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THE TRANSITION OF THE DISRUPTIVE ECOSYSTEM VALUE PROPOSITION: THE CASE OF TRANSPORTATION MOBILITY TECHNOLOGIES

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1. Introduction

Businesses are constantly searching for new opportunities to create value propositions within the competitive global setting. This growing number of propositions fuels the development of innovations and entire ecosystems to capture these opportunities (Christensen et al., 2018; Kumaraswamy et al., 2018; Palmié et al., 2019). With the power to impact markets, these disruptions can even change the entire value proposition of the ecosystem.

In innovation ecosystems, businesses develop actions, decisions, and investments in a collaborative and complementary way to create value from technical or business innovation that is impossible in isolation (Adner, 2006; Holgersson et al., 2022; Yaghmaie & Vanhaverbeke, 2019). Such innovation ecosystems have the ability to impact markets (Granstrand & Holgersson, 2020; Palmié et al., 2019), as studies on disruptive innovation point to the impact of new technologies and/or business models on the value structure of an existing ecosystem (Adner & Lieberman, 2021; Christensen et al., 2018). The ecosystem theory indicates that technological advancement and market needs drive ecosystem transformation through value creation (Oghazi et al., 2022), where the impact of disruptive innovation can only occur when the entire ecosystem is considered (Williams, 2014). In this sense, technological transitions are significant long-term technological changes that reconfigure the industry (Geels, 2002) and must consider within the scope of ecosystems.

The mobility sector is one of the most innovative ecosystems today: the standard of internal combustion engines (ICEs) suffers from the impact of new technologies for electric vehicles (EVs) that are beginning to enter the market; autonomous vehicles (AVs) are still in the testing phase; and even electric vertical take-off and landing vehicles (eVTOL), bringing a new aerial perspective to transportation mobility. According to Silva et al. (2022 – Article 2), the strategic perspective of businesses is moving towards the development of these technologies, raising the importance of investigating the change in the value proposition of these technologies in the ecosystem and understanding the change in the value proposition in the face of possible disruption.

Multiple authors have suggested that disruption can transform an ecosystem's entire initial value proposition and value chain (e.g. Christensen, 2006; Christensen et al., 2018; Dedehayir; Ortt & Seppänen, 2017; Jacobides; Cennamo & Gawer, 2018). When disruptive innovation drives a rapidly changing environment, one should not neglect the power of the forces that build and transform ecosystems (Kumaraswamy et al., 2018; Palmié et al., 2019). However, the academic literature has not yet provided a clear picture of the impact of disruptive innovation on the value proposition. There is a lack of studies specifically on transportation mobility – only a few studies have sought to understand how disruptive innovations can disrupt existing industries and build new ecosystems (Ansari et al., 2016; Oghazi et al., 2022; Ozalp et al., 2018; Pushpananthan & Elmquist, 2022). Such disruptive innovations and technological advances are responses to market needs that drive ecosystem transformation through the creation of new value (Oghazi et al., 2022), and generate creative destruction in an existing ecosystem (Clarke, 2019; Dedehayir et al., 2017; Nicolaï & Faucheux, 2015). This evolution of a new disruptive ecosystem, based on new technologies and a new business model, is in itself worthy of research (Christensen et al., 2015; Palmié et al., 2019; Pushpananthan & Elmquist, 2022).

Starting from the possibility of a disruption in the transportation mobility ecosystem, this study questions how the dynamics of evolution of the value proposition of a disruptive ecosystem occur? We propose that disruptive innovations can go beyond just changing the initial value proposition and turning it into a "dynamic value proposition". Thus, the objective of this study proposes to explore the value proposition dynamics evolution of potentially disruptive innovations in the transportation mobility ecosystem. We will employ the Disruptive Ecosystem Evolution model by Silva and Grützmann (2022), which focuses on the disruptive technological change to an existing ecosystem, and use the model to carry out a longitudinal case study of the transition dynamics of the value proposition of transportation mobility technologies.

The core contributions to the literature come from a deeper understanding of the ecosystem's value proposition for developing new potentially disruptive technology within the existing transportation mobility ecosystem. As the value proposition is central to the ecosystem and its transformation (Oghazi et al., 2022), this study also addresses the ecosystem where disruptive innovation occurs, which can help interpret and analyze the differentiated value proposition promoted in the new ecosystem. In this case, as a practical contribution, this study presents the new value proposition of the evolution of the transportation mobility ecosystem. This information would provide a broader picture of how disruptive technologies and business models will affect established ecosystems, leading to the reconfiguration of existing value. This study also seeks to contribute to the management literature with a dynamic of value transition to new technologies and the adaptation of businesses to the new ecosystem and market that emerge.

2. Theoretical Background

2.1. Disruptive Innovation and Innovation Ecosystems

The theory of disruptive technology explores how innovations with different characteristics have come to outperform dominant technologies in the market (Christensen, 1997; Christensen et al., 2018). We can describe business models for disruptive innovations as strategic architectures that redefine the meaning, creation, and capture of value (Cozzolino et al., 2018; Teece, 2010). Thus, technologies become disruptive innovations when they are caused by changes in technology and business models to create a new value proposition for the market (Christensen, 2006; Petzold et al., 2019).

An ecosystem is an arrangement of businesses collaborating to create value jointly (Adner, 2006). Ecosystems operate through constantly evolving actors, activities and artifacts, institutions, and relationships (Beltagui et al., 2020). An innovation ecosystem is based on technology development (Ansari et al., 2016; Sandström, 2016). On the other hand, the business ecosystem represents an environment in which businesses must monitor and react (Li, 2018), to adapt to the development of emerging technologies and business ideas (Adner & Kapoor, 2010). Gomes et al. (2018) point out that innovation ecosystems are more related to value creation, while business ecosystems are more related to value capture. In this sense, in the ecosystem, a market develops around the value proposition of an innovation (Hou & Shi, 2020; Ma et al., 2018).

One of the characteristics of potentially disruptive innovations is that the value proposition of disruption can lead to the creation of new markets (Christensen et al., 2001; Nagy et al., 2016). We need to consider the disruption along with the innovation ecosystems in which they operate (Beltagui et al., 2020; Liu et al., 2020). In this way, businesses are linked to an ecology of value and must align their strategies for ecosystem success (Bers et al., 2012; Moore, 1993; Zalan & Toufaily, 2017) and the disruption within the ecosystem (Dedehayir et al., 2017). Since competition in technology-intensive industries is increasingly taking place between ecosystems (Beltagui et al., 2020; Moore, 1993), ecosystems play a crucial role in the emergence of new technology. As innovation develops in the ecosystem, companies need to find new business models to coordinate the balance between cooperation and competition and allow the creation of value for the ecosystem (Holgersson et al., 2022). In this way, the evolution of new and old technologies and the ecosystems and business models shape the technological substitution in that they are embedded (Adner & Kapoor, 2016).

