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ORIGINAL RESEARCH ARTICLE

Leadership Cognition as A Driver of Ecosystem Strategies in Sustainable Business Ecosystems

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Abstract

This paper identifies the cognitive capabilities of leaders that enable them to implement ecosystem strategies in sustainable business ecosystems. We analyze the relation between three concepts – cognitive capabilities, ecosystem strategies, and sustainable business ecosystems – in the empirical context of autonomous electric vehicles (AEVs). We used Factiva and online video material to analyze data on the ecosystem strategies of Tesla and General Motors (GM) and their leaders' cognitive capabilities from 2020 until 2024. Our results show that GM applies a component strategy, collaborating with other firms in the ecosystem, whereas Tesla implements a system strategy, developing most of its technologies in-house with a focus on competition over collaboration. Tesla takes on the role of ecosystem orchestrator, setting the standard for electric vehicle charging and autonomous technology. While cognitive empathy – which includes stakeholder cooperation, building trust, and encouraging others' initiative – supports a component strategy, a system strategy is driven by a future orientation that involves foreseeing novel AEV technologies, advancing an ecosystem vision, and persuading others to embrace that vision. Our study makes a novel contribution by linking specific cognitive capabilities to distinct ecosystem strategies in sustainable business ecosystems. By grounding this relationship in the dynamic managerial capabilities' framework, we highlight the microfoundations through which leaders shape ecosystem strategies in sustainability contexts.

Keywords: *Cognitive capabilities; Ecosystem strategies; Autonomous electric vehicles; Sustainable business ecosystems*

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Leaders need to become increasingly adept at using technologies to create sustainable value for their stakeholders. Consumers, supply chain partners, and regulators frequently demand more sustainable products. Transitions toward sustainable modes of production and consumption are multidimensional and socio-technical, cross industry boundaries and require leaders to engage in ecosystem strategizing with diverse actors (Culot & Battistella, 2024; Markard et al., 2012). Firms need to integrate sustainable technologies into collective value propositions in sustainable business ecosystems.

However, two important gaps exist in the literature, hindering our understanding of how leaders develop effective strategies in sustainable business ecosystems. First, while prior research has identified ecosystem strategies in business ecosystems for economic value, it remains unclear how these strategies materialize in sustainable technology contexts. Current ecosystem strategies include system strategies, in other words, a focus on multiple ecosystem components, in-house production, and competition; component strategies, that is, a focus on fewer ecosystem components and collaboration; and ecosystem orchestration (Hannah & Eisenhardt, 2018). Ecosystem orchestrators are keystone players in the configuration of ecosystems (Theodoraki et al., 2022, p. 355). Assuming the automatic transferability of these strategies to sustainable ecosystems is problematic because sustainability introduces a different strategic purpose: the collective creation of environmental value as opposed to a sole emphasis on economic value. For instance, the exploitation of bottlenecks in ecosystems for economic value may stall collective progress in sustainable ones in which the resolution of bottlenecks by orchestrators is critical for environmental value creation rather than their exploitation. Similarly, system strategists who typically seek control by minimizing dependence on rivals (Hannah & Eisenhardt, 2018) may, in sustainable technology contexts, depend on rivals adopting their standards to resolve bottlenecks. A similar tension emerges with component strategies.

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While they are typically understood as mechanisms of specialization and differentiation (Hannah & Eisenhardt, 2018), in sustainable ecosystems, they may need to reduce costs because emerging technologies such as autonomous electric vehicles (AEVs) lack economies of scale. Such tensions suggest that ecosystem strategies designed around economic value cannot fully explain strategies that must also serve an environmental purpose.

Second, we lack a clear understanding of how leaders' capabilities shape ecosystem strategies in sustainable business ecosystems. Prior research shows that leaders with dynamic managerial capabilities – the ability to sense and seize opportunities and reconfigure assets – are effective in ecosystems for economic value (Teece, 2007). More recently, scholars have argued for analyzing the microfoundations of dynamic managerial capabilities, and hence managers' cognitive capabilities that underpin their dynamic managerial capabilities (Bacha & Niesten, 2024; Helfat & Martin, 2015; Helfat & Peteraf, 2015). Cognitive capabilities help leaders perceive their environment, solve problems, cooperate, communicate, or build trust, thereby shaping how they sense and seize opportunities and reconfigure assets (Helfat & Peteraf, 2015). While this perspective has clarified how cognitive capabilities impact firm strategy (Eisenhardt et al., 2010; Furr & Eisenhardt, 2021), it remains unclear how these capabilities impact ecosystem strategies (Gomes et al., 2021; Han et al., 2025; Helfat & Raubitschek, 2018; Krome & Pidun, 2023). Importantly, assuming that the same cognitive capabilities are sufficient in sustainable ecosystems is problematic because sustainable technologies introduce a distinct strategic purpose of balancing economic and environmental objectives. To study what unique cognitive capabilities drive what type of ecosystem strategies in sustainable ecosystems, we rely on emerging research on cognitive capabilities relevant to implementing sustainable technologies, such as cognitive empathy and future orientation (Nair & Bhattacharyya, 2022). This perspective enables us to analyze how leaders' cognitive capabilities drive strategies that integrate sustainable technologies in ecosystems.

We aim to answer the following research question: *what cognitive capabilities do leaders use to implement ecosystem strategies in sustainable business ecosystems?* In addressing this question, we make several contributions to the literature. First, we advance our understanding of ecosystem strategies – component, system, or orchestrator roles – that firms adopt to co-create sustainable value, responding to calls for more research on ecosystems for the planet (Josserand et al., 2024; Snihur & Bocken, 2022). Second, we identify the cognitive capabilities leaders employ to implement these strategies. These insights contribute to emerging literature on cognitive capabilities for sustainable technologies and on microfoundations that drive ecosystem strategies.

Theory

Ecosystem strategies and sustainable business ecosystems

A business ecosystem is a group of interacting firms performing activities, such as producing products and services, which together comprise a coherent solution aimed at value creation and value capture (Hannah & Eisenhardt, 2018). It does not only comprise heterogeneous actors but also the technologies, regulations, and physical infrastructures with which these actors interact (Demil et al., 2018). A firm chooses an ecosystem position and has direct and indirect links with complementary partners to deliver a collective value proposition (Adner, 2017; Shipilov & Gawer, 2020). Within these business ecosystems, firms adopt different ecosystem strategies, which reflect their decisions on where to position themselves in the ecosystem, that is, whether to concentrate on one component or diversify into multiple components, and how to govern their relations with partners, in other words, whether to collaborate or vertically integrate ecosystem components. In a component strategy, firms enter one or a few ecosystem components and collaborate with complementors, whereas in a system strategy, they enter multiple components and focus on competition (Hannah & Eisenhardt, 2018). Firms may also take on the role of ecosystem orchestrator and actively steer the development of the ecosystem by setting standards, creating or resolving bottlenecks, and mobilizing partners, which requires agility, customer orientation, and a vision for the ecosystem (Autio, 2022; Dattée et al., 2018; Jacobides, 2019; Radziwon et al., 2022).

Research on ecosystem strategies in sustainable business ecosystems is largely absent, despite their importance for understanding sustainability transitions – long-term, multidimensional transitions that create new interdependencies across industries (Culot & Battistella, 2024). In such transitions to sustainable technologies, firms must engage in ecosystem strategizing and manage the complexities of within-ecosystem collaboration. Recent work has called for more research on business ecosystems that create value for the planet (Snihur & Bocken, 2022). We define sustainable business ecosystems as those that integrate sustainable technologies into their value proposition, thereby creating and capturing both environmental and economic value. Our study contributes by examining what types of strategies are implemented in such ecosystems, and how these are shaped by leaders' cognitive capabilities.

Cognitive capabilities of ecosystem actors

Leaders with dynamic capabilities are more effective at shaping ecosystems (Teece, 2007). Such capabilities – defined as the capacity to sense and seize opportunities and reconfigure resources in changing environments (Mention et al., 2019; Teece, 2007; Teece et al., 1997) – were long studied at the firm level, but recent work analyzes leaders' dynamic managerial capabilities as well as the microfoundations of these capabilities that shape strategy at the level of the individual manager (Helfat & Peteraf, 2015).

In this paper, we rely on the study by Helfat and Peteraf (2015), which identifies different types of cognitive capabilities as the microfoundations of dynamic managerial capabilities for sensing, seizing, and reconfiguring (Table 1). Cognitive capabilities 'comprise the abilities to perform mental activities and use mental structures that play roles in cognitive representations of external realities' (Bacha & Niesten, 2024, p. 1048; Helfat & Peteraf, 2015, p. 833–835). The capacity to sense opportunities draws upon managers' cognitive capabilities for attention and perception, and thus, their abilities to focus on perceptual information, detect signals, and interpret this information in effective ways (Helfat & Peteraf, 2015). The capacity to seize opportunities relies on managers' cognitive capacity for problem solving and reasoning through controlled mental processing or automatic, heuristic-based information processing to make quick decisions (Helfat & Peteraf, 2015). The capacity to reconfigure assets relies on managers' communication and social cognition skills. Managers can inspire others with their vision and storytelling skills, encourage others to undertake new initiatives, orient them toward common goals, and collaborate or build trust in relationships (Helfat & Peteraf, 2015).

Cognitive capabilities for sustainable technologies

An emerging research field aims to illustrate how cognitive skills support the development and adoption of sustainable technologies. Loder et al. (2024) link executives' sensing capabilities – the cognitive processes involved in perceiving environmental changes – to firms' strategic realignment with low-carbon transitions, including electric vehicle development in the automotive sector. Nair and Bhattacharyya (2022) focus on three cognitive capabilities for green innovation. First, systems thinking is the ability to understand the social and ecological environment as a complex, adaptive system and to recognize interdependencies – particularly through stakeholder engagement (pp. 823, 825). Second, future orientation involves anticipating long-term changes and adopting forward-looking perspectives that guide the organization's actions for green innovation (pp. 822, 825). Third, cognitive empathy allows managers to adopt stakeholders' viewpoints, facilitating the integration of diverse knowledge essential for sustainable innovation (p. 826). Cognitive empathy resembles the skill of reflective capacity, which concerns managers with heightened stakeholder awareness and access to a broader range of information (Jia et al., 2021). CEOs with greater reflective capacity are more effective at addressing sustainability challenges (Jia et al., 2021). In this paper, we rely on this emerging research to explore if these cognitive capabilities for sustainable technologies also drive ecosystem strategies.

