • Although not yet comparable to other vehicles (e.g. due to initial investments for xEVs and infrastructure), the total costs of ownership for xEVs are becoming attractive. However, operating xEVs is only considered financially viable in the long run
EC(e)	• Shifting too far away from their core competencies and competing with OEMs is unattractive • Although the market for xEVs is seen as promising, ECs see the need to offer reliable technological solutions that can recoup investments	• Proactively install electric charging infrastructure • Energy companies collaborate to increase overall coverage of charging infrastructure • The number of suppliers for xEV technologies in the ecosystem has increased	• Offer public infrastructure and solutions for electric charging to B2B (e.g. closed off company-infrastructure) and B2C customers (e.g. domestic charging solutions) • ECs see potential in offering "complete" solutions to bind customers to the company	• Efficient monitoring, booking, and billing of infrastructure require digital solutions. Current energy prices are seen as potentially too low for large-scale xEV charging. However, providing energy for xEV charging is perceived as an attractive business • Cost efficiency could be improved by integrating xEVs in the energy grid and managing charging loads

(*continued*)

	Strategic influences on BM design	Value creation	Value proposition and delivery	Value capture
EC(p)	• *No significant changes*	• Partly build up new competencies but predominately rely on suppliers for technological solutions	• *No significant changes*	• *No significant changes*
INF	• They experience significant influence from their shareholders (primarily companies from the energy and technology sectors). Try flexibly addressing customer requirements by providing financially feasible and technologically robust solutions with its ecosystem partners • See the need for higher volumes of xEVs to ensure the viability of xEV technologies	• Perform funded research projects with multiple partners and rely on its partner network for innovations • The overall aim is to quickly establish a minimum viable product that can be tested with customers • Act as coordinator for several suppliers to offer customers charging solutions	• Offer (semi-) public charging solutions to B2C customers that customers of other charging companies can also access for a fee • Establish and operate electric charging infrastructure for B2B customers and municipalities • They also provide “white label” products to ECs and support customers with digital solutions and processes	• They are generating revenues through “basic fees,” fees for electric charging, and through cooperation with OEMs • Aim to mitigate investments in the energy grid using “intelligent” solutions (e.g. flattening load curves)

Source(s): Own elaboration

Table 3.

Infrastructure Companies (INF) are tasked with providing user-friendly charging solutions and navigating the influence of OEMs in the ecosystem. As OEMs increasingly enter the charging infrastructure sector, INF find themselves engaged in a balance of cooperation and competition.

Condensing Table 2, Figure 2 presents the identified most significant interactions and dependencies in the xEV ecosystem based on the follow-up workshops.

4.2 Changes in business model design and strategic influences (RQ 2)

Table 3 gives an overview of *Strategic Influences on BM Design, Value Creation, Value Proposition and Delivery,* and *Value Capture,* separated for the different ecosystem roles and shows the condensed categories for each actor type. As for Table 2, we summarize the most prominent contents below.

OEMs are strategically focusing on scaling up xEV technology and charging infrastructure. They recognize the critical importance of timing in scaling up these technologies, such as incorporating electric drivetrains. Additionally, OEMs are increasingly reliant on partnerships with other ecosystem actors to offer complementary solutions, such as electric charging infrastructure, in their pursuit of holistic xEV offerings to satisfy evolving customer demands and regulatory requirements.

ETPs face significant uncertainty stemming from competing technologies in the xEV landscape. They rely on profits from traditional petrol-based technologies to finance a diverse portfolio of xEV-related innovations. Collaborative efforts with RI, start-ups and other partners, as well as acquiring companies, are measures to augment ETPs' capabilities.

RI observed that xEVs are primarily utilized for portraying a positive image and report uncertainty surrounding the dominance of specific xEV technologies. They report from endeavors to maximize profits from traditional petrol-based vehicles while striving to make xEVs commercially viable.

SUPs, especially those focusing on xEV technologies (SUP(e)), establish independent organizational units and aim for modularization to streamline component production for both xEVs and traditional vehicles. They collaborate extensively with RI, engineering and technology providers, and other partners to enhance their capabilities and navigate the complexities of the xEV ecosystem.

Retailers (RET) rely on collaborations with OEMs to provide charging solutions, aiming to reduce dependence on external infrastructure providers. FO gradually integrate xEVs into their fleets, with a particular emphasis on establishing proprietary charging infrastructure to ensure reliability and cost-effectiveness.