2.2. Disruptive Ecosystems

Disruptive innovations are usually developed and commercialized in ecosystems and not via isolated businesses (Beltagui et al., 2020; Dedehayir et al., 2017), as the themes of disruptive innovation and innovation ecosystem intersect (Palmié et al., 2019). Business models draw the prospect of inserting disruption within the innovation ecosystem and become an important tool for the demand for the co-evolution of business strategies (Kumaraswamy et al., 2018; Rabin et al., 2020).

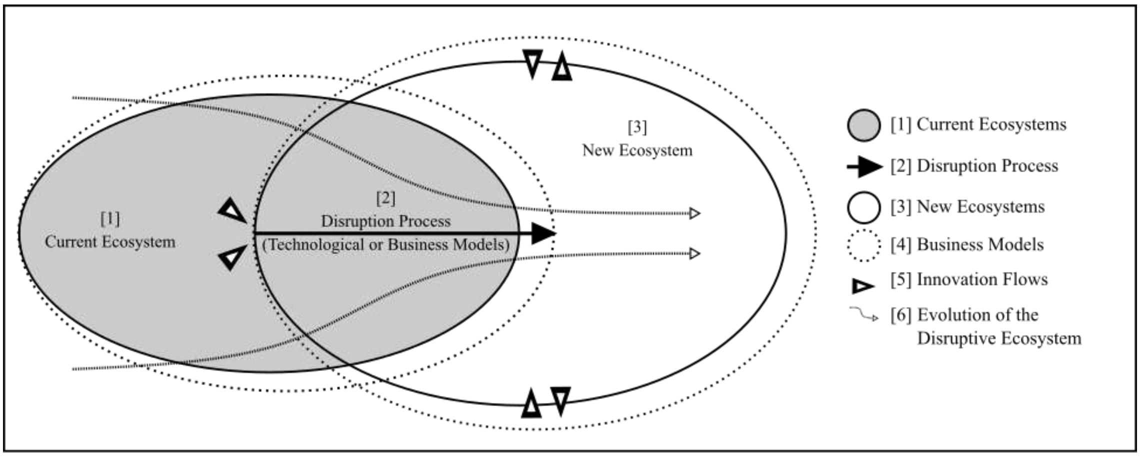
In this sense, a disruptive innovation ecosystem combines the definitions of disruptive innovations and innovation ecosystems so that an ecosystem develops and grows around an innovation (Palmié et al., 2019). Embedding a disruptive innovation in an ecosystem, complementary innovations from ecosystem members can increase the innovation's appeal and emphasize the disruption's potential to dominate the market. Here, a disruption can cause creative destruction and generate a new ecosystem based on the disruption's value proposition and business model (Clarke, 2019; Dedehayir et al., 2018). Thus, it is necessary to analyze the value generated by disruptions through a holistic perspective of the ecosystem(Adner, 2017; Jacobides et al., 2018). For disruptors, the task is to unite a new ecosystem around disruptive innovation to gain access to complementary resources from those responsible for the ecosystem they disrupt (Kumaraswamy et al., 2018).

According to the Christensen Institute (2021), three elements are necessary for disruption: the Technology, to make the product more accessible; the Business Model, to target new or marginalized consumers; and the Value Network, which targets disruption prosperity. As disruptive innovation generates great potential for change, it is usually incompatible with existing value propositions (Christensen et al., 2018; Keller & Hüsig, 2009). Thus, disruptions are innovations that can revolutionize an entire industry and substantially change its competitive patterns and value creation (Christensen et al., 2015; Kumaraswamy et al., 2018). They reconfigure strategic architectures that redefine the meaning of creating and capturing value in markets (Petzold et al., 2019; Teece, 2010). In this integration, disruptive innovation creates a demand for a new value proposition, which allows the creation of a new market (Ansari et al., 2016; Christensen et al., 2018; Kumaraswamy et al., 2018; Palmié et al., 2019; Petzold et al., 2019).

2.3. Evolution of the Disruptive Ecosystem

Silva and Grützmann (2022) present a Disruptive Ecosystem Evolution Model based on technological dynamics and innovation value, which states that disruptive innovation has the potential to transform the entire ecosystem, and it is up to the actors to co-evolve through the business models. Through the impact of **creative destruction**, disruptive innovations have the potential to transform and evolve the entire existing technological ecosystem and create new value between **incumbents** and **new entrants**. As for the ecosystem, it suffers the impact of disruption and is affected by **internal forces**, which create joint value and develop innovation within the ecosystem, and **external forces** (such as legislation, environmental pressures, social environment and supporting ecosystem) that can stop or drive disruption. Disruption business models takes the technological and strategic interdependencies between actors and become a tool for the open co-evolution of business strategies.

Figure 1 - Theoretical Evolution of the Disruptive Ecosystem Framework.



Source: Silva e Grützmann (2022).

The Disruptive Ecosystem Evolution Model (Figure 1) shows the forces that work with the impact of disruption towards the evolution of a new ecosystem. In this model, incumbents and new operators must cooperate and evolve for disruption. This process of evolution is due to the destruction of existing technologies and business models. In this process of ecosystem evolution, the idea of disruptive innovation prevails (Christensen, 1997, 2006; Christensen et al., 2018), with characteristics of old and new actors and with characteristics of old and new technologies and business models, where organizations that do not adapt to the evolving environment are disrupted and cease to exist. Hence, the model presents disruption as a tool for destroying and creating ecosystems and reconfiguring the existing value.

3. Methodology

This study aims to explore the value proposition dynamics evolution of potentially disruptive innovations in the transportation mobility ecosystem. The technological transition theory also addresses these long-term changes and is relevant to the ecosystems theory (Geels, 2002). However, this study analyses only the dynamics of the value proposition as the scope for the impact of disruption on the ecosystem.

The focus of the study was the context of new transportation mobility technologies and the latest technologies under development (EVs, AVs, and eVTOLs) as a case of ecosystem evolution. Researchers have addressed these technologies before also in the context of innovation research (Cohen et al., 2021; Cowan et al., 2014; Cugurullo et al., 2020; Fagnant & Kockelman, 2015; Rajendran & Srinivas, 2020; Wang et al., 2011).