The impact of cognitive capabilities on ecosystem strategies

We analyze the impact of cognitive capabilities on ecosystem strategies by adopting a microfoundations perspective that identifies the underlying causes of strategic outcomes at the individual level (Eisenhardt et al., 2010; Felin et al., 2015). Research on cognition and strategy highlights how leaders 'strategize by thinking', using their mental models to guide decision-making (Furr & Eisenhardt, 2021, p. 1924). Managers with more complete and forward-looking mental models, such as blueprints or visions of the future, tend to create better strategies, as these models often serve as starting points for strategic choices (Furr & Eisenhardt, 2021). Cognitive capabilities also help leaders recognize opportunities, follow emerging technologies, and identify new markets, enabling strategic transformation (Cao et al., 2020). They are key to managing change, responding to uncertainty (Adner & Helfat, 2003; Cao et al., 2020; Zhang & Rajagopalan, 2010) and supporting innovation (Cao et al., 2020; Talke et al., 2010). In this study, we follow Helfat and Peteraf (2015) and argue that the cognitive capabilities that underpin sensing help spot and shape new opportunities, those for seizing drive strategic investment, and those for reconfiguring enable firms to realign assets and overcome resistance to change.

Table 1. Microfoundations of dynamic managerial capabilities: cognitive capabilities

Sensing opportunities and threats	Seizing opportunities	Reconfiguring assets
Attention: focused awareness on a subset of perceptual information by orienting to sensory events, detecting signals, and maintaining an alert state	Problem solving, reasoning, and decision-making: controlled processing and extensive analysis of multiple possibilities and automatic, heuristic processing and using short cuts to make quick decisions	Communication: persuading others; communicating a vision to inspire others, encourage initiative, drive entrepreneurial growth; storytelling to transfer knowledge, drive innovation, and mobilize around strategic problems
Perception: construction of meaningful information about an environment; rapid pattern recognition and data interpretation by experts		Social cognition: inducing cooperation among organizational members; understanding others; fostering trust and mutual understanding

Source: own elaboration, based on Helfat and Peteraf (2015).

Recent research has extended the analysis of cognitive capabilities – viewed as microfoundations that influence firm strategy – to examine them as proximate causes of changes in a firm's business model (Laszczuk & Mayer, 2020) and ecosystem (Cao et al., 2020; Foss et al., 2023; Helfat & Raubitschek, 2018). Gomes et al. (2021), in a qualitative study, identify cognitive capabilities such as sensemaking and theorizing as essential for learning and knowledge sharing among ecosystem partners. Earlier conceptual work has pointed to cognitive skills relevant for leaders in ecosystems, including opportunity recognition, problem solving, and decision-making (Nambisan & Baron, 2013), as well as innovation, environmental scanning, sensing, and integrative capabilities for orchestrating ecosystems (Helfat & Raubitschek, 2018). Han et al. (2025) identify a broad range of cognitive capabilities within top management teams that enhance effectiveness in ecosystems, such as the ability to detect problems, mobilize resources, build shared communication platforms, foster trust, attract partners, and engage them in a common vision. Despite these emerging insights, the field remains underdeveloped. A recent review highlights the need for further research on which capabilities drive effective ecosystem strategies (Krome & Pidun, 2023).

Conceptual model

Figure 1 visualizes the current state of the literature by highlighting both established knowledge and research gaps. On the left-hand side, we illustrate in blue that we build on existing knowledge on business ecosystems and ecosystem strategies, the impact of cognitive capabilities on ecosystem strategies, and cognitive capabilities for sustainable technologies and sustainable ecosystems. We also illustrate in red what the research gaps are: firms' ecosystem strategies in sustainable business ecosystems, and the type of cognitive capabilities that impact these strategies. Figure 1 also visualizes how we link these gaps to our conceptual model. On the right-hand side, in green, it illustrates that we aim to make a novel contribution by studying the relation between leaders' cognitive capabilities – as microfoundations of dynamic managerial capabilities for sensing, seizing, and reconfiguring – and ecosystem strategies in sustainable business ecosystems.

Recent studies have begun to analyze this relation. Chen et al. (2019) show that ecosystem strategies can foster sustainable development by building shared visions, common goals, cooperation, and trust among ecosystem members. Liu et al. (2022) complement this perspective by illustrating how leaders can create roadmaps for sustainable ecosystem evolution through cooperation, knowledge sharing, and tension reduction. Together, these contributions highlight the importance of ecosystem-level mechanisms for advancing sustainable technologies. At the same time, their studies do not rely on established conceptualizations of ecosystem strategies (Hannah & Eisenhardt, 2018) or integrate theory on cognitive capabilities (Helfat & Peteraf, 2015). Building on these foundations, we ground our study in theories on ecosystem strategies and cognitive capabilities and expand existing theory by filling in gaps in our knowledge on how cognitive capabilities impact ecosystem strategies in sustainable business ecosystems.

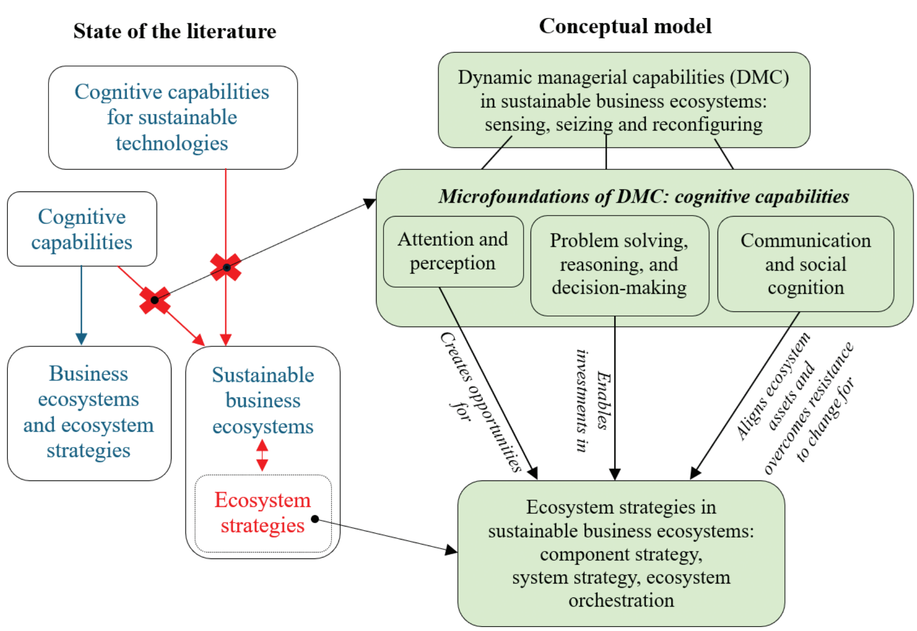

Figure 1. From literature insights and gaps to conceptual model.
Source: own elaboration.

Background on AEVs

The empirical context of our paper is the sustainable business ecosystem of AEVs, in which self-driving technologies such as artificial intelligence (AI), sensor technologies, and communication and computational resources are integrated in electric vehicles (EVs) (Thomson et al., 2022). Car manufacturers are integrating different levels of autonomy in EVs with the objective of obtaining full autonomy. The Society of Automotive Engineers International has identified six levels of autonomous driving. In levels 0 to 2, people are driving the vehicle and must constantly supervise the automatic support features. In levels 3 and 4, the vehicle can drive autonomously under limited conditions, and in level 5 under all conditions (SAE International, 2021).

Autonomous technologies in EVs are designed to optimize driving by improving traffic flow, reducing congestion, and making routes more energy efficient (Nastjuk et al., 2020). Self-driving can reduce carbon emissions and enhance affordability of mobility when autonomous vehicles are shared and connected (Jiang et al., 2023). These sustainability benefits directly align with the environmental goals of EVs, which produce zero emissions when in operation, contributing to a sustainable transport system (Alali et al., 2022).

Methods

Choice of firms and leaders

Our study operates at two levels of analysis: the ecosystem strategies of car manufacturers and leaders' cognitive capabilities. First, at the firm level, we selected General Motors (GM) and Tesla because they represent two distinctly different firms within the automotive industry. GM, with its extensive history as a traditional car manufacturer, illustrates the challenges and opportunities faced by established firms transitioning from internal combustion engine vehicles to electrification and new mobility solutions. In contrast, Tesla is a relatively young firm and a pure-play AEV manufacturer. Despite their differences, both firms are currently operating within the same sustainable business ecosystem and are facing comparable pressures related to electrification, autonomy, infrastructure development, regulatory demands, and standard setting. They are both visible actors in the AEV ecosystem and are led by leaders with contrasting public profiles. Other firms, such as Nissan, BMW, or Volkswagen, also produce EVs and have made significant contributions to the EV market, but they do not present the same stark contrast between legacy automaker and disruptor as GM and Tesla do.

Second, at the individual level, the leadership of these two firms is different. GM's current CEO has distinguished herself by steering GM toward a future focused on sustainability and electrification while also managing the complexities of a legacy car manufacturer. She started working at GM in 1980 and took over as CEO in 2014. In contrast, Tesla has been led by a serial entrepreneur whose leadership has developed Tesla from a start-up to a firm with a high market capitalization in the automotive industry, while at the same time building firms in the adjacent solar and energy industries. We expect these differences between firms and leaders to manifest in different cognitive capabilities and ecosystem strategies; however, such differences will need to result from our data collection and analysis.