Electric energy companies (EC(e)) focus on offering reliable technological solutions to recoup investments while increasing overall coverage of charging infrastructure through collaboration with other ecosystem partners. They aim to deliver value to customers through efficient monitoring, booking and billing of infrastructure. Meanwhile, petrol energy companies (EC(p)) endeavor to build new competencies while primarily relying on suppliers for technological solutions.

INF play a pivotal role in coordinating suppliers and offering charging solutions to both business and consumer customers, generating revenue through various fee structures while leveraging intelligent solutions to mitigate investments in the energy grid.

Figure 3 subsumes Table 3 regarding the alignment of Business Models in the xEV ecosystem b and highlights the most important interdependencies across actors.

Table 4 presents the degree of business model changes for the investigated actor types. Change intensity is characterized by the scope of business model change and the novelty of a business model to a company or industry. The typology used is based on characterizations of business model changes by Foss and Saebi (2017). RI were left out of this analysis due to a lack of changes in the business models of the investigated actors.

Business model change type	Change intensity	Planned outcome	Roles in ecosystem	Position in ecosystem
Business model evolution	New to company	Minor adjustments	Providers of engineering and technology (ETP)	Upstream
			Established automotive suppliers (SUP)	Upstream
			Energy companies (petrol) (EC(p))	Downstream
Business model adaptation	New to company	Align with environment	Original Equipment Manufacturers (OEM) (Core Business)	Central
Focused BMI	New to industry	Disrupt market conditions	Energy companies (electric) (EC(e))	Downstream
			Fleet Operators (FO)	Downstream
Complex BMI	New to industry	Disrupt market conditions	Focused suppliers of xEV technologies (SUP)	Upstream
			Infrastructure companies (INF)	Downstream

Source(s): Own elaboration

Table 4. Degree of business model change, according to Foss and Saebi (2017)

5. Discussion and conclusion

5.1 Ecosystem roles and degree of BMI

The ability and incentive to change business models may depend on the actor's specific type, role and ecosystem position. Upstream actors tend to perform more evolutionary or adaptive approaches in changing their business models. Downstream ecosystem actors rather perform more focused or complex BMI, as described in Table 4 (Saebi *et al.*, 2017; Foss and Saebi, 2017). The results of the actor interactions extend recent findings in emerging manufacturing ecosystems literature, such as Kazantsev *et al.* (2023), as an individual actor becomes increasingly challenging. Hence, companies must (1) develop their business models with respect to their ecosystem and (2) rely on upstream and downstream external actors for network-based BMI.

The results indicate that the influence of individual actors on other ecosystem actors' business models is closely related to their ecosystem position and the actor's ability to create value (Adner and Kapoor, 2010). Central actors – in our case, mainly automotive OEMs – taking on the role of an ecosystem leader could be particularly well suited to pursuing this undertaking. Specifically, central ecosystem leaders could influence upstream suppliers to ensure the alignment of the actors' business models (Adner, 2017). As indicated in Table 4, we confirm extant research that upstream actors adopted or evolved their business models rather than downstream actors (Saebi *et al.*, 2017). Concerning downstream actors offering complementary value, ecosystem leaders could pursue a keystone approach (Iansiti and Levien, 2004) to improve ecosystem health. Our data suggest that aligning downstream actors to fulfill the ecosystem value proposition requires high degrees of BMI or even actors who introduce new business models to the industry (Saebi *et al.*, 2017).

These results extend the insights provided by Foss and Saebi (2017) in two ways. First, our data on the actors' business models indicate that the actors' influence and ecosystem position affected their incentive and ability to influence the business models of other ecosystem actors. Second, the degree of business model change necessary to establish alignment to fulfill an ecosystem value proposition seems to depend on the actor's ecosystem position. As Fjeldstad and Snow (2018) note, for ecosystems confronted with technological shiftsincremental BMI to match external conditions might be insufficient. We give further insights regarding this evaluation, highlighting that downstream ecosystem actors tend to require focused or complex BMI. In contrast, upstream actors are instead often engaged in business model adaptation, as illustrated in Table 4. This outcome highlights the relationship between the structure and governance of an ecosystem with the changes in the involved actors' business models.