This study chose a longitudinal exploratory case study to understand better the dynamics of the value proposition transition between ecosystem technologies (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 1994). It is possible to use a longitudinal case study when there is a large source of data over time (Karlsson & Åhlström, 1995) to study the change of different conditions focusing on the evolution of a particular aspect (Yin, 2009). This method helps observe the emergence and stabilization of an innovation (Hargadon & Douglas, 2001) when theories do not answer the existing question and when the question relates to a process or a strategic interaction perspective that evolves (Hannah & Eisenhardt, 2018; Holgersson et al., 2018). Similar studies have been conducted in the literature to present the transition of technologies (Ansari et al., 2016; Bohnsack et al., 2021; Holgersson et al., 2018; Ozalp et al., 2018). To describe the dynamics of the value proposition between generations of transportation mobility technologies, it is important to emphasize that previous studies present past technological transitions. In contrast, this exploratory longitudinal study seeks to shed light on the technologies currently being developed in the market.

Such longitudinal studies are essential to understand the formation of generations of product and/or process innovations over long periods of time; they are an opportunity for comparative studies where generational changes tend to involve more drastic or discontinuous changes; and are helpful in managing the dynamics of technological transitions and disruptive innovations, in the sense of Schumpeterian competition, leading to changes in product generation and promoting incremental changes between these transitions; and, lastly, they focus on unique technological dynamics of disruptive innovation rather than a sequence of several innovations(Christensen et al., 2018; Holgersson et al., 2018; Ozalp et al., 2018).

3.1. Data Collection

In this study, we analyse the value proposition of the innovation ecosystem of EVs, AVs, and eVTOLs technologies under the theory of disruptive ecosystems. Factors such as actors, products, relationships, resources, activities, risks, dependencies and value created were analysed (Ansari et al., 2016; Beltagui et al., 2020; Granstrand & Holgersson, 2020; Hou & Shi, 2020). or this study, each case addresses a different technology. We followed the evolution of the value proposition within the ecosystem.

For data collection, it used secondary data sources of technologies in the market, such as reports elaborated by technology development businesses and consulting firms (Holgersson et al., 2018; Langley, 1999; Ozalp et al., 2018). In total, 25 reports of EVs, 6 of EVs and AVs, 52 of AVs, 1 of AVs and eVTOLs, and 47 of eVTOLs were collected, totaling 131 reports with 6,111 pages of documents for analysis. There sourced the list of the world's largest EV, AV, and eVTOL technology developers, as noted by Silva et al. (2023 – Article 2). Businesses' websites and the respective value statements of technology developers were analyzed to enhance the value propositions they intend to deliver to the market (Bart, 1998; Campbell, 1991; Lynn & Akgu, 2001; Raynor, 1998; Waddock & Smith, 2015). All pages were visited and collected information on 22 sites about EVs and 33 about AVs, and 10 sites with information about eVTOLs. Complementarily, for eVTOLs technology, the TNMT Innovation Hub list was also used. This data points out the leading players in the Aviation sector (6), the Automotive sector (7), the Technologies sector (5), and the leading Startups (11), and the list of the top 20 businesses in the total amount of technology patents (Lufthansa Innovation Hub, 2021). In total, the collection of information occurs on 68 websites of businesses related to the development of technologies.

Following Bohnsack et al. (2021), this study does not select scientific journals to ensure a purely narrative and non-analytical description of the analyzed data. This study analyzes 199 documents between 2009 and 2022 that contribute to developing the value proposition of technologies within the ecosystem. Combinations of these sources contributed to the data triangulation. They allowed comparing ex-post information to reduce the risk of incorrect inferences and to follow the evolution of technologies and the construction of the value proposition of technologies.

3.2. Data Analysis

The analysis started by combining data from different sources to build a comprehensive historical case for each technology (Dubois & Gadde, 2002; Eisenhardt, 1989; Holgersson et al., 2018; Ozalp et al., 2018; Yin, 1994). This study uses content analysis to build a comprehensive historical case of the value proposition of each technology in the ecosystem. As this study's scope is the dynamics of evolution, to identify and analyze changes in the value proposition of the ecosystem based on disruption, we used the Disruptive Ecosystem Evolution Model proposal to create the initial categories of the closed grid kind. We identified emerging patterns by analyzing the evolution of each technology's value proposition (Eisenhardt & Graebner, 2007; Yin, 1994). The concentration of information sought to corroborate the multiple sources of data found.

In section 4 we present a comparison between cases of the dynamic value proposition of technologies and those analyzed within the Disruptive Ecosystem Evolution Model to verify the evolutionary structure of the disruptive ecosystem. Then, in section 5, the data analysis is compared with the literature to refine the model proposal.

4. Findings

The dynamics of disruption in the innovation ecosystem affect the business ecosystem and, consequently, the business market. We recognize that the disruption will also impact the business ecosystem. As these ecosystems are interdependent, the focus is the Evolution of the Value Proposition of the Disruptive Ecosystem of Transportation Mobility Technologies in the face of a disruption which affects both the innovation ecosystem and the business ecosystem.

Our analysis begins with the presentation of the cases. Next follows the analysis of the first category of the model, Disruptive Innovation and Changing Technological Patterns, which corroborates the idea of the subtopics of Creative Destruction and Historic Operators and New Operators. The second category presents the analysis of the Innovation Ecosystem and the Driving Forces in the Internal Environment and External Environment of the Ecosystem. The third category presents the analysis of the Business Models that involve the environment and the Evolution Flows of Innovation. Finally, according to the model, we present the Evolution of the Disruptive ecosystem of transportation mobility. Even though the borders of each category overlap, we present all the categories below in isolation to facilitate the research context. The extension of the reference list is too large to present in this article, so we present a snippet of the references with numbers in parentheses, which can be seen in Appendix I.

4.1. Technology Cases

Few products have had such a profound influence on the world as transport vehicles. The automotive industry has been a force for innovation and economic growth worldwide. The combination of oil-powered ICE has dominated global transportation mobility for more than a century. That was an optimization to produce and sell ICE-based vehicles. However, since the introduction of Henry Ford's moving assembly line, changes have been both incremental and evolutionary (37; 40).

In the first decades of the 21st century, the pace of innovation is accelerating, and industry, market, resource constraints and social pressures (58; 51; 34; 57; 54) demand technological innovation with the potential to reshape the market (38). New technology with new business models different from those that currently exist could change the entire pattern of innovation and business in the existing ecosystem (25).

Introducing a more sustainable vehicle technology powered by electricity, autonomous technologies, and the possibility of air transport, for example, can trigger a disruption in the existing ecosystem (17; 34; 60; 67). EVs and AVs can change the current configuration of the transport system making it faster, more convenient, safer, more economical, sustainable and smarter. eVTOLs allow transport even faster by airspace, with minimal infrastructure, and make it possible to fly to remote areas where there is currently no infrastructure. These technological revolutions can change how our society works, improving safety and efficiency and reducing congestion and emissions (51; 26; 59; 8; 54; 46; 9).