Data collection

The limited empirical research on the microfoundations of dynamic capabilities typically relies on single-case studies (Albort-Morant et al., 2018). We use a multiple comparative case study design with data from Factiva and online video material. Prior studies have used Factiva data and online videos to measure cognitive capabilities and frames (Arrese & Vara-Miguel, 2016; Gamache & McNamara, 2019). They argue that data from letters to shareholders are a 'meaningful way of capturing managerial cognition' (Kaplan, 2008, p. 679). Factiva data and online videos have also been used to measure cognitive complexity of a CEO regarding sustainability initiatives (Gröschl et al., 2019). We follow the example of these studies by using data in which leaders are frequently being interviewed or quoted in shareholder meetings, investor days, quarterly earnings calls, and keynotes.

We implemented focused search criteria to narrow the scope of our data collection, targeting specific types of communication, time periods, and geographic regions to keep the dataset manageable yet rich in relevant descriptive content. Our study and its data collection are restricted to communication by leaders on their automotive firms reflecting their firms' strategies in the specific context of AEVs and do not extend beyond that focus. We restricted our data collection to the 5-year period 2020–2024 and explicitly do not include more recent developments from 2025 onward. In 2020, policy developments across the United States and Europe established foundational frameworks for autonomous vehicle (AV) deployment, marking this year as an ideal starting point for our analysis. In the United States, the National Highway Traffic Safety Administration introduced AV Guidelines 4.0, prioritizing safety and data privacy standards for automated driving systems (NHTSA, 2020). Exemptions within the Federal Motor Vehicle Safety Standards allowed AVs to be tested without traditional controls like steering wheels and pedals, paving the way for more innovative designs (NHTSA, 2020). In Europe, the United Nations Economic Commission for Europe (UNECE) WP.29 framework for automated driving systems introduced standards around emergency response protocols, providing essential regulatory consistency for AV developers (Fernandez Llorca & Gómez Gutiérrez, 2021). Appendix 1 visualizes the timeline of events at Tesla and GM and illustrates that from 2020 onward, EVs integrate autonomous technology. We also restrict our data to Western markets, due to differences between ecosystem strategies in different regions; for example, in China, stringent regulations focus on local partnerships and compliance.

In Factiva, we employed the following search query for Tesla: 'Musk AND Tesla AND (electric vehicle* OR electric car*) AND (autonomous driv* OR self driv* OR self-driv* OR autonomous technolog* OR autonomous vehicle*) AND (ecosystem OR partner* OR collaborat* OR alliance)', which yielded 3,614 articles. For GM, the search terms used were: 'Barra AND (GM OR General Motors) AND (electric vehicle* OR electric car*) AND (autonomous driv* OR self driv* OR self-driv* OR autonomous technolog* OR autonomous vehicle*) AND (ecosystem OR partner* OR collaborat* OR alliance)', which resulted in 1,110 articles. We conducted a manual review of all articles excluding those where the occurrence of the specified keywords was coincidental (Gamache & McNamara, 2019) and not directly relevant to Tesla or GM.

We also used online video material containing interviews with the two leaders discussing their firm's strategy for AEVs. One reason for using videos is the argument by Helfat and Peteraf (2015) that CEO oral communication is very effective at capturing cognitive capabilities because it relies 'less on controlled mental processing compared to written communication' (Choudhury et al., 2019, p. 1707). In addition, using video data avoids the social desirability bias in survey research, has greater validity than self-reported measures, and mitigates concerns about data sterilization frequently occurring in written data (Gupta et al., 2019; Petrenko et al., 2016). Finally, the videos enabled us to triangulate our data with the written statements by the CEOs and ensure consistency of our findings. It has been shown that coding of CEO videos exhibits a strong correspondence with archival indicators (Gupta et al., 2019). Table 2 summarizes the amount of data we have used in our analyses, and Appendix 2 lists the Factiva and video data sources referenced in the results.

Data coding and analysis

Table 3 describes the codes that we have used in NVivo to analyze our data. Since ecosystem strategies are defined by the degree of cooperation versus activity integration and competition, and how many ecosystem components are covered by firms (Hannah & Eisenhardt, 2018), we code for inter-firm relations and presence in ecosystem components as shown in Table 3. We relied on Helfat and Peteraf (2015) to code the leaders' cognitive capabilities.

In line with our data collection, we restricted our coding to content related to AEVs and to statements and decisions expressed by leaders on their automotive firms' strategies. Coding was conducted through two methods: keyword searches in the Factiva transcripts and full reviews of the texts and videos to capture instances reflecting the meaning of our key concepts. Two researchers jointly conducted the coding, initially focusing on ecosystems, ecosystem strategies, and cognitive capabilities, as well as their interrelations. They met regularly to compare and align their coding, ensuring consistency (Cao et al., 2024). In the second phase, one researcher coded the CEOs' cognitive capabilities, while the other coded Tesla's and GM's ecosystem strategies. In the third phase, both researchers collaboratively reviewed the complete dataset to

Table 2. Data collection

Firm and time span	Archival documents	Archival video material (minutes)
Tesla (2020–2024)	376 files 1,210 pages 908,130 words	116.73
GM (2020–2024)	201 files 793 pages 428,220 words	95.88

Source: own elaboration.

Table 3. Data coding

Concepts	Codes used in NVivo
AEVs	Autonomous fleets, autonomous vehicles, self-driving vehicles
Ecosystems	Bottleneck, complement, component, orchestration, value capture, value creation, value proposition
Ecosystem strategies	*Inter-firm relations*: acquisition, merger, divestment, alliance, collaboration, cooperation, partnership, supplier, contract, competition, differentiation, integration *Ecosystem components*: distribution, marketing, production, R&D, retail, supply chain, activities, resources
Cognitive capabilities for sensing	Attention, awareness, detect signals, maintain an alert state, rapid pattern recognition, and interpretation
Cognitive capabilities for seizing	Problem-solving, controlled processing of multiple possibilities, reasoning, automatic, heuristic processing, make quick decisions
Cognitive capabilities for reconfiguring	Communication, inspire with a vision, encourage initiative, storytelling, persuade others, social cognition: cooperation, understanding others, mutual understanding, trust

Source: own elaboration.

code for the relationships between cognitive capabilities and ecosystem strategies. Finally, a comparative analysis was conducted. Although each firm and leader was coded separately, the two cases were compared to examine how variations in cognitive capabilities translated into different ecosystem strategies. While our empirical approach is exploratory and inductive – relying on qualitative data to identify how leaders' cognitive capabilities align with ecosystem strategies – to fill in the gaps in the literature, our conceptual framing also draws deductively on existing literature to locate the study within prior research. Hence, our design is best characterized as abductive (Timmermans & Tavory, 2012): iterating between theory and data to generate propositions rather than testing predefined hypotheses.

Results

We approach sustainable business ecosystems as those that integrate sustainable technologies in the ecosystems' value proposition. Tesla and GM contribute to such a value proposition in the AEV ecosystem, as is evident in our data. Tesla's objective for the entire ecosystem is 'to accelerate the growth of sustainable energy' (Factiva-010121NF), 'to maintain a forward-looking vision for sustainable transportation' (Factiva-072023F), and 'to impact not only the auto industry but also sustainable mobility of all kinds' (Factiva-082024W). On the other hand, GM focuses on how its position in the ecosystem contributes to a sustainable value proposition: 'Climate change is real, and we want to be part of the solution by putting everyone in an electric vehicle'. 'We are transitioning to an all-electric portfolio from a position of strength' (Factiva-112220JA). 'Sustainability is not just good policy. It's good business – good for the company, for employees, and for recruiting and retaining the best people' (Factiva-050124EN). Thus, we observe that both firms view their ecosystem as one focused on a sustainable value proposition, although from different positions in the ecosystem. In what follows, we describe their ecosystem strategies in this sustainable ecosystem.

Tesla's system strategy

Tesla implements a system strategy in the AEV ecosystem, characterized by in-house technology development and production in multiple ecosystem components, and limited collaboration but intense competition with other firms in the ecosystem (Figure 2).

Tesla is well known for developing and manufacturing most of its technologies in-house (Factiva-012423FC; Factiva-072324EN; Factiva-011123NF). It also acquires other companies to support its vertical integration. In 2019,

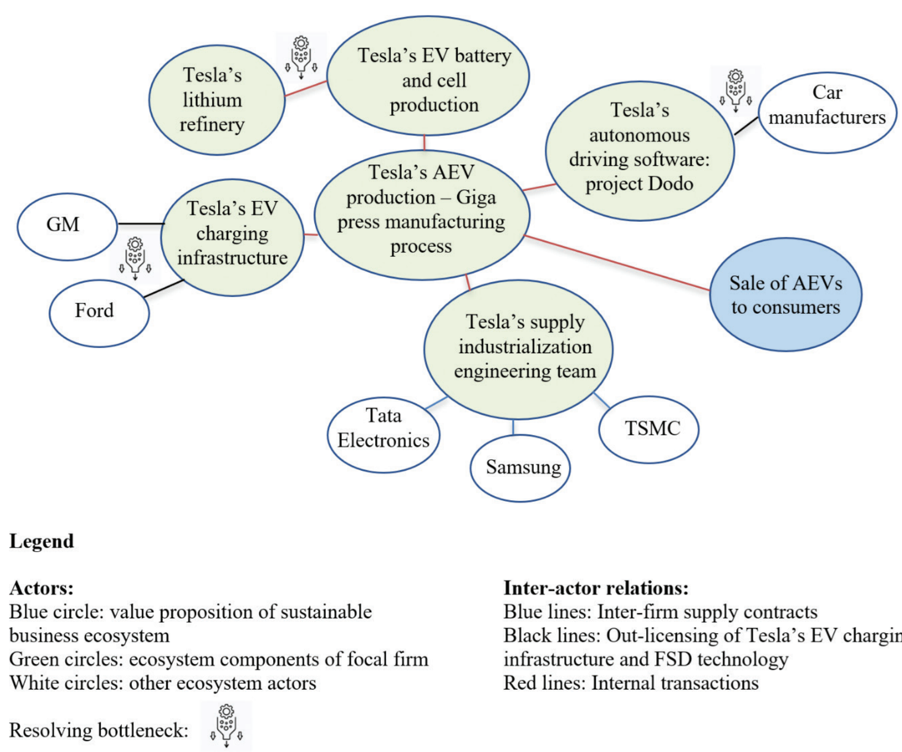

Figure 2. System strategy of Tesla.
Source: own elaboration.

it acquired Maxwell Technologies to improve its batteries and produce these at lower costs (Factiva-030123FN). This focus on internalization is the case for its EVs and EV superchargers, and Tesla is extending this strategy to its self-driving cars (Factiva-041524BF; Factiva-121522IBD). In 2023, Tesla announced that the carmaker 'plans to invest more than $1 billion on its so-called Project Dojo – an in-house supercomputing project – by the end of 2024 […]. The supercomputer is being designed to handle massive volumes of data, especially video feed from Tesla cars needed to create the autonomous-driving software' (Factiva-073023A). Tesla is also designing its own D1 chips to process the video data of the cars' environment and customizes the AI software to its own needs. The company 'plans to move AI training from (the outsourced) Nvidia processors to Dojo' (Factiva-073023A), thereby further integrating the development of its autonomous technology.