For some ecosystem members, the involved technologies pose considerable challenges while they provide little objective value. As the results suggest, smaller suppliers with different business models have less impact and benefits and must thus be integrated into the entire ecosystem (Kazantsev *et al.*, 2023; Schmidt *et al.*, 2023).

5.2 Ecosystem change and governance

The results demonstrate that aligning business models to overcome bottlenecks in creating ecosystem value might be particularly challenging, as this alignment must be established nearby, i.e. locally and temporally. Actors that aim to contribute value to an ecosystem focused on technological innovation are confronted with many uncertainties influencing their business model change activities. These uncertainties are primarily rooted in customer requirements and the type and timing of technologies when participating in an ecosystem, as illustrated in *Strategic Influences on Interactions* in Table 2.

Regarding ecosystem governance, OEMs facilitate changes in the ecosystem's architecture, as described for OEMs in Table 2. These changes aim, e.g. to shorten development processes and modularize offers. Companies pursue modularized offers to adjust their business models in response to technological developments and customer demand. Moreover, modularity could support the coordination and exchange of values between ecosystem actors (Jacobides *et al.*, 2018).

The results concerning the actors' business models indicate that their position in the ecosystem (Table 4) also influences their abilities to change their business models and the respective drivers (Table 3). OEMs pursued different strategies in the upstream and downstream ecosystems. This finding is also reflected in the respective business models they pursued. Their business models were designed to introduce xEVs in the market. They were primarily adapted concerning how they could create value compared to their further business models, as described in Table 3. However, OEMs as central ecosystem actors must introduce additional business models to provide complementary offers for xEVs on a large scale. In our case, they do so by forging collaborations and facilitating the introduction of separate actors who could provide complementary offers as the main value proposition, making the ecosystem value proposition for xEVs more attractive (Aaldering *et al.*, 2019). The results further indicate that upstream actors performed lower degrees of business model change than downstream actors, as shown in Table 4.

Moreover, the results suggest that ecosystem leaders, such as OEMs, must coordinate actors and align their business models with overcoming relevant bottlenecks simultaneously, ensuring the ecosystem's overall health (Dattee *et al.*, 2018). Therefore, successful ecosystem strategies must consider all the necessary actors' business models to be critical (Adner, 2017). Establishing good alignment among actors' business models might help create an attractive value offer (Adner, 2017) and encourage additional actors to participate in the ecosystem (Dattee *et al.*, 2018).

Finally, the findings support the notion that management commitment is a prerequisite for changing business models (Saebi *et al.*, 2017; Witschel *et al.*, 2023) and aligning them to fulfill a joint ecosystem value proposition (Adner, 2017; Talmar *et al.*, 2018). The data indicate that this particularly applies to business models contributing to an ecosystem for technological innovation in its early stages, as the actors potentially face substantial uncertainty. This extends the findings on challenges of bottlenecks and requirements of orchestrating different organizational cultures and approaches to ecosystems (Kazantsev *et al.*, 2023). This is particularly relevant as different types of ecosystem bottlenecks (Adner and Kapoor, 2010) may exist simultaneously, e.g. upstream and downstream complement bottlenecks. Adner (2017) noted that some bottlenecks could be partly due to technological difficulties. Other bottlenecks might stem from difficulties coordinating systems and the late emergence of respective markets (Adner, 2017). The latter two factors arguably relate to the misalignment of the ecosystem actors' business models in our research setting.

5.3 Theoretical contribution

This research derives results from 27 ecosystem members covering the most relevant roles of an xEV ecosystem, representing one of the most detailed analyses of an ecosystem to this date in comparison to extant research (e.g. Hoch and Brad, 2020; Palmié *et al.*, 2022; Yi *et al.*, 2022).

Our research contributes to the nascent research stream of manufacturing ecosystems. While Kazantsev *et al.* (2023), Schmidt *et al.* (2023) or Suuronen *et al.* (2022) describe Industry 4.0 technologies, such as digital platforms, as enablers for manufacturing ecosystems, we highlight the shift to a new vehicle propulsion technology as supporting the further transition of a manufacturing ecosystem. This is because new entrants are required for xEV technologies to enter the ecosystem, as mentioned in Table 2 and 3,for providers of engineering and technology, RI and established automotive suppliers.