The transportation mobility market tends to be driven by electric, autonomous, intelligent, connected, and airspace exploration technologies (Advanced Air Mobility - AAM). We are currently in the early stages of a potentially disruptive evolution. These new technologies are mainly products based on new hardware and software systems (12; 56; 57; 43). Established players and new entrants are working to develop this new transport reality (46; 42; 25).

Technology will play a vital role in the evolution of this ecosystem, and the pace of innovation is accelerating (17). Rather than a technological monolith, these new technologies will coexist, and innovation will continue on multiple fronts, building a blended technological ecosystem within the market (40; 16; 20). A broad and rapid reorganization of these ecosystems in the face of these potential disruptions could have far-reaching consequences for the entire market value proposition. The following sections present the impact of disruption and the change in the value proposition in the ecosystem according to the Disruptive Ecosystem Evolution model.

4.2. Disruptive Innovation and Changing Technological Patterns

Disruptive innovation has the potential to transform the entire ecosystem, as EVs, AVs, and eVTOLs technologies have the potential to have the disruptive effect of transforming or evolving the ecosystem. EVs are emerging, with various players within the auto industry developing electromobility technology. In the process of EV disruption, there will be various hybrid combinations to meet market needs until complete disruption happens (40). Strategies will require rebuilding technological resources to catch up with the dominant players' operations and manufacturing levels. The Renault-Nissan-Mitsubishi alliance is a sign of this restructuring of the EV market (59; 51). Disruption occurs in the electric motor world, where ICEs cease to exist. The transition to EVs will occur gradually as it significantly impacts the current value structures of all ecosystem actors (25; 15).

AVs combine artificial intelligence, user-centered design, connectivity, and sophisticated manufacturing (43; 9; 30). This transformation will occur with the evolution of EV companies and technologies and by new technological and software players. Orange, IBM, Google, and Amazon are companies that participate in building this connectivity through artificial intelligence as a key factor in AVs (52; 31). is transformation is changing the automotive industry's value chain and creating an intelligence-based ecosystem. Automation technology will power on-demand mobility as a service (MaaS) and could disrupt the market

(56; 12). In the long term, the evolution of these advances will cause a rebalancing of the value chain, with non-traditional companies playing a more significant role.

On the other hand, the eVTOLs disruptive process demands a high intensity of technological development, which can even create a new segment of commercial mobility (46; 65). In this evolving ecosystem, the opportunities are relevant for all players, but the risks seem more significant for aerospace companies that may experience disruption. Companies such as Bell, Leonardo, and Honeywell are developing the technology to actively participate in disruption (12; 13: 14; 21; 4; 44; 29). Although current operators may risk suppression by the new ecosystem of eVTOLs, the AAM will not replace the existing mobility system but will integrate it as a complementary element to the future mobility ecosystem (60; 20; 46). The main disruption factor is anchored in the collaboration of different actors for the evolution of the ecosystem and the creation of a new segment of commercial mobility in the market.

4.2.1. Creative Destruction

Creative destruction occurs when new technologies allow new and better products to displace the dominant products in the market. The effect of creative destruction occurs even more quickly due to the potential disruption of the three technologies addressed in this study. Manufacturing is no longer the core competency, which explains new entrants as part of the disruption. Software-defined vehicles replace the traditional lifecycle, value chain, and especially the value proposition of the mobility ecosystem that is being redefined based on electrification, automation, connectivity, and aerial technologies (43; 13: 14; 25; 47; 54).

Within the business ecosystem, vehicle assembly companies are increasingly focusing on manufacturing EVs (51; 59; 26; 64). There are partnering with companies and startups for investments in automation and connectivity technologies. Companies such as Google, Intel, Tencent, Aurora, Cruise, and Uber (37; 12; 48), and in air forms of transport such as Embraer, Joby Aviation, and Lilium (18; 35; 45), are signals that the destruction of the existing pattern is already taking place. This strong demand (and supply) from the ecosystem and new disruptors have leveraged the development of new technological standards.

4.2.2. Historical and New Operators

The change in the value chain, integrating new actors into the existing ecosystem, can be a source of competitive advantage to face disruption. Actors make the EV ecosystem from within the auto industry itself: the Renault-Nissan-Mitsubishi alliance and the partnership between Honda and General Motors are examples of partnerships and collaborations to develop and explore the market (28; 59; 51). Evolving EV companies and adding new entrants from the software technology industry make the AV ecosystem. Traditional car manufacturers such as Toyota, Nissan, and Fiat have decades of experience designing and manufacturing vehicles and are currently adapting to the demand for EV manufacturing (64; 51; 26). Meanwhile, the disruption of AVs by new entrants such as Tesla and Uber, incumbents of technology such as Google/Waymo and IBM have developed the technologies needed to automate and connect vehicles (62; 66; 2; 32).

The new eVTOLs ecosystem is even broader, with manufacturers from the automotive sectors like Honda, Hyundai, and Porsche, aerospace like Airbus and Boeing, ride-sharing companies like Uber, broader transport companies like Toyota or JetBlue and retailers like Amazon, and startups like Volocopter, Skydrive and Terrafugia operating in this space (28; 30; 53; 1; 7; 66; 49; 46). Startups are dominating the eVTOL innovation ecosystem, partly because they have market-critical technology and partly because they have higher risk tolerance. What remains common to the disruption of EVs, AVs, and eVTOLs technologies are the relationships created between the different historical and new actors in developing the new ecosystem.

4.3. Innovation Ecosystem

Ecosystems are networks of interconnected and interdependent businesses to develop technologies. The EV ecosystem is evolving in a market with many experienced ICE players. This disruption occurs due to a substitution in the technological standard, which affects all actors in the value chain (25). Some ICE manufacturing companies have chosen to leverage their own technologies in isolation, such as Toyota and BMW, while others, such as Fiat, Chrysler, and Nissan, have chosen to form partnerships to develop the technological ecosystem (64; 6; 26; 51). In turn, AVs take advantage of the EV ecosystem to evolve alongside new companies in automation technologies, connectivity, the internet of things, artificial intelligence, cloud computing, and big data, among others (43; 43; 67). Cooperation has become key to developing automation technology and accelerating the ecosystem.