Tesla's system strategy is driven by the need to hedge against high price increases from suppliers as well as a lack of component suppliers. Regarding the need for hedging, Tesla decided to internalize battery cell production: 'if we have an internal cell production, then we have that hedge against demand shocks with too much demand. We did the cell program in order to address the crazy increase in cost per kilowatt hour from our suppliers due to gigantic orders placed by every carmaker on Earth' (Factiva-042324V). Because Tesla does not outsource its software to third parties and writes its own code, it can also replace chips that are in short supply with those that are available and then rewrite the software (Factiva-011622NF). Regarding the lack of component suppliers, Tesla responded by building a lithium refinery: 'We're going to address whatever we think the limiting factor is at a point in time. It's really the refining capacity that is the biggest choke point. So that's why we're building a lithium refinery in Corpus Christi' (Factiva-011622NF). Tesla thus decided to internalize component production to resolve a bottleneck in the ecosystem that hinders its growth.

When Tesla outsources component production, it manages every detail of the supply chain via extensive integration of its suppliers (Factiva-030123FN). Its supply industrialization engineering team turns component drawings into a manufacturing concept, selects the equipment, and goes to the supplier for months to ensure the component is produced at the right quality, cost, and yield (Factiva-030123FN). Examples of these suppliers are Samsung Electronics, Taiwan Semiconductor Manufacturing Company (TSMC), and Tata Electronics (Factiva-051523M; Factiva-122623TI; Factiva-041824Y; Factiva-090523B; Factiva-042621E).

In addition to a focus on internal production for multiple ecosystem components, Tesla's system strategy is also characterized by intense competition with rival car manufacturers. In the last few years, Tesla reduced the price of its EVs in multiple markets to cope with growing competition (Factiva-042524DW; Factiva-042924CNN; Factiva-122223B).

Tesla's ecosystem orchestration

Tesla uses its system strategy to be more successful at orchestrating the AEV ecosystem. Its autonomous driving technology is different from the technology of other car manufacturers, and Tesla is aiming for it to become the ecosystem standard:

> It just needs to be obvious that our approach is the right approach […] with 12.3 (full self-driving supervised software) […] it is obvious that our solution with a relatively low-cost inference computer and standard cameras can achieve self-driving. No LiDARs, no radars, no ultrasonic, nothing […]. Once it becomes obvious that if you don't have this in a car, nobody wants your car. (Factiva-042324V)

Tesla's leadership is persuading other car manufacturers to sign a licensing contract giving them the right to use Tesla's full-self driving (FSD) technology, pushing for the technology to become the ecosystem's dominant design (Factiva-030123FN): 'We're in conversations with one major automaker regarding licensing FSD' (Factiva-042324V). 'I think they (rival automakers) don't believe it's real quite yet'. 'If I were CEO of another car company, I would definitely be calling Tesla and asking to license Tesla's full self-driving technology' (Factiva-040524Q).

Tesla's domination of the market with its autonomous technology is widely shared (Factiva-052623BI). Nvidia's CEO stated that 'Tesla is far ahead in self-driving cars' (Factiva-062824IBD). Others argued that Tesla 'could one day control other parts of the EV ecosystem too, such as self-driving technology', because of 'the auto industry's quick adoption of Tesla's electric vehicle charging standard' (Factiva-062323A). The same strategy for orchestrating FSD technology is also used for EV charging technology in the AEV ecosystem. For the latter, Tesla sets the standard for EV charging and contracts with car manufacturers to use its technology, thereby resolving this ecosystem bottleneck: 'GM and Tesla announced an agreement that will have GM's electric vehicle drivers charging at Tesla's supercharger network. It's a similar deal Tesla struck with Ford' (Factiva-060923DJ). 'The charging standard war in the United States appears to have entered the beginning of its end' because 'three automakers that currently command about 70% of US EV sales are adopting the Tesla charging system' (Factiva-060923RN). We thus observe that in the AEV ecosystem, Tesla's system strategy focuses on developing technologies in-house and positioning in many ecosystem components to retain control while convincing its rivals to adopt Tesla's ecosystem standards, as well as on resolving ecosystem bottlenecks, which will enhance environmental and economic value creation (Figure 2).

Sensing and seizing capabilities of Tesla's leadership

It has been noted that the CEO's 'foresight, determination, and hard work ethic' are significant reasons for Tesla's success (Factiva-061723B). This foresight and determination refer to his ability to sense opportunities by being aware of AEV developments, foreseeing what technologies will play an important role in the future AEV ecosystem, and even orchestrating what these technologies will be. Initially, his focus was on EVs, charging infrastructure, battery technology, and sustainable energy, but recently, this focus shifted to autonomous driving by 'placing a renewed emphasis on robotaxis, as well as robotics and artificial intelligence' (Factiva-060524IBD). We argue that such foresight and determination play a role in Tesla's system strategy in which it focuses on internal technology development and ecosystem orchestration.

Since 2020, Tesla has faced intense competition and a decrease in demand (Factiva-040824C). However, it has often been noted that its CEO 'has a reputation for overcoming obstacles' (Factiva-040824C), and that 'his ability to overcome these obstacles and move forward with his vision has been a constant' (Factiva-081424NF). To solve the competition and demand problem, Tesla's leadership took several decisions. First, Tesla invested in the Giga Press manufacturing process to reduce EV production costs (Factiva-040824C), and second, it cut EV prices to counter the competitive pressures of EV makers (Factiva-043024S). Third, its CEO also made the quick decision to cut costs by firing employees in the EV charging business (Factiva-050824DJ; Factiva-050224BT).

The CEO's confidence in solving problems is evident from reflections on the internal 4680 battery cell production, which were described as a limiting factor for industry growth, and hence an ecosystem bottleneck: 'Our focus right now is on the dozens of little issues that inhibit the production ramp of the 4680 […] when something is revolutionary, there's a lot of unknowns that have to be resolved. We're confident of resolving those unknowns but it's very, very difficult' (Factiva-072322H). With respect to FSD, he mentioned that there are 'a lot of false dawns with FSD, you think you have solved the problem but then you just hit a ceiling. The progress of FSD is like a series of log curves, fairly straight and then it tails off, and then there are diminishing returns' (Tesla, 2022).

Building on the above, we propose that the cognitive capabilities of Tesla's leader shape the firm's system strategy and ecosystem orchestration. His sensing capabilities, marked by environmental awareness and foreseeing and manifesting future technologies, drive Tesla to develop technologies in-house and set ecosystem standards for FSD and EV charging. His seizing capabilities, focused on rapid problem-solving and quick decision-making, support vertical integration of multiple ecosystem components and the resolution of key bottlenecks. This positions Tesla as an orchestrator, advancing the ecosystem while encouraging competitors to adopt its standards.

Reconfiguring capabilities of Tesla's leadership

The vision for the future of the automotive industry of Tesla's leadership is that 'all cars will go to fully electric and autonomous' (Factiva-030123FN). This vision includes that FSD technology is 'critical to the future of the electric vehicle market', and that 'everything else is like variations of a horse-drawn carriage' (Factiva-051124NF). In an investor-day presentation in 2021, Tesla's leadership 'laid out a clear vision of a future where Tesla uses self-driving technology to enable a "robo-taxi" function for its customers. The goal is for Tesla customers to be able to send off their self-driving cars to pick up and drop off other people and make rental income in the process' (Factiva-011521FA).

With this vision for AEVs, the CEO was able to persuade consumers and investors of Tesla's competitive advantage (Factiva-061723B). The 'visionary approach to electric vehicles, pushing for greater efficiency, longer ranges, and improved technology, resonated with consumers and investors alike. Notably, the successful launch of the Model Y further strengthened the company's position in the market' (Factiva-072023F). This vision entailed that Tesla is not just a car company, but an ecosystem combining charging stations, in-home batteries, solar roofs, AI, and software (Times, 2018). Tesla's CEO 'has been vocal about his vision for Tesla to accelerate the world's transition to sustainable energy, and his ability to execute on that vision has helped to build investor confidence in the company' (Factiva-012223C).

Tesla's leadership is persuading others of this vision for the firm by constantly communicating about it. At an investor day in 2023 and earnings call in 2024, the CEO focused on storytelling around a future sustainable transport system driven by autonomous technology: 'what we're trying to convey is a message of hope and optimism. And optimism that is based on actual physics and real calculations, it's not wishful thinking. Earth can and will move to a sustainable energy economy and will do so in your lifetime' (Factiva-030123FN). 'If somebody doesn't believe Tesla is going to solve autonomy, I think they should not be an investor in the company – but we will and we are' (Factiva-042324V).