We further contribute to understanding ecosystem governance (Ates *et al.*, 2023) and extend Riasanow *et al.* (2021) in understanding distinct manufacturing ecosystem characteristics, especially automotive manufacturing ecosystems. The role of the central actor and the trust and interaction with the OEM seems particularly important in the automotive industry due to its often still hierarchical structure, extending Das and Dey's (2021) non-industry-specific assessment. Further, while several authors rely on literature reviews (e.g. Das and Dey, 2021; Schmidt *et al.*, 2023; Suuronen *et al.*, 2022), we are able to present empirical insights from an entire ecosystem rather than single actors (e.g. Ates *et al.*, 2023).

The empirical results connect two largely distinct constructs: business models and ecosystems (Moore, 1996; Iansiti and Levien, 2004). The results extend the understanding of business model change to align with the environment (Saebi *et al.*, 2017; Foss and Saebi, 2017). The findings further contribute to this nascent field in the literature by providing evidence that the environmental alignment of individual business models is insufficient. Instead, individual actors must consider business models in their ecosystem (Adner, 2017) and ensure the overall alignment of their individual business models in the automotive industry (Secinaro *et al.*, 2020).

5.4 Managerial implications

The study offers insights into the automotive industry's transition to electric vehicles. Practitioners must be aware of the chosen ecosystem's characteristics concerning their business models, which is relevant because ecosystems can involve actors and their business models from several newly included industries.

First, when multiple actors start to engage in activities to contribute to a joint ecosystem value proposition (Adner, 2017; Talmar *et al.*, 2018), practitioners might need to consider that the individual actors' business model change activities (Saebi *et al.*, 2017; Foss and Saebi, 2017) must be governed to ensure that individual contributions add to the ecosystem value proposition. Practitioners must also be aware of the potential misalignment of the individual actors' business models.

Second, the analyses presented in Figures 2 and 3 could serve as a starting point to consider the state of an ecosystem and could offer guidance to practitioners who aim to address misaligned business models in a coordinated manner. This could prevent spending time or resources on resolving isolated bottlenecks and creating ecosystem value while failing to ensure an attractive value offer. Leading ecosystem actors who take on the role of ecosystem governance could be particularly well suited for this undertaking.

Third, the data indicate that changes in business models to establish alignment with other actors and provide a joint ecosystem value proposition seem to depend on the specific position and type of ecosystem actor. As discussed, upstream actors tend to take more evolutionary or adaptive approaches to change their business models. In contrast, actors downstream pursue focused or complex BMI (see Table 4). In addition, central ecosystem actors wield substantial influence and control a significant number of resources. Thus, they possess the position to adopt or introduce business models to fulfill specific ecosystem functions. Therefore, practitioners are presented with a starting point when considering which approach to BMI could suit their particular circumstances.

5.5 Limitations and further research

The major limitation of this research is that it exclusively relies on qualitative data. Publications combining business models and ecosystems represent a nascent stream in extant literature (Adner, 2017). Thus, a qualitative approach was deemed suitable to generate novel insights through a case-study approach (Yin, 2017). An extensive database of 27 ecosystem actors was established, relying on data from interviews with 46 respondents and a workshop with industry professionals. Further, detailed arguments were provided regarding the chosen methodological approach and data-source selection. Rich data were gathered from multiple sources, allowing for the replication of findings between similar cases. In addition, triangulation in terms of the chosen methods, informants and researchers was applied whenever possible.

The case study within Germany and Austria limits the generalizability of the study findings. Due to the likely differences in market behavior, industry structure and regulatory regimes between individual geographic regions and technological settings, the findings might not fully apply in other regions or technological settings. To explore the issue further, future research could be performed that considers the insight from additional ecosystem actors (e.g. private customers of xEVs or new OEMs and suppliers entering the ecosystem). Moreover, this study could be repeated in diverse empirical settings to gain broader insight into the relationships between business models and ecosystems. This could include different geographical settings, e.g. automotive manufacturing ecosystems worldwide or alternative technological transitions. In addition to qualitative approaches, quantitative inquiries on comparable ecosystems could provide interesting insights in this context.