The eVTOL ecosystem encompasses the activities of its wide range of participants (see topic 5.1.2) as they collaborate to develop the various necessary technologies. Partnerships became the foundation for success in this new and complex AAM space. Joby Aviation has partnerships with Hyundai and Toyota, in addition to having acquired Uber Elevate, Google has acquired Kittyhawk, and several other companies and startups are seeking partnerships (35; 36). This approach promotes shared ideas and nurtures new opportunities for research, technology development, infrastructure, management, and market exploration (46; 63; 44).

The competitive landscape of these new mobility industries is constantly changing. Cooperation is a prerequisite in all areas of the ecosystem to mitigate complex challenges. The wide range of skills and capabilities needed to develop the technologies is almost nonexistent in a single player (12). Software competence is becoming one of the most critical differentiators for the industry (43; 46; 47). In addition to the lack of technological or process knowledge, there are other reasons to join forces, such as reduced development costs, reduced technological innovation cycles, greater competitiveness, more significant influence in defining standards of autonomous driving systems, and risk sharing (60; 43). In this more complex and diverse scenario, established players will force competition simultaneously on multiple fronts and cooperate with competitors.

4.3.1. Driving Forces: Internal and External Environment of the Ecosystem

The ecosystem unification depends upon the forces that drive the necessary change. As a technology with the potential to create disruption in the existing ecosystem, EVs, AVs, and eVTOLs experience forces that can block or drive the disruptive potential.

- The role of the government's **Policy and Regulation** is necessary so that tax benefits and government incentives can release and expand the development of technologies and the market itself (34; 40; 24; 60; 47).
- **Environmental Pressures** for a global climate agenda is another relevant factor. New technologies can reduce fossil fuel consumption and greenhouse gases and are viable solutions to the current model based on ECIs (58; 51; 34; 57; 54).
- In **Social Environment** the public perception of benefits (such as cost reduction, reduction of road maintenance costs, reduction of accidents, reduction of traffic jams, increase in speed and economy, gain in travel time and the new safe experience of MaaS on-demand) are positive factors that can drive technology acceptance and market development (60; 27; 46; 22).

- The **Technological Support Environment** is necessary to support nascent technologies' development. Smart vehicles need smart infrastructure for vehicle-to-vehicle communications. The technological maturity of components (such as batteries and software are necessary, as well as the 5G technology infrastructure for intelligent communication between vehicles, the charging infrastructure for EVs and AVs, and the eVTOLs take-off and landing points adopted in cities, the network of providers of services, among others) are necessary to support the nascent technology and reach market diffusion (40; 43; 60; 39; 41; 23; 33; 55; 13; 50).

New technologies are still in their early stages in many emerging markets and developing economies. Working with technology that did not exist before implies an infrastructure that does not exist yet, and requires new regulations. New technologies offer countries and regions a variety of opportunities to exceed carbon transport standards, boost economic efficiency, and circumvent or alleviate negative impacts such as air pollution and congestion. Failure to properly develop the technologies and ecosystem can create bottlenecks. However, the correct investment in the ecosystem and the future market can expand the development and growth of the technology.

4.4. Business Models

Business models are a set of procedures and principles of value creation and can be very distinct between companies. As previously shown, some companies such as Tesla, Toyota, and BMW chose to develop technologies in isolation in search of competitive advantage. In contrast, other companies chose to carry out partnerships, mergers, and/or acquisitions to develop the EV ecosystem. Many vendors seek to combine components to facilitate the vehicle integration ecosystem (25; 11; 43). This adaptability of technologies seeks to make vehicle manufacturing more flexible and dynamic. This causes most major industry players to collaborate across the value chain to leverage partners' technology capabilities (25). These strategies will shape the transformations and generate a competitive advantage for the ecosystem against competitors.

There is no clear leader in the AV ecosystem in developing this technology, and no dominant design exists. Some technologies are used on all fronts, but a clear path to automation still needs to be defined (43). Companies are collaborating to develop technology while competing to get market share. There is a combination of the experience of incumbents in designing and manufacturing vehicles with the ability of technology companies and startups to develop the necessary software. Cooperation between various parties is forming new industrial chains for AV development (58; 59; 2; 66). Several partnership strategies seek to fill the skills or technology gaps needed to accelerate the development of AVs and remain competitive in this evolution.

The dynamic evolution of eVTOLs is even greater. Incumbent operators from various markets and startups to develop technologies for exploring the future market. Startups are created exclusively to develop and exploit this technology, are at the forefront of technology and have greater flexibility to adapt to changes in the market (64; 30, 35; 45; 68; 4; 44). Large-scale incumbents actively participate in market development but hold out for the market to mature first. Thus, incumbents can ally with startups to mitigate risks (46; 13). The collaboration of all these members aims to share problems and answers and develop a dominant technology design, seeking a share of this new market.

Business models are the most apparent difference in the three technologies business ecosystem. While EVs tend to continue the vehicle acquisition model adopted in ICEs, AVs, and eVTOLs are mostly on-demand MaaS (38; 40; 43; 47; 51; 26; 61). The eVTOLs are responsible for medium-distance trips and the AVs for short distances, such as the first and last miles (66; 17). Disruption of EVs, therefore, occurs in the value chain of the technology innovation and production ecosystem. However, the disruption brought by AVs and eVTOLs happens as much in the innovation ecosystem value chain as it does in the market and business ecosystem.

4.4.1. Innovation Flows

Disruption can benefit members of the ecosystem-built coopetitive processes through flexible and open Innovation processes. In the case of EVs, some companies have chosen to maintain a closed innovation flow, focusing on internal competencies to generate unique value in the development and exploration of the market. The clearest example is Tesla, which committed to vertical integration, manufacturing everything from its production equipment to a charging station network (62; 40). On the other hand, other companies opted for a more open flow of innovation, as is the case of the Renault-Nissan-Mitsubishi alliance and Fiat Chrysler (59; 51; 26) for the development of the market's technology and business ecosystem.

In the case of AVs and eVTOLs, open innovation flows predominate. Different technologies are necessary for developing these markets: experience and manufacturing capacity, batteries, sensors, propulsion, automation software development, connectivity, 5G, the internet of things, artificial intelligence, cloud computing, big data, among others. The partnership between BMW, Mobileye and Intel aims at developing automation technologies (43; 31; 32; 9; 52; 46; 13; 10; 5). In this model, companies open up to a diverse group of external players (partners, suppliers, competitors, startups, universities, among others) in several countries and with very different realities, which promotes an ecosystem of creativity for the development of new technological solutions. Open Innovation drives growth through an innovative collaboration between all parties. This diverse innovation ecosystem can leverage the best of all actors to build disruption within the ecosystem itself.