While Tesla's leadership has been able to persuade others of this vision by storytelling, it is less able to do so by building trust. Others have argued that Tesla's CEO 'has a habit of reneging on his promises time and time again' (Factiva-040824NF). 'Previously (he) has made promises that don't come true […] in 2019 he promised a fleet of fully autonomous robotaxis […] Nearly three years later, Tesla has yet to sell any autonomous vehicles' (Factiva-022623DH). 'He hoped to build the next-gen EV in the second half of 2025, though he admitted he's often "optimistic" about timelines' (Factiva-033024IBD; Tesla, 2024). One of the exceptions is the scaling of Tesla's EV production from 2014 to 2020, but most often media narratives focus on mistaken timelines (Tesla, 2022).

Based on the above, we propose that the reconfiguring capabilities of Tesla's CEO help the firm to orchestrate the AEV ecosystem by setting the EV charging standard and pushing Tesla's FSD technology as the dominant design. He reconfigures resources, positions, and relations within the AEV ecosystem by storytelling, communicating a vision for a future AEV ecosystem and persuading others of his vision, but less so by building trust. These capabilities also facilitate a system strategy with Tesla positioned in multiple ecosystem components in which it collaborates to license access to its EV charging network and FSD technology and competes for the sale of EVs (Factiva-040924FA). It has been noted that 'Tesla's vision extends beyond manufacturing electric cars. The company is positioning itself as both a collaborator and competitor in the automotive space' (Factiva-040924FA). In Figure 4, we visualize how the cognitive capabilities of Tesla's CEO impact the firm's system strategy in the AEV ecosystem.

GM's component strategy

In contrast to Tesla, GM adopts a component strategy focusing on collaboration in multiple ecosystem components, including EV charging infrastructure, EV production, batteries, autonomous driving, and dealerships (Figure 3). With respect to EV charging, GM signed a contract with Tesla in which it purchases the right to use Tesla's charging standard and infrastructure. Additionally, GM collaborates in a joint venture with six car manufacturers (BMW Group, Honda, Hyundai, Kia, Mercedes-Benz Group, and Stellantis) to build EV charging infrastructure (Factiva-080123AJ) and to collectively reduce costs (Factiva-270723WSJ). GM's CEO highlighted the importance of collaborating across the industry for EV charging: 'GM's commitment to an all-electric future is focused not only on delivering EVs our customers love but investing in charging and working across the industry to make it more accessible' (Factiva-080123AJ).

In 2022, GM's CEO announced a continuation of the GM-Honda partnership to produce affordable EVs:

> General Motors and Honda will jointly develop affordable electric vehicles the companies plan to sell by the millions worldwide starting in 2027. The collaboration will take advantage of the companies' technology, sourcing and design resources, and GM and Honda also will work toward standardizing equipment and processes to achieve quality and affordability goals. (Factiva-040622W)

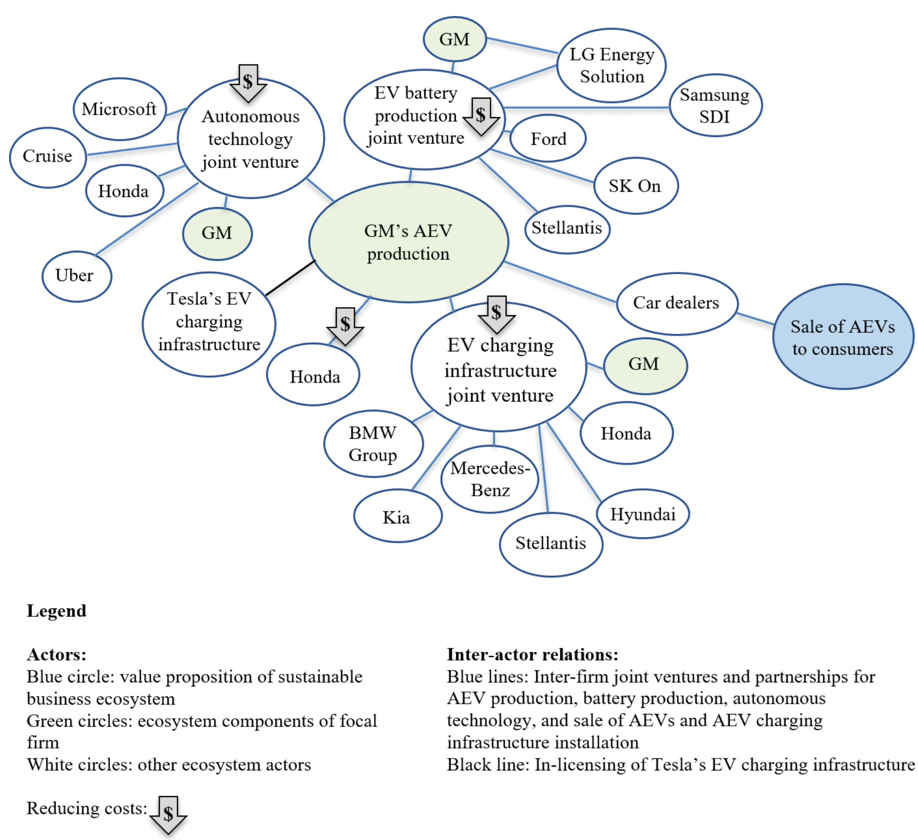

Figure 3. Component strategy of GM.
Source: own elaboration.

The collaboration's purpose is to reach GM's goal of being a sustainable firm: 'the arrangement will help GM reach its goal of being a carbon-neutral company by 2040 and its target to offer a zero-emissions lineup of vehicles in the U.S. by 2035' (Factiva-040722B).

With respect to EV batteries, GM acknowledges that costs need to be reduced to enhance EV profitability. Currently, GM is funding its transition to AEVs with revenues from internal combustion engine vehicles but aims to improve EV profit margins (Factiva-021823DFP). To cut costs, it partners with suppliers such as LG Energy Solution to help it manufacture EV batteries (Factiva-021823DFP). 'GM aims to have industry leading margins as it continues to invest in partnerships' (Factiva-021823DFP). Together with LG Energy Solution, SK On, Samsung SDI, Ford, and Stellantis, GM has planned a $28 billion investment in US EV battery factories that will be run as joint ventures to produce cost-effective batteries (Factiva-102423J; Factiva-011223TOI).

To integrate autonomous technology in GM's vehicles, GM announced in 2016 that it acquired equity in Cruise, a start-up founded in 2013 focused on developing a self-driving car. Cruise is majority owned by GM, but since 2018, Honda has a share in the company to jointly mitigate risk and cost (Reuters, 2018). Cruise's CEO mentioned that 'Cruise will continue to operate as it does today – an independent company working alongside GM in a flexible, collaborative partnership' (Factiva-031822F). In 2021, GM announced a collaboration with Microsoft: 'Microsoft will help us accelerate the commercialization of Cruise's all-electric, self-driving vehicles' (Factiva-011921BI). In 2023, GM, Cruise, and Honda announced a new joint venture that will launch a driverless transportation service in Japan (Factiva-102323NF; Factiva-102423AC). In 2024, GM and Uber started a partnership in which US customers can book Chevrolet Bolt AVs using Cruise's technology through the Uber platform (Factiva-082324DPA). Even though Cruise said that it 'remains focused on relaunching its own driverless app and service' (Factiva-082324USA), it builds partnerships in the interim with ride-hailing services. This contrasts with Tesla that proposed to launch a competitor platform that is a 'combination of Airbnb and Uber' (Factiva-080624Q).

GM has historically had an extensive dealer network through which it sells its vehicles to consumers. GM believes that the dealers remain a competitive advantage in the EV market (Factiva–111920FN) and extends collaboration with its dealers to sell EVs and install charging infrastructure. In 2021, GM 'announced a new Dealer Community Charging Program to install up to 40,000 Level 2 EV chargers across the U.S. and Canada. Working with our dealers, we intend to expand access to charging in local communities' (Factiva-020222P).

Hence, we observe that in a sustainable business ecosystem, GM's component strategy is aimed at collaborating with others to reduce the costs of sustainable technologies while serving the mutual benefit of GM and its ecosystem partners.

Sensing and seizing capabilities of GM's leadership

GM's CEO described the transition to AEVs as 'a once-in-a-generation opportunity to really transform the business' (Factiva-022322FN; GM, 2024ac). This transformation is critical to GM's future: 'we want to lead in EVs. Full stop' and 'we know the demand (for EVs) is here' (Factiva-013122FN). GM plans over a 5-year horizon but adjusts the plan every year to where it believes demand is and what the important customer segments are: 'we are constantly improving our plan, adjusting to where the world is' (GM, 2024c). GM's CEO sees opportunities in attracting consumers buying their second EV and persuading them to move from a competitor to GM[6]. Hence, awareness of the industry environment is focused on GM's adaptation to changes in EV demand.

In 2023, a GM-Cruise AEV collided with a pedestrian who had earlier been struck by another vehicle. This accident was used as a 'lightning rod effect' to engage 'the entire top leadership team […] making it very clear what expectations are for performance and accountability' (Factiva-112923VIQ). The CEO implemented 'a lot of leadership changes' and ensured that a 'cultural change is already underway' (Factiva-112923VIQ). 'And then […] we will chart the course forward […] (and) demonstrate we have the right relationship and have built trust with regulators, with first responders, with the community' (Factiva-112923VIQ; GM, 2024b). Hence, the CEO took quick decisions to solve problems with GM's majority-owned Cruise and relied on collaboration and trust to solve these problems. She commented on the complexities of her job and making difficult decisions by stating: 'I'm an engineer, so I'm a problem solver' (Factiva-071822I). Another example of her ability to make quick decisions and seize environmental opportunities is the development of the GM Ultium EV platform that will allow GM to respond more quickly to the market. The Ultium platform speeds up the launch time of EV models: the 'CEO said that GM's flexible Ultium EV architecture has helped cut vehicle development time by nearly 50%. She said the launch of the Cadillac Lyriq SUV had been moved up about nine months from the date initially announced. GM will speed up the launch timing of 12 EV models, some by as much as 40 months' (Factiva-050721IBD). GM and Honda will jointly develop EVs for Honda using the Ultium platform (Factiva-111920FN).