Further, as the data were collected over a limited time frame, they do not allow for a process perspective. Important further influences, such as the governmental or political perspective, were only uncovered in the later stages of research. Those aspects could be enhanced in a long-term perspective on the evolution of the ecosystem. As the collected primary data only allow for a snapshot of the ecosystem state and the involved actors' business models, process studies on the investigated relationships between business models and ecosystems might yield novel insights. Therefore, investigations that rely on consistently available secondary data and cover more extended periods might be examples of a feasible approach that can be taken to investigate the processes and dynamics of an ecosystem and its actors' business models. While qualitative research is well suited for nascent research fields, a mix of qualitative and quantitative or even fully quantitative investigations based on this research could provide additional insights.

The findings could further be transferred to other settings concerning the literature emphasizing the external orientation of business models (Saebi *et al.*, 2017) and the alignment of ecosystem actors (Adner, 2017; Talmar *et al.*, 2018). Examples include ecosystems that have formed around a technological innovation (Dattee *et al.*, 2018; Dedehayir *et al.*, 2018). Further, those examples could face similar shortcomings concerning the structure of actors providing components and complementary offerings to add value with their business models to the ecosystem value proposition (Adner, 2017; Talmar *et al.*, 2018; Jacobides *et al.*, 2018). This situation might be particularly applicable where regulators, standardization bodies, laws, social behaviors and business ethics impose similar constraints on ecosystem actors. In these cases, actors are confronted with similar rules, providing productive grounds to transfer the insights to the respective settings.

Finally, an extension to the ecosystem perspective on xEVs could be the recycling or Circular Economy aspect of batteries, xEVs as part of hydrogen ecosystems, or including sustainable business models driven by regulation in the automotive industry. Such a perspective could help to better understand recent developments in sustainable mobility and academic research toward sustainability aspects in BMI.

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(The Appendix follows overleaf)

Appendix 1

Actor	Description	Participant	Duration (h:min)	Form of interview
OEM alpha	Automotive OEM	Team leader engineering	n.a.	In person
OEM alpha	Automotive OEM	Team leader engineering	n.a.	In person
OEM beta	Automotive OEM	Manager engineering	0:43	Via phone
OEM beta	Automotive OEM	Manager engineering	0:38	Via phone
OEM gamma	Automotive OEM	Manager engineering	1:15	Via phone
OEM delta	Automotive OEM	Managing director engineering	1:09	In person
ETP alpha	Engineering and technology provider (Subdivision 1)	Manager engineering	1:10	In person
ETP alpha	Engineering and technology provider (Subdivision 1)	Team leader	0:41	In person
ETP alpha	Engineering and technology provider (Subdivision 1)	Team leader	0:45	In person
ETP alpha	Engineering and technology provider (Subdivision 2)	Manager	1:04	In person
ETP alpha	Engineering and technology provider (Subdivision 2)	Team leader	0:55	In person
ETP alpha	Engineering and technology provider (Subdivision 2)	Manager engineering	1:08	In person
ETP alpha	Engineering and technology provider (Subdivision 2)	Manager sales	0:48	In person
ETP beta	Engineering and technology provider	Team leader engineering	0:44	In person
ETP beta	Engineering and technology provider	Manager	1:05	In person
RI alpha	Research institute	Professor	1:00	In person
RI beta	Research institute	Team leader	0:47	In person
SUP(e) alpha	Tier 1 supplier	Team leader	1:05	In person
SUP(e) alpha	Tier 1 supplier	Team leader	0:45	In person
SUP(e) alpha	Tier 1 supplier	Vice president	0:36	In person
SUP(e) beta	Tier 1 supplier (Subdivision 1)	Team leader	0:56	In person
SUP(e) beta	Tier 1 supplier (Subdivision 1)	Head level	0:39	In person
SUP(e) beta	Tier 1 supplier (Subdivision 1)	Team leader engineering	0:37	In person
SUP(e) beta	Tier 1 supplier (Subdivision 2)	Team leader engineering	1:14	In person
SUP(e) beta	Tier 1 supplier (Subdivision 2)	Team leader	1:21	In person
SUP(e) beta	Tier 1 supplier (Subdivision 2)	Manager mobility	1:21	In person
SUP(e) beta	Tier 1 supplier (Subdivision 2)	Head of strategy	1:26	In person
SUP(e) gamma	Tier 2 supplier	Managing director	1:18	In person
SUP(e) delta	Tier 2 supplier	Team leader innovation	0:42	Via phone
SUP(f) epsilon	Focused technology supplier	Manager engineering	1:04	Via phone
SUP(f) zeta	Focused technology supplier	Managing director	1:26	In person
SUP(f) zeta	Focused technology supplier	Business development	1:22	In person
RET alpha	Automotive retail	Manager	n.a.	In person
RET beta	Automotive retail (subsidiary)	Managing director	1:16	In person
FO alpha	Fleet operator	Manager operations	1:28	In person
FO alpha	Fleet operator	Team leader operations	1:15	In person