4.5. Evolution of the Disruptive Transportation Mobility Ecosystem

In this process of Evolution of the Disruptive Ecosystem, the ecosystem must evolve into a new ecosystem through disruptive Innovation. Research data points to companies belonging to the ICE ecosystem as the basis for the evolution of the EV ecosystem (11; 43). The process started based on a disruptor actor, but almost all actors responsible for manufacturing, suppliers, and infrastructure, among others, were part of the composition of the newly evolved ecosystem. Another part was made by new entrants who challenged the status quo of technology and dominant companies. As part of the disruption principle, companies that did not follow such evolution of the disruptive process tended to disappear from the ecosystem. The business ecosystem value proposition was applied based on the advantages of the new technology, mainly concerning the sustainable gains of EVs. For the innovation ecosystem, the value proposition changed entirely based on the new value chain produced by electromobility technology.

AV technology was built on the electromobility ecosystem created by EVs. With disruptive automation and connectivity technology created by new entrants, incumbents, and startups from the software and internet sector, it was possible to evolve into the new transportation mobility ecosystem (43; 43; 67). Although there is no clear leader, the collaboration between the companies was a fundamental factor in developing the technology. In this impact, the value proposition of the business ecosystem would be most strongly affected by factors such as travel security, reduced ownership costs, and especially by offering MaaS on-demand (43; 51). On the other hand, the value proposition of the innovation ecosystem changes with the insertion of new entrants with the disruptive technology of automation and connectivity. The vehicle's manufacturing capacity ceased to be the main factor within the ecosystem and became the production of automation technology. The entire ecosystem was changed based on the new disruptive technology. A new ecosystem was created based on the existing mobility companies and the new entrants in the technology sector.

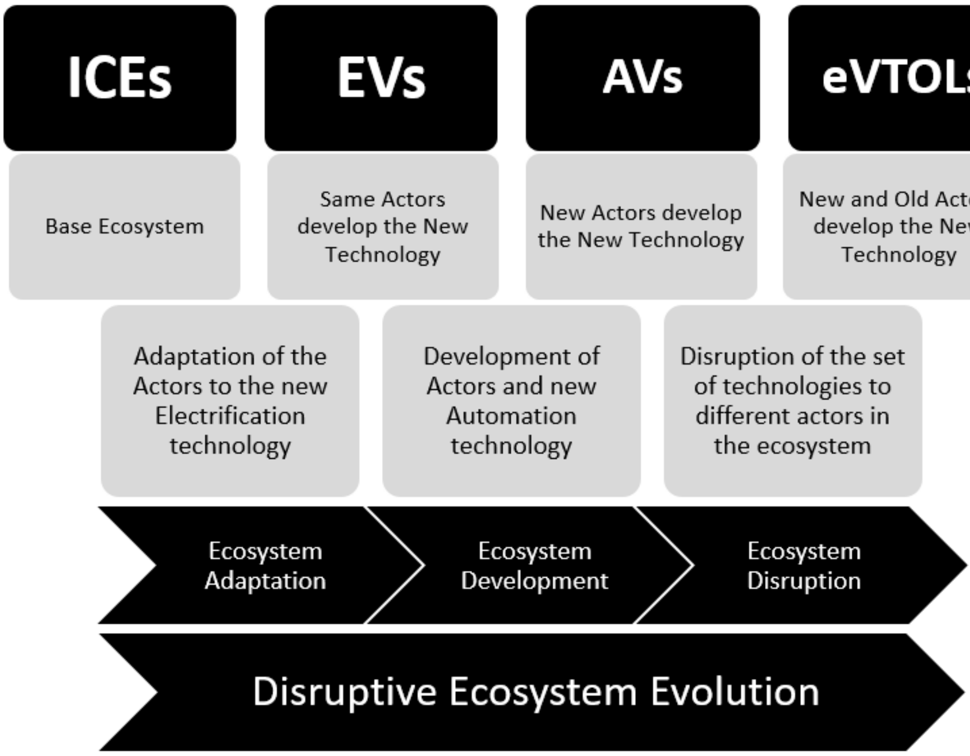
Lastly, in a similar fashion, the ICE ecosystem evolved into the EV ecosystem, and this one which, with the participation of new entrants from the technology sector, also evolved into the AV ecosystem, may evolve into the eVTOL ecosystem. The most important factor is that the eVTOL ecosystem is made up of companies from the automobility and aeromobility sectors, but the essential technology for the development of this ecosystem comes from the technology and software sector, which already participated in the previous AV ecosystem (28; 30; 53; 1; 7; 66; 49; 46). Startups play a crucial role in developing this ecosystem, as they can take risks that large companies cannot. The most critical tool in developing this ecosystem is the collaboration of the various actors (35; 19; 68; 36; 3).

For the various sectors that invest in eVTOL technology, the value proposition of the business ecosystem is the possibility of evolving their own businesses, be it transport, logistics, retail, or military, among others, or of capturing a slice of the new and immense market that is about to open. As for the innovation ecosystem, the value proposition was the total change of the ecosystem. It was composed of different sectors of manufacturing technology, in particular automotive and aerospace, but in which the software and connectivity technology sector became a priority. Prototypes of flying vehicles have existed but have never been commercially produced. The project was only possible thanks to the development of electric battery technologies for EVs and automation for AVs. This enables the evolution of innovation ecosystems based on the disruptions that affect them.

5. Discussions

This study aims to present the evolution of EVs, AVs and eVTOLs as technologies with the potential to change the technological and value standard of the current transportation mobility market. As this is an evolving ecosystem, it is composed of different actors who participated in the initial ecosystem and new entrants who adapted to the development of the disruption and developed the new disruptive ecosystem. Figure 2 shows the Evolution of the Disruptive Ecosystem. This proposal remains in line with the theory that points out that disruptions have the potential to create value based on the disruption changing the entire ecosystem (Adner, 2006; Granstrand & Holgersson, 2020; Holgersson et al., 2022; Palmié et al., 2019; Yaghmaie & Vanhaverbeke, 2019), even creating new markets (Christensen et al., 2018; Cohen et al., 2021; Kumaraswamy et al., 2018; Nagy et al., 2016; Silva & Grützmann, 2022).

Figure 2 - Evolution of the Disruptive Ecosystem.



Source: Research data.

Our results point out that the transformation of the intelligence-based mobility market is changing the entire value chain and proposition, where manufacturing is no longer a core competency of the transportation mobility industry. The research results also point to the entry of actors from different sectors to the development of a new technology, which hints towards a disruptive process in the ecosystem. These findings corroborate studies that indicate that the value proposition is central to ecosystem transformation (Dedehayir et al., 2018; Oghazi et al., 2022; Palmié et al., 2019; Tsujimoto et al., 2018) and that technologies and actors can be the start of disruption in the ecosystem (Ansari et al., 2016; Nagy et al., 2016; Ozalp et al., 2018).