Hence, the CEO's sensing capabilities focus on being aware of changes in demand, which create opportunities for positioning GM within the larger AEV ecosystem. She solves problems and makes quick decisions to build trust among GM's stakeholders. This seizing capability enables GM to invest in partnerships with competitors, suppliers, regulators, and the community.

Reconfiguring capabilities of GM's leadership

GM's CEO developed a new vision for the firm focused on affordable AEVs and has consistently communicated about this vision:

> At General Motors, our vision is to create a world with 0 crashes, 0 emissions and 0 congestion. We are committed to an all-electric future, and we believe in an autonomous future. And to deliver this, we believe in 2 fundamental beliefs that, one, we want to provide EVs for everyone and everyone who'd like an EV should have one. (Factiva-091222FN)

Media narratives focus on the CEO's ability to implement this new vision arguing that she: 'has transformed General Motors in the nearly 10 years she's been CEO, setting the company up as an early mover in the electric car market and investing in futuristic solutions like self-driving cars' (Factiva-121623BI).

GM's CEO puts a strong emphasis on trust-based cooperation with partners, of which the long-standing partnership with Honda is a prominent example that speeds up the transition to sustainable transport: 'By working together, we'll put people all over the world into EVs faster than either company could achieve on its own' (Factiva-040722B). Trust-based partnerships in the supply chain are highly valued as well: 'We feel it is very important to have a good relationship with our suppliers because we're in this world of transformation and a lot of innovation and we want suppliers to believe in us to bring their best technology to us [...] and to do that though you have to have trust' (GM, 2024c). Although the CEO acknowledges that the automotive industry has historically not been very good at collaboration, she argues that it is time to change this, especially in areas where car manufacturers do not compete:

> I actually think (collaboration) is where the auto industry could be more efficient because there are a lot of things that we all do that are not customer facing [...] we could do a better job of sharing platforms [...] I think now is a prime time (for collaboration) with all the investment that needs to be made, so we continue to explore opportunities. (GM, 2024c)

GM and Cruise also continue to build trust with regulatory partners and communities (Factiva-112824DF; Factiva-111023R). Trust is not only valued in collaboration with external partners but also within the company itself: 'We created CruiseFlex, basically saying whatever mechanism is going to make you productive, so it's a high-trust environment [...] And that has helped us stay extremely competitive' (Factiva-091222FN).

The CEO encourages initiative among external partners and employees so that they contribute to a more sustainable transport system: 'General Motors is joining governments and companies around the globe working to establish a safer, greener and better world'. 'We encourage others to follow suit and make a significant impact on our industry and on the economy as a whole' (Factiva-010221J). GM's SVP of Innovation & Growth states that GM's strategy toward an autonomous EV future:

> specifically calls out how our people are part of this journey [...] it's been the guidepost [...] we encourage everyone to really take ownership for the direction of where we're going and innovate. So that to me is the magic of great companies that disrupt themselves, when everyone is on board, everyone is creating the future. (Factiva-092221FN)

Based on the above, we propose that these reconfiguring capabilities facilitate a component strategy by communicating GM's vision, building trust-based cooperation horizontally, vertically, and with stakeholders, and encouraging initiatives by others to support GM's position in the sustainable ecosystem. In Figure 4, we visualize how the CEO's cognitive capabilities impact GM's component strategy in the AEV ecosystem.

Discussion

Our analysis demonstrates that GM and Tesla pursue fundamentally different ecosystem strategies. GM adopts a collaborative component strategy, whereas Tesla engages in a high-control system strategy, characterized by vertical integration and ecosystem orchestration. These differences are visualized in Figures 2 and 3, which show that Tesla is positioned in more ecosystem components, whereas GM has more ecosystem partners. These strategic divergences can be attributed to differences in the cognitive capabilities of their respective leaders (Figure 4). While Tesla's CEO directs sensing toward long-term technological foresight for the entire sustainable AEV ecosystem, GM's CEO senses by monitoring short-term fluctuations in AEV demand and assessing implications for GM's ecosystem position. With respect to seizing, Tesla's CEO focuses on solving complex technical challenges and ecosystem bottlenecks to advance proprietary technologies and establish ecosystem standards. GM's CEO, by contrast, emphasizes collaborative problem-solving based on trust. In terms of reconfiguring, Tesla's CEO formulates a vision that spans the entire ecosystem, while GM's CEO reconfigures its strategy in alignment with cooperative stakeholder engagement.

Since our research is exploratory in nature, we develop three propositions to summarize our findings and stimulate further empirical research. We propose the following comparative propositions on how cognitive capabilities impact ecosystem strategies in a sustainable business ecosystem:

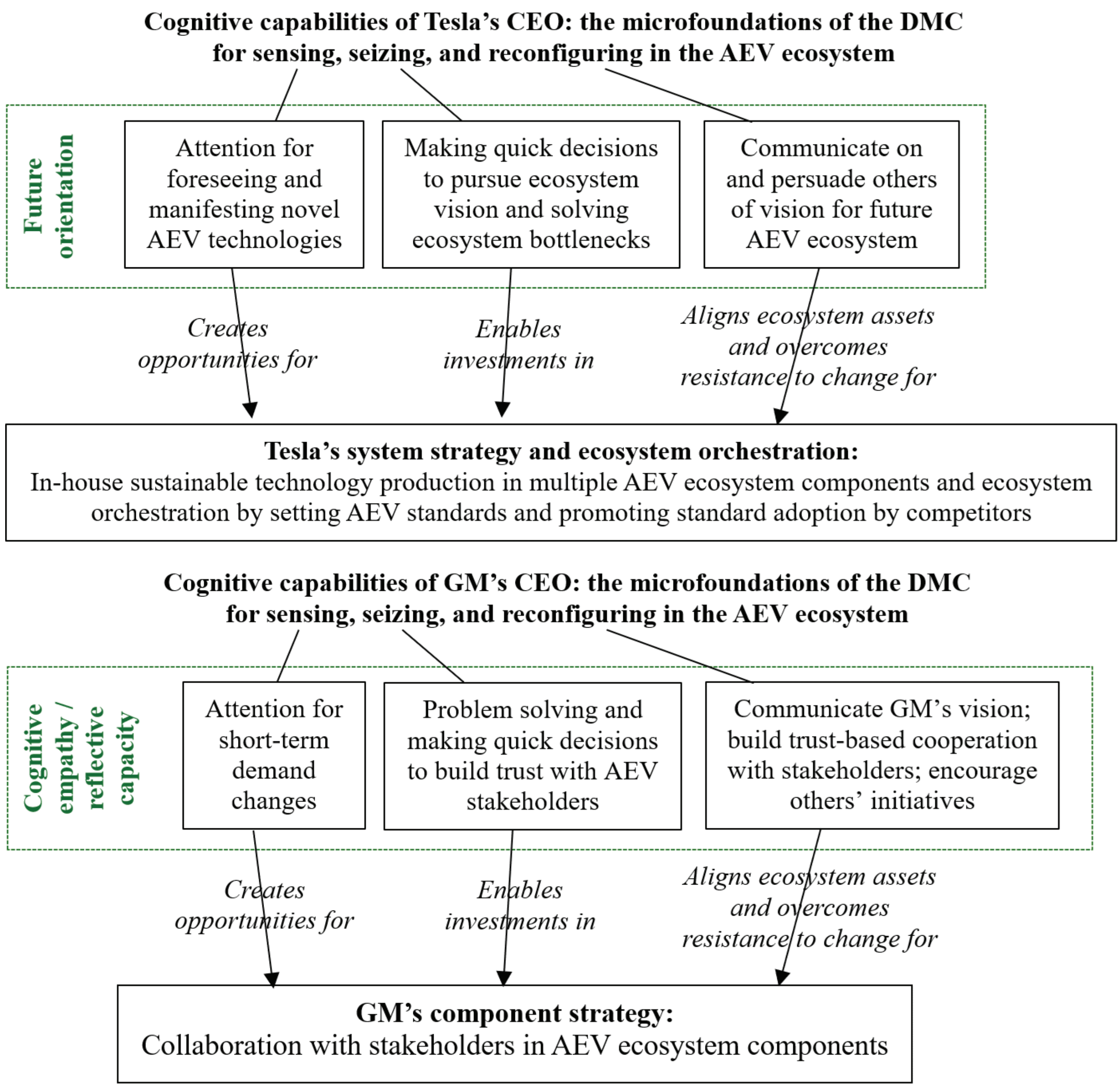

Figure 4. Role of leaders' cognitive capabilities in Tesla and GM's ecosystem strategies.
Source: own elaboration.

Proposition 1 on sensing

Leaders with attention for foreseeing and manifesting novel sustainable technologies create opportunities for in-house technology production in multiple ecosystem components (system strategy) and for orchestrating the ecosystem, whereas attention for short-term demand changes creates opportunities for collaboration with ecosystem partners and fewer positions in the sustainable business ecosystem (component strategy).

Proposition 2 on seizing

Leaders who make quick decisions to pursue their ecosystem vision and resolve ecosystem bottlenecks enable investments in in-house sustainable technology production in multiple ecosystem components (system strategy) and ecosystem orchestration, whereas leaders who make quick decisions and solve problems to build trust with stakeholders enable investments in collaboration within a sustainable business ecosystem (component strategy).

Proposition 3 on reconfiguring

Leaders who communicate on and persuade others of a vision for a sustainable ecosystem enable the firm to align its assets in multiple ecosystem components and overcome resistance to its ecosystem standard (system strategy), whereas leaders who communicate the firm's vision, develop trust-based cooperation, and encourage others' initiatives enable the firm to align its assets with those of ecosystem complementors (component strategy).