Table A1.
Participants

(*continued*)

Actor	Description	Participant	Duration (h:min)	Form of interview
EC(e) alpha	Energy company and charging infrastructure	Manager Electric mobility	0:59	In person
EC(e) beta	Energy company and charging infrastructure	Head of mobility and infrastructure	1:03	In person
EC(e) beta	Energy company and charging infrastructure	Manager mobility and infrastructure	1:26	In person
EC(e) gamma	Energy company and charging infrastructure	Team leader business development	1:12	In person
EC(p) delta	Petrol and energy	Senior director	0:47	Via phone
EC(p) epsilon	Petrol and energy	Head of new energy	0:47	Via phone
INF alpha	Public infrastructure	Team leader infrastructure	1:34	In person
INF beta	Charging infrastructure	Team leader operations	0:37	Via phone
INF beta	Charging solutions	Team leader operations	0:53	In person
INF delta	Charging solutions	Managing director	2:22	In person

Source(s): Own elaboration

Table A1.

Appendix 2
Interview guideline

(1) Questions relating to role and experience

(2) Strategic influences on interactions (RQ 1)

- How do you assess the impact of external influences (e.g. stakeholders, political influences)?
- How does your company deal with technological innovations related with electromobility?
- Are these technological changes more likely to stem from the environment of company or from your company itself?
- What concrete measures are you taking to respond to changes in technological conditions (regulatory interventions, changes in customer behavior, . . .) to be able to react appropriately?
- Where do you see the risks in the introduction and application of new technologies?

(3) Business Model Innovation: Overview (RQ 2)

- What does your company's business model look like?
- How does your company create value for its customers?
- How do you generate revenue from this benefit? (*Value Proposition, Value Creation, Value Capture)*
- How do you assess the need to adapt or revise the current business model for your company?
- Which triggers have led to changes in your company's business models?
- How have technological changes in the past impacted your company's business models?

(4) Strategic Influences on Business Model Design (RQ 2)

- Which specific changes in the business model were triggered by electrification of vehicles?
- What is the impact of electrification on the benefits that your company generated for customers (value proposition, products)?

- Which services relevant to your company's success (products, services) do you source from your value network?
- What services do you provide to customers in your value network?
- How would you assess the influence of your business environment (ecosystem) on your business model?
- How would you assess the impact of your company on business models by business partners in the corporate environment?
- How do you assess the influence of the environment (e.g. network, suppliers, partners, customers, stakeholders, . . .) of your company on the information provided by your company.?
- How does your company influence the development of technologies in your environment (e.g. network, suppliers, partners, customers, stakeholders, . . .)?

(5) Change of Ecosystem Value Creation Architecture (RQ 1)

- What role do competitors play for your company?
- What were the most relevant influences during the period under review?
- How would you improve the relationship with partners in the corporate environment?
- Which are the influential actors in the business environment (Ecosystem) of your company?
- Which are specific partners or companies you work with?
- Which activities in the value chain are covered by the cooperation with the respective partners or companies?
- What do you see as the main reasons for working with the respective partners or companies?
- What role does your company play in its business environment (Ecosystem)?
- How would you estimate the impact of your company on partners in the business environment (Ecosystem)?
- How would you reduce your company's dependence on partners?

(6) Governance and Type of Interactions (RQ 1)

- What major changes have there been in your business environment/ecosystem in recent years (changes in partners, changes in cooperation with partners, changes in the services offered by partners)?
- From your point of view, what were the reasons for changes in the cooperation?
- How do you assess the effect of external influences (e.g. stakeholders, political influences) on cooperation with companies from your company's value network?
- With regard to the electrification of vehicles, what were the main influences on your cooperation with partners in the corporate environment (Ecosystem)?
- With regard to the interaction with your Ecosystem, which actors govern interactions and cooperation and how?

Source(s): Own elaboration

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