The research also points out that EV, AV, and eVTOL technologies are becoming part of an evolutionary process, creating value within the perspective of technological development (Innovation Ecosystem) and will be complementary within the market value capture perspective (Business Ecosystem). These findings corroborate previous research on creating and capturing ecosystem value (Gomes et al., 2018; Granstrand & Holgersson, 2020; Gu et al., 2021; Pushpananthan & Elmquist, 2022; Tsujimoto et al., 2018). Also corroborating the existing literature (Clarke, 2019; Dedehayir et al., 2017; Sandström, 2016), our results point out that both ecosystems are part of the process of creative destruction within the existing ecosystem and create a new disruptive ecosystem with a new value offer.

The research results also highlight that in this new ecosystem, actors seek the necessary resources (technical and non-technical) to integrate them into the ecosystem's various business models and be well-positioned for the future. The opening of the ecosystem's disruptive process promotes collaboration between actors from different technological sectors for the development of EVs, AVs, and eVTOLs technologies. Collaboration is already taking place across the ecosystem, and various actors are working to develop this universe utterly different from the current mobility industry. These findings support the innovation ecosystem theory, where the ecosystem creates value through collaboration and long-term benefits for all those involved in the ecosystem's future (Adner, 2006; Ansari et al., 2016; Beltagui et al., 2020; Sandström, 2016). Our findings also validate the literature (Adner & Kapoor, 2010; Bers et al., 2012) where the ecology of actors' value is linked to the success of the ecosystem. A development cycle dictates the uneven evolution of technology in the face of ecosystem participants.

As for the business ecosystem, our results show that the forces that drive technology and time will be critical factors for the technologies' success. The shift to new technologies will not likely be linear, as incumbents need to sustain their core businesses. This will require a balance between business first-movers, demand from the driving forces of new technologies, and technology substitution advantages. A mixed landscape of the evolution of the business ecosystem will occur, with different technologies cohabiting the transportation mobility ecosystem until the new technologies mature and surpass the existing ICEs. These results are in line with the theory regarding the evolution of ecosystems (Adner & Kapoor, 2016; Beltagui et al., 2020; Pushpananthan & Elmquist, 2022; Silva & Grützmann, 2022), and will allow old and new operators to gain space if they adapt to the new ecosystem in disruption.

According to the Disruptive Ecosystem Evolution Model proposal, the ecosystem innovation flow between collaborating actors aims to develop disruption within the new ecosystem. An evolutionary adaptation occurs, generating disruptive changes in the ecosystem. Unlike radical innovation that destroys the ecosystem pattern, disruptive innovation will generate evolution and adaptation along with the ecosystem. To this end, we propose the concept of a "Dynamic Value Proposition" that accompanies the impact of disruption and adaptively evolves the value proposition along with the ecosystem. Thus, this dynamic of evolution and adaptation of the value proposition of the disruptive ecosystem of EVs, AVs and eVTOLs constitutes the new Transportation Mobility Value Ecosystem. These findings align with the disruptive ecosystem's theoretical proposal in which the entire ecosystem adapts to disruptive change (Christensen et al., 2018; Cohen et al., 2021; Dedehayir et al., 2017; Palmié et al., 2019; Silva & Grützmann, 2022).

5.1. Theoretical Contributions

This study presents essential contributions to the literature. First, it contributes to expanding knowledge about the impact of a disruption on an innovation ecosystem (Christensen et al., 2018; Kumaraswamy et al., 2018; Palmié et al., 2019). Disruption can generate waves of evolution and adaptation of the actors, creating a new ecosystem based on disruptive technology and based on the different actors that enter the ecosystem. Likewise, this study also contributes to the innovation ecosystem value proposition literature (Christensen, 2006; Christensen et al., 2018; Dedehayir et al., 2017; Jacobides et al., 2018). As a clearer picture of the impact of disruptive innovation on this initial value proposition, our study shows that when the disruption impacts the ecosystem, it changes its value proposition to adapt to the disruptive process. To this end, innovation ecosystems undergo an adaptation of the value proposition, creating a new ecosystem with characteristics of the new technology and the different actors that coexist and collaborate.

This study also contributes to the business ecosystem literature (Adner & Lieberman, 2021; Christensen et al., 2018) by expanding the knowledge of new technologies and their impact on the market. When under the effect of a disruption, the ecosystem seeks to adapt to the disruptor and the disruptive effect, creating a space for developing new technology. In this case, incumbent operators and new entrants can add value while remaining within the evolutionary strategy of disruption within the ecosystem.

The applications of the Disruptive Ecosystem Evolution Model should be considered. This model, initially developed to represent the impact of a disruption in the ecosystem, proved to be a valuable tool for discussing the evolution of the ecosystem's value proposition in the face of disruptions. In addition to the results of this study confirm the evolution model of the disruptive ecosystem, it was also possible to present the evolution of the value proposition based on the technological transition. This study also contributes to creating the Dynamic Value Proposition concept, which adapts and evolves along with the disruptive ecosystem.

5.2. Practical and Managerial Contributions

For practice, this study contributes to understanding the impact that new technologies of EVs, AVs, and eVTOLs can have on current transportation mobility. Companies must prepare for the impact of disruption on different actors and the possible creative destruction of the ecosystem. Understanding the driving forces needed to pave the way for disruption and the business models to leverage this tangle of ecosystem actors is necessary. In the case of the evolution of the transportation mobility market, managers need to prepare for the process of adapting to disruption.

This study also contributes to understanding the impact of EVs, AVs, and eVTOLs technologies on the market value proposition. Value chains are changing, new and different actors are contributing to the growth of technologies, and new actors will appear to use the business ecosystem. Since the joint effort to develop these technologies is broad and covers several technology fields, managers must prepare for the market disruption's effect and the new opportunities that will appear.

6. Conclusions

This study aimed to explore the value proposition dynamics evolution of potentially disruptive innovations in the transportation mobility ecosystem. To this end, a longitudinal study of the Disruptive Ecosystem Evolution Model was carried out to understand the dynamics of transition and adaptation of the value proposition of new transportation mobility technologies. In the proposed model, it was possible to understand the evolution of ecosystems based on the disruption of EVs, AVs, and eVTOLs technologies.