Our analysis has illustrated that the cognitive capabilities of Tesla's CEO focus on foreseeing novel AEV technologies, resolving ecosystem bottlenecks, and persuading others of a vision for the future of the AEV ecosystem. These capabilities resemble what Nair and Bhattacharyya (2022, p. 825) define as 'future orientation' – the ability to anticipate, adopt a long-term perspective, and envision the unfolding of sustainable innovations. In contrast, the cognitive capabilities of GM's CEO resemble 'cognitive empathy' and 'reflective capacity' (Jia et al., 2021; Nair & Bhattacharyya, 2022), understood as the capacity to adopt stakeholders' perspectives, understand their needs, and integrate diverse knowledge into decision-making on sustainable technologies. Figure 4 visualizes these cognitive capabilities in green and shows first that leaders' cognitive capabilities in a sustainable business ecosystem can be classified as future orientation or cognitive empathy, and second that these two capability types lead to different ecosystem strategies.

Contributions

In this paper, we addressed two main gaps in the literature. First, we identified the ecosystem strategies in sustainable business ecosystems and demonstrated that system and component strategies take on distinct features in sustainable technology contexts. For system strategies, prior research on business ecosystems for economic value has emphasized competitive behaviors such as creating and exploiting bottlenecks by acquiring control over key components to block rivals' access (Hannah & Eisenhardt, 2018). In contrast, in sustainable business ecosystems, system strategists like Tesla use their position to resolve ecosystem bottlenecks to enable sustainable ecosystem growth. This shift reflects a key difference: in sustainability transitions, resolving bottlenecks is often more valuable than creating them, as ecosystem expansion enlarges the potential for environmental value creation. Moreover, while system strategists in business ecosystems for economic value often pursue control and value capture by minimizing dependence on rivals, in sustainable business ecosystems, they are dependent on rivals to choose their ecosystem standard to resolve the bottleneck. This introduces a paradox: although system strategists aim to control multiple components, their success depends on rivals adopting their standards, making interdependence a necessary condition for ecosystem orchestration. This complements prior work on standard competition in sustainability transitions (Markard et al., 2020) by clarifying the strategic role of system strategists in these battles.

Turning to component strategies, previous literature has emphasized that innovation, mutual specialization, and differentiation are key to success (Hannah & Eisenhardt, 2018). In contrast, we show that component strategies in sustainable business ecosystems are often driven by the need to reduce the costs of emerging technologies. GM uses partnerships to share the financial burden of developing AEV technologies, which remain expensive and lack the cost advantages of incumbent technologies. Thus, collaboration in component strategies becomes not only a path to specialization but also a cost-sharing mechanism. Similarly, Geels (2019) notes that sustainable innovations initially suffer from high costs and limited economies of scale. Our study shows that a component strategy can focus on collaborative cost-sharing to reduce barriers to sustainable innovation and enhance environmental value creation.

Second, our findings and propositions contribute to the microfoundations literature by offering an empirical study on the role of cognitive capabilities in ecosystem strategies, where prior research is mostly of a conceptual nature (Foss et al., 2023; Helfat & Raubitschek, 2018). We offer a novel contribution by mapping specific cognitive capabilities of leaders onto ecosystem strategies, extending the dynamic managerial capabilities framework to sustainable business ecosystems. By theorizing this link, our study moves beyond listing relevant capabilities and strategies and offers an integrated explanation of how leader cognition shapes strategic action in sustainable ecosystems. Specifically, we extend Helfat and Peteraf (2015) by showing that cognitive capabilities not only enable strategic change but also impact how leaders configure value in ecosystems. In addition, our empirical research extends the conceptual study by Helfat and Raubitschek (2018) on leaders' environmental sensing and integrative capabilities in ecosystems. Environmental sensing is argued to be relevant for spotting unexploited market needs and changes in customer preferences (Helfat & Raubitschek, 2018), as we show for GM. 'Integrative capabilities are fundamental to the business models and competitive success of firms at the center of business ecosystems because they enable firms to better orchestrate alignment of activities' (Helfat & Raubitschek, 2018, p. 1395), which we show with the ability of Tesla's CEO to persuade competitors to adopt Tesla's charging standard.

In addition, we illustrate what unique cognitive capabilities for sustainable technologies play a role in sustainable business ecosystems. Our study identifies two different types of cognitive capabilities that helped the leaders in implementing their distinct ecosystem strategies. We show that future orientation facilitates the implementation of a system strategy and ecosystem orchestration, while cognitive empathy enables a component strategy (Nair & Bhattacharyya, 2022).

Limitations and future research

This study has several limitations that offer opportunities for future research. First, the empirical scope is limited to the automotive sector, with a focus on AEV production. Future research could investigate whether similar patterns of leadership cognition and ecosystem strategy are observable in other sectors contributing to the AEV ecosystem. Such cross-industry comparisons would strengthen the generalizability of our findings and clarify whether our insights extend beyond incumbent and early-mover car manufacturers.

Second, our identification of cognitive capabilities relied on publicly available data. Future studies could explore three components of dynamic managerial capabilities – managerial human capital, social capital, and cognition – (Adner & Helfat, 2003) and examine these quantitatively using validated survey scales (Heubeck, 2023). Moreover, incorporating executive interviews or internal strategic documents could enhance the richness and validity of findings through data triangulation. The expansion of data collection could allow future research to classify leaders into different cognitive profiles and explore whether the profile attributes remain separate or can be integrated into the same cognitive profile.

Third, the study's time frame (2020–2024) restricts the analysis to short- and medium-term dynamics. Longitudinal studies extending beyond this period would provide deeper insights into how cognitive capabilities evolve over time and influence ecosystem strategies, particularly in the context of technological disruption and sustainability transitions.

Practical implications

This study provides insights for leaders navigating similar sustainable business ecosystems, suggesting that specific cognitive capabilities can be instrumental in choosing an effective strategic approach. Leaders with future-oriented cognitive capabilities – encompassing the foresight of emerging AEV technologies, the development of an ecosystem vision, and the ability to persuade others to adopt it – are well equipped to pursue a system strategy that enables them to set ecosystem standards and orchestrate the broader ecosystem. On the other hand, leaders who demonstrate cognitive empathy – marked by cooperation, trust building, and support for others' initiative – are well positioned to implement a component strategy that creates sustainable value in collaboration with stakeholders. They can use their component strategy to share the costs of developing and producing the more sustainable technology with complementors. Because cognitive capabilities are not easily interchangeable, firms should recognize that leaders' cognitive profiles tend to shape which ecosystem strategy is feasible, and that this can inform their recruitment decisions. By recruiting a leader whose capabilities fit with shareholders' needs for strategic change, firms can more effectively shape ecosystem roles and create a competitive edge by implementing their chosen ecosystem strategy.

Conclusion

Our study addresses the question of what cognitive capabilities leaders use to implement ecosystem strategies in sustainable business ecosystems. We find that leaders draw on future orientation to implement system strategies, enabling ecosystem orchestration through long-term vision and technological foresight, or on cognitive empathy to implement component strategies, fostering collaboration and trust-based partnerships. These findings reveal that strategies in sustainable ecosystems differ from those in ecosystems for economic value by striving to resolve bottlenecks and share the costs of sustainable technologies. By linking cognitive capabilities to ecosystem strategies, we extend the dynamic managerial capabilities framework and highlight the role of leader cognition in shaping sustainable value creation.

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Appendices

Appendix 1. Timeline of Tesla and GM

Year	Tesla	GM	Industry significance
2003	Tesla was founded		Begins its role as a disruptor in automotive industry
2008	Launches Roadster, entering EV market		Proves viability of EVs
2012	Model S released, achieving commercial success; introduces Supercharger network		Establishes EVs as viable for a larger market, influencing global automakers; starts to develop ecosystem charging standard
2014		Mary Barra becomes CEO	GM's leadership shift prioritizes EV transition and autonomy
2015	Launches Model X		Broadens EV appeal with luxury SUV model
2016	Unveils Model 3, acquires SolarCity	Acquires majority stake in Cruise for autonomous tech	Tesla targets mass-market EVs; GM secures early position in autonomous tech
2017	Begins Gigafactory construction		Influences large-scale battery production trend across industry
2019	Acquires Maxwell Technologies, focuses on in-house autonomous tech		Tesla pushes vertical integration to cut costs and reliance on suppliers
2020	Launches Full Self-Driving (FSD) beta, becomes profitable	Commits to all-electric future and carbon neutrality by 2040	Tesla and GM reinforce industry-wide shift toward autonomy and sustainability
2021	Establishes Dojo supercomputing for AI, develops in-house D1 chips	Partners with Microsoft to advance autonomous and EV tech	Tesla accelerates AI-driven autonomy; GM enhances cloud partnerships for tech advancements
2022		Partners with Honda to co-develop affordable EVs	Collaborative focus on affordability addresses barriers to EV adoption
2023	Opens Supercharger network to other automakers, gains adoption of charging standard	Establishes joint venture with Honda and Cruise for driverless services in Japan	Tesla's charging standard gains traction; GM fosters international collaboration on autonomy
2024	Invests over $1 billion in Project Dojo for AI development	Partners with Uber to enable autonomous bookings with Cruise technology	Both companies advance autonomy, signaling future potential in driverless consumer technology

Source: own elaboration

Appendix 2. Factiva data sources referenced in the results

Factiva number	Article name	Date	Source
Factiva-111320B	EVs are the future, GM's Mary Barra says. Where the CEO sees growth	13 November 2020	Barron's online BON
Factiva-111920FN	General Motors Co at Barclays Global Automotive Conference (virtual)—Final	19 November 2020	CQ FD Disclosure FNDW
Factiva-112220JA	GM boosts EV investment and model line	22 November 2020	Just-Auto JUAUT
Factiva-010121NF	Elon Musk: 'We're going to have so many vaccines that we won't know what to do with them'	1 January 2021	CE Noticias Financieras NFINCE
Factiva-011521FA	MIL-OSI Global: Pursuing Tesla's electric cars won't rev up VW's share price	15 January 2021	ForeignAffairs.co.nz PARALL
Factiva-011921BI	GM jumps 9% to record high after Microsoft announces investment in the company's self-driving car subsidiary Cruise	19 January 2021	Business Insider BIZINS
Factiva-010221J	General Motors plans to be carbon neutral by 2040	1 February 2021	Just-Auto JUAUT
Factiva-042621E	Partnership between Samsung and Tesla begins to expand	26 April 2021	The Electronic Times
Factiva-050721IBD	Is GM stock a buy after strong earnings? General Motors' EV, AV plans race ahead despite chip woes	7 May 2021	Investor's Business Daily INVDAI
Factiva-092221FN	Tesla's global supply chain strategy amid chip shortages	22 September 2021	Financial News
Factiva-011622NF	Chip shortage: why Tesla managed to outperform other electric car makers such as Ford and GM	16 January 2022	CE Noticias Financieras
Factiva-013122FN	GM amping up; Michigan battery projects fill in more of EV production map	31 January 2022	Automotive News
Factiva-020222P	GM—Annual Report (Form 10-K)	2 February 2022	Securities and Exchange Commission (SEC) Filings SAEXC
Factiva-022322FN	General Motors Co at Wolfe Research Global Auto, Auto Tech and Mobility Conference—Final	23 February 2022	VIQ FD Disclosure, CQ-Roll Call, Inc.
Factiva-031822F	GM buying SoftBank's Cruise stake, pouring additional $1.35 billion into robocar company	18 March 2022	Forbes.com FBCOM
Factiva-040622W	GM, Honda to codevelop affordable electric vehicles	6 April 2022	WardsAuto
Factiva-040722B	GM, Honda to codevelop new line of EVs	7 April 2022	USA Today
Factiva-071822I	The AP Interview: GM's Barra stands by ambitious EV pledge	18 July 2022	Independent Online INDOP
Factiva-072322H	'Unknowns' delay Tesla's ramp-up of its own cutting-edge batteries	23 July 2022	The Hindu Online
Factiva-091222FN	General Motors Co at Goldman Sachs Communacopia + Technology Conference—Final	12 September 2022	VIQ FD Disclosure FNDW
Factiva-121522IBD	Can Mobileye extend its auto software dominance into driverless cars?	15 December 2022	Investor's Business Daily
Factiva-011123NF	Tesla, on the chopping block: Is it time for Elon Musk to leave the electric car company?	11 January 2023	CE NoticiasFinancieras NFINCE
Factiva-012223C	Disrupting the status quo: Tesla's journey to the top of the electric vehicle industry	22 January 2023	The Chronicle

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Appendix 2 (Continued). Factiva data sources referenced in the results

Factiva number	Article name	Date	Source
Factiva-012423FC	How Tesla's design took it from innovator to dud	24 January 2023	Fast Company FSTC
Factiva-021823DFP	GM CEO Barra has plans for automaker to lead industry in EV profits	18 February 2023	Detroit Free Press
Factiva-022623DH	Mexican states in hot competition over possible Tesla plant	26 February 2023	Daily Herald
Factiva-030123FN	Tesla Inc Investor Day—Final	1 March 2023	VIQ FD Disclosure, CQ-Roll Call, Inc.
Factiva-051523M	Samsung, Tesla boost car chip partnership as Lee, Musk Meet	15 May 2023	Maeil Business Newspaper
Factiva-052623BI	Tesla just gave away one of its biggest advantages in the EV race	26 May 2023	Business Insider
Factiva-060923DJ	Tesla expands production capacity in Asia amid rising EV demand	9 June 2023	Dow Jones Newswires
Factiva-060923RN	Tesla's new production facility in Shanghai: A strategic shift	9 June 2023	Reuters News
Factiva-061723B	How high will tesla stock climb?	17 June 2023	Barchart News BARC
Factiva-062323A	Tesla partners with BYD for advanced battery technology	23 June 2023	Asia Times
Factiva-072023F	Elon Musk 's astounding surge in wealth: From $24 billion to $219 billion in just two years	20 July 2023	Financial Express Online FIEXON
Factiva-072723WSJ	Carmakers Join EV Charger Push—GM, Honda and Stellantis are among those investing in US joint venture	27 July 2023	The Wall Street Journal
Factiva-073023A	Tesla increases focus on supply chain sustainability to meet regulatory demands	30 July 2023	Asia Times
Factiva-080123AJ	South Korea's car export hits all-time high in Q2 driven by green vehicle demand	1 August 2023	Acquisdata Global Industry SnapShot
Factiva-090523B	Samsung becomes Tesla cars' eyes as it will now supply camera modules to Elon Musk's EV company	5 September 2023	Benzinga.com
Factiva-102323NF	Automotive industry General Motors, Cruise, and Honda set up autonomous cab company in Japan	23 October 2023	CE Noticias Financieras NFINCE
Factiva-102423AC	Industry snapshots—Japan Automotive 24 Oct 23	24 October 2023	Acquisdata Global Industry SnapShot ACQIND
Factiva-102423J	GM is still making billions of dollars despite auto workers' strike	24 October 2023	Jalopnik
Factiva-111023R	FOCUS-Investors pull away from GM's Cruise bet	10 November 2023	Reuters News, LBA
Factiva-112824DF	GM to scale back spending on self-driving unit Cruise after pedestrian accident	28 November 2023	The Detroit Free Press Online
Factiva-112923VIQ	General Motors Co Business Update—Final	29 November 2023	VIQ FD Disclosure, CQ-Roll Call, Inc.
Factiva-011223TOI	GM anticipates reduction in electric vehicle costs, aiming for profitability in sustainable transportation	1 December 2023	The Times of India
Factiva-121623BI	GM's CEO said 2023 would be 'a breakout year' for EV production. But demand has fallen sharply	16 December 2023	Business Insider BIZINS
Factiva-122223B	Tesla gets price target boost to $350 as Wedbush's Ives foresees EV giant regaining $1 trillion market cap in 2024	22 December 2023	Benzinga.com

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Appendix 2 (Continued). Factiva data sources referenced in the results

Factiva number	Article name	Date	Source
Factiva-122623TI	Elon Musk's Tesla may adopt TSMC's 3nm chips in 2024: What it means for both companies	26 December 2023	The Times of India
Factiva-033024IBD	Tesla deliveries set to plunge as bulls pin hopes on FSD; BYD leads price war	30 March 2024	Investor's Business Daily
Factiva-040524Q	Elon Musk offered Tesla's Full Self-Driving system to other automakers. No one took him up on it	5 April 2024	Quartz
Factiva-040824C	Tesla's innovation and resilience could see it through this rough patch	8 April 2024	The Conversation
Factiva-040824NF	The 6 key reasons why Tesla sales have plummeted	8 April 2024	CE Noticias Financieras
Factiva-040924FA	Tesla's innovation and resilience could see it through this rough patch	9 April 2024	ForeignAffairs.co.nz
Factiva-041524BF	Job cuts could be coming to Tesla's Buffalo factory	15 April 2024	The Buffalo News
Factiva-041824Y	Elon Musk shakes hands with Ratan Tata: A power move for India's semiconductor surge?	18 April 2024	Your Story
Factiva-042324V	Q1 2024 Tesla Inc Earnings Call—Final	23 April 2024	VIQ FD Disclosure, CQ-Roll Call, Inc.
Factiva-042524DW	Tesla's moment of truth	25 April 2024	Die Welt
Factiva-042924CNN	Elon Musk wins official praise for Tesla during surprise visit to China	29 April 2024	CNN
Factiva-043024S	Key hurdles cleared after Musk's quick visit	30 April 2024	The Standard
Factiva-050124EN	Journey to zero: General Motors unveils 2023 sustainability report	1 May 2024	ENP Newswire ENPNEW
Factiva-050224BT	Tesla layoffs: Shares dropping since CEO Elon Musk fired around 500 people in Tesla Supercharger team	2 May 2024	Business Today Online
Factiva-050824DJ	Heard on the street: Tesla faces strong self-driving rivals in China	8 May 2024	Dow Jones Institutional News
Factiva-051124NF	Elon Musk fires Tesla executives after negotiations in China	11 May 2024	CE Noticias Financieras
Factiva-060524IBD	Tesla holds support amid EV woes; BYD flashes buy signal on sales, 1,300-mile EVs	5 June 2024	Investor's Business Daily INVDAI
Factiva-062824IBD	Tesla stock breaks out, BYD near 2024 highs with Q2 deliveries on tap	28 June 2024	Investor's Business Daily
Factiva-072324EN	What to expect from Tesla results? Energy storage and AI in focus	23 July 2024	Euronews
Factiva-080624Q	Uber stock is climbing after a strong quarter and optimism over its self-driving vehicle plans	6 August 2024	Quartz QUARTZ
Factiva-081424NF	Elon Musk built his business empire from a modest company	14 August 2024	CE Noticias Financieras
Factiva-082024W	Wards100: The most impactful auto execs of the 21st century	20 August 2024	WardsAuto WAW
Factiva-082324DPA	Cruise and Uber enter partnership for customers to access AV rides	23 August 2024	dpa trends Cars & Driving DPACAR
Factiva-082324USA	Uber partners with GM's Cruise to offer self-driving ride service	23 August 2024	USA Today Online USATONL

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Appendix 2 (Continued). Factiva data sources referenced in the results

Factiva number	Article name	Date	Source
Tesla (2022)	Elon Musk: A future worth getting excited about | Tesla Texas Gigafactory interview | TED	18 April 2022	https://www.youtube.com/watch?v=YRvf00NooN8
Tesla (2024)	Elon Musk's predictions	14 June 2024	https://www.youtube.com/watch?v=X4kRzIffBBI
GM (2024a)	GM CEO Mary Barra talks future of EVs, leadership, crisis management, and culture	28 March 2024	https://www.youtube.com/watch?v=Ot4QAAPLIt4
GM (2024b)	GM's $280 Billion Bet on EVs	2 May 2024	https://www.youtube.com/watch?v=AeWWmARalVQ
GM (2024c)	A conversation with General Motors Chair and CEO Mary Barra	23 May 2024	https://www.youtube.com/watch?v=E5Jtf2xFeDs

Source: own elaboration