In light of the evolution and adaptation of the disruptive ecosystem, the entry of new technologies and companies in the transportation mobility ecosystem impacts incumbent operators and new entrants. This impact of technology on actors due to disruption generates a process for adapting to the new ecosystem (Dedehayir et al., 2017; Palmié et al., 2019; Silva & Grützmann, 2022). Actors who do not adapt to the process may be left out of the ecosystem (Christensen et al., 2018). Disruptive innovation will thus direct the ecosystem's future, in the form of a mosaic, with part of the historical and current capabilities within that ecosystem.

The Evolution Dynamics of the Value Proposition show the makeup of a new ecosystem based on the capabilities of the initial ecosystem. Until disruption occurs, a mosaic of technology development predominates with features from the dominant incumbents of the ICE ecosystem evolving into EVs and the new entrants of AVs, and eVTOLs. Faced with the impact of disruption, collaboration is a fundamental factor for the dynamics of adaptation of the value proposition and the evolution of new ecosystems. Based on the disruptive impact of EVs, AVs, and eVTOLs, the dynamic value proposition is part of the evolution of technologies and the transportation mobility ecosystem.

6.1. Limitations and Suggestions for Future Research

This study has a few limitations: first, it was limited to using a single model to discuss the transition of the value proposition of technologies. Based on the research of the Disruptive Ecosystem Evolution Model, we suggest further studies to understand the dynamic effect of the ecosystem value proposition during a disruptive process. As the value proposition of transportation mobility technologies is continuously changing, there is a need to expand research in this area, which is why we also recommend researching future scenarios related to developing these new technologies. It is also suggested to use the value proposition transition research in other sectors to validate the Disruptive Ecosystem Evolution Model. This study was also limited by design to the exclusive use of industry reports and websites for development – we suggest using other sources such as scientific articles, patents, interviews, podcasts and even companies' social networks for data collection and triangulation.

Appendix I

№	Source	№	Source
1	Airbus, 2022 (Official Website)	35	Joby Aviation, 2022 (Official Website)
2	Alphabet/Google, 2022 (Official Website)	36	KittyHawk, 2022 (Official Website)
3	Autoflight Global, 2022 (Official Website)	37	KMPG, 2012 (Report: Self-driving cars- The next Revolution)
4	Bell, 2022 (Official Website)	38	KPMG, 2018 (Report: Autonomous Vehicle Readiness Index)
5	BMW, 2017 (Report: In Sprints towards Autonomous Driving)	39	KPMG, 2020 (Report: Shifting gears- the evolving electric vehicle landscape in India)
6	BMW, 2022 (Official Website)	40	KPMG, 2021 (Report: Place your billion-dollar bets wisely)
7	Boeing, 2022 (Official Website)	41	KPMG, 2022 (Report: Electric vehicle charging – the next big opportunity)
8	Catapult, 2019 (Report: Market Forecast For Connected and Autonomous Vehicles)	42	KPMG, 2022 (Report: Elevate Perspectives)
9	Daimler, 2022 (Official Website)	43	KPMG, 2022 (Report: Levelling Up China's race to an autonomous future)
10	Dell, 2021 (Report: A Complete, Open and Hybrid Approach to Autonomous Vehicle Development)	44	Leonardo, 2022 (Official Website)
11	Deloitte, 2017 (Report: Framing the future of Mobility)	45	Lilium, 2022 (Official Website)
12	Deloitte, 2019 (Report: Autonomous Driving Moonshot Project with Quantum Leap from Hardware to Software & AI Focus)	46	Lufthansa, 2021 (Report: Are Air Taxis Ready For Prime Time?)
13	Deloitte, 2019 (Report: Change is in the air The elevated future of Mobility)	47	McKinsey, 2016 (Report: Automotive revolution – perspective towards 2030)
14	Deloitte, 2019 (Report: Change is in the air The elevated future of mobility: What's next on the horizon?)	48	McKinsey, 2016 (Report: Automotive Revolution)
15	Deloitte, 2022 (Report: Electric vehicles Setting a course for 2030)	49	NASA, 2021 (Official Website)
16	Dunsky, 2019 (Report: City of Toronto Electric Vehicle Strategy)	50	NHTSA - Federal Automated Vehicles Policy, 2016 (Report: Accelerating the Next Revolution In Roadway Safety)
17	Embraer X, 2020 (Report: Flight Plan 2030)	51	Nissan Motor, 2022 (Official Website)
18	Embraer, 2022 (Official Website)	52	Orange, 2022 (Official Website)
19	EVE, 2022 (Official Website)	53	Porsche, 2022 (Official Website)
20	Evtol Insights, 2020 (Podcast: Ep. 1 - Lilium's Oliver Walker-Jones, head of communications)	54	PWC, 2018 (Report: Five trends transforming the automotive industry)
21	Evtol Insights, 2020 (Podcast: Ep. 27 - Adam Cohen of UC Berkeley, California)	55	PWC, 2018 (Report: Industrial Mobility and Manufacturing)
22	Evtol Insights, 2020 (Podcast: Ep. 31 - Yolanka Wulff, Co-Executive Director of the Community Air Mobility Initiative (CAMI))	56	PWC, 2020 (Report: Digital Auto Report- Navigating through a post-pandemic world - Volume 1)
23	EY, 2022 (Report: Mobility Consumer Index Study)	57	PWC, 2021 (Report: Digital Automotive Report- Accelerating towards the new normal)
24	EY, 2022 (Report: Power sector accelerating e-mobility)	58	PWC, 2021 (Report: E-mobility in India)
25	EY, 2022 (Report: Unlocking the Electric Mobility Value Pools)	59	Renault, 2022 (Official Website)
26	Fiat Chrysler Automobiles, 2022 (Official Website)	60	Roland Berger, 2018 (Report: Urban air mobility - The rise of a new mode of Transportation)
27	Fukushima, 2019 (Report: Headed towards "Air Mobility Revolution")	61	Rolls-Royce Holdings, 2022 (Official Website)
28	Honda, 2022 (Official Website)	62	Tesla, 2022 (Official Website)
29	Honeywell, 2022 (Official Website)	63	The Business Research Company, 2022 (Report: eVTOL Aircraft Global Market Report)
30	Hyundai, 2022 (Official Website)	64	Toyota, 2022 (Official Website)
31	IBM, 2021 (Report: Automotive 2030 Racing toward a digital future)	65	Uber Elevate, 2016 (Report: Fast-Forwarding to a Future of On-Demand Urban Air Transportation)
32	IBM, 2022 (Official Website)	66	Uber, 2022 (Official Website)
33	ICCT, 2018 (Report: The continued transition to Electric Vehicles in US Cities)	67	Volkswagen, 2022 (Official Website)
34	IEA, 2022 (Report: Global Electric Vehicle Outlook 2022)	68	Volocopter, 2022 (Official Website)

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