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THE EVOLUTION OF THE DISRUPTIVE ECOSYSTEM: A SCENARIO PROPOSITION FOR THE DISRUPTION OF EVTOLS TECHNOLOGY AND THE ADVANCED AIR MOBILITY ECOSYSTEM

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1. Introduction

Technological change is perhaps the most powerful driver of market development. Currently, it cannot know from which direction a disruptive innovation will come, although the market shows readiness for future disruptive innovations (Klenner et al., 2013). Recent studies point out how an increasing number of disruptions have the potential to reshape the way companies and industries operate (Christensen et al., 2018; Kumaraswamy et al., 2018). Because these disruptions are not easily accessed or copied (Mukhopadhyay & Whalley, 2021), disruptions become ongoing challenges that shake many industries and ecosystems and can lead to the opening of new markets (Palmié et al., 2019). In this way, disruptions are not developed and marketed by isolated companies but by ecosystems (Ansari et al., 2016; Kumaraswamy et al., 2018).

Studies indicate that the occurrence of disruption can transform the entire structure of an ecosystem (Christensen et al., 2018; Kumaraswamy et al., 2018; Palmié et al., 2019). Several examples of disruption in ecosystems can be cited: the TiVo technology in the television market (Ansari et al., 2016); Netflix's video-on-demand technology in the film industry (Salvador et al., 2019); Airbnb's business model in the hotel market (Tham, 2016); open education models compared to the traditional education system (Rabin et al., 2020); or the new technologies of fintechs compared to traditional banking institutions (Lee & Shin, 2018; Palmié et al., 2019; Zalan & Toufaily, 2017). We learn from these cases that ecosystems are rarely stable since the forces (technology) that affect their structure, over time, cause the dynamics of evolution (Holgersson et al., 2022). However, new studies need to understand the creation, evolution and replacement of current standards by new technologies (Gu et al., 2021).

Academic literature still needs to provide a clear picture of the impact of disruptive innovation on the ecosystem. The literature only explores how existing ecosystems are affected by disruptive innovations (Ansari et al., 2016; Oghazi et al., 2022; Ozalp et al., 2018). This gap is related to the fact that disruption actors can impact the ecosystem, reconfiguring the disruption value model and resulting in the creation of a new ecosystem (Ansari et al., 2016; Dedehayir et al., 2017; Ozalp et al., 2018; Palmié et al., 2019; Silva & Grützmann, 2022). Therefore, it becomes necessary to understand the evolution of ecosystems, considering the potential of disruptive innovations (Christensen et al., 2015; Oghazi et al., 2022; Palmié et al., 2019; Silva & Grützmann, 2022).

The gap in the evolution of ecosystems becomes more evident as investigations focus on the ex-post effect of innovation (Chen et al., 2016). Although some more recent studies have focused on the antecedents of ecosystem evolution ex-ante (see Blume et al., 2020; Chen et al., 2016; Govindarajan & Kopalle, 2006; Keller & Hüsig, 2009; Klenner et al., 2013; Müller & Kunderer, 2019; Schoemaker & Mavaddat, 2000; Sood & Tellis, 2011), there seem to be inconsistencies in this theme, especially concerning the transition of the technological standard, ecosystem value proposition, market logic and evolutionary elements based on disruption (Oghazi et al., 2022). Following this example, Silva e Grützmann (2022) present a Disruptive Ecosystem Evolution Model that considers the transition model of disruptive technology in an existing ecosystem and proposes an evolution process for a new ecosystem. Therefore, investigating where and how ecosystem evolution occurs helps to interpret and analyze how disruptive innovation affects industries and triggers new business models and innovation ecosystems (Dedehayir et al., 2017; Palmié et al., 2019).

Such a gap was also not researched in the transportation mobility sector. In this sense, the transportation mobility industry has suffered a great impact in the insertion of the most recent technologies. The current market standard centered on the technology of internal combustion engines (ICE) suffer the impact of the insertion of new electrification technologies (Electric Vehicles - EVs) and vehicle automation (Autonomous Vehicles - AVs). In their infancy, electric vertical take-off and landing vehicles (eVTOL) bring a new perspective to Advanced Air Mobility (AAM), where Urban air mobility (UAM) is a subset of AAM, and contemplate possibilities for market Development (this article will refer to AAM to booth concepts) (Cohen et al., 2021; NASA, 2020; Reich et al., 2021; US Department of Transportation, 2022). Faced with the impact of a potential disruption represented by the new technology of eVTOLs, it is important to design the possible scenarios in which innovation can disrupt the ecosystem (Blume et al., 2020; Christensen, 2006; Christensen et al., 2018; Kumaraswamy et al., 2018; Lavikka et al., 2018; Schoemaker & Mavaddat, 2000). Specifically, in this study, the current transportation mobility ecosystem.

Based on the identified gaps and an exploratory approach, this study asks what are the possible scenarios for the potential disruption of eVTOLs and the Urban Air Mobility Ecosystem? In this way, the research aims to identify and to analyze the possible scenarios for the potentially disruptive innovations of eVTOLs and the Advanced Air Mobility ecosystem. This study proposes to use the Disruptive Ecosystem Evolution Model to carry out an exploratory study with a predictive purpose to explore the insertion of a potentially disruptive technology of eVTOLs in the existing transportation mobility ecosystem.

Assuming that disruption occurs as a process over time, the occurrence of disruption may only be evident after introducing the innovation to the market. This makes it challenging to collect data on disruptive innovations within an analysis period in an innovation survey (Christensen, 1997; Christensen et al., 2018; OECD, 2018). Therefore, due to a lack of defined frameworks for identifying the insertion of disruptive innovations, we applied the Disruptive Ecosystem Evolution Model to perform an ex-ante analysis of the disruptive potential of eVTOLs.

This study contributes to the theory of disruptions and ecosystems by using it to perform a study to perform the insertion of a disruptive technology ex-ante of market insertion. It also contributes by applying an ex-ante analysis method with current data on a potential technological change in the real market and providing insights into the impact of a potential disruption on the ecosystem. In this way, the knowledge generated, in a managerial way, provides direction for developing technology within the new ecosystem and the market. Therefore, this article can be seen through the logic of developing strategies for implementing technologies and innovations within the ecosystem.

2. Theoretical Background

2.1. Disruptive Innovation and Innovation Ecosystems

The theory of disruptive technologies explores how innovations with different characteristics have come to outperform dominant technologies in the market (Bower & Christensen, 1995; Christensen, 1997; Christensen et al., 2018). These technologies become disruptive innovations caused by changes in technology and business models to create a new value proposition for the market (Christensen, 2006; Petzold et al., 2019). In this way, disruptive innovations are a powerful means to expand and develop new markets, breaking existing market linkages (Adner, 2002; Christensen, 1997, 2006; Christensen et al., 2018; Christensen & Raynor, 2003).

The ecosystem is a collaborative arrangement where companies jointly create value for their customers that could not be created in isolation (Adner, 2006). Ecosystems operate through constantly evolving actors, activities and artefacts, institutions and relationships (Beltagui et al., 2020). An innovation ecosystem is based on the development of a technology (Ansari et al., 2016; Sandström, 2016) and emphasizes collaboration, complementarity and competition between actors around technological artefacts (Granstrand & Holgersson, 2020). On the other hand, the business ecosystem represents an environment in which the company must monitor and react (Li, 2018) to adapt to 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 the ecosystem, the development of a market and an economy around innovation occurs, operated by business models that sew the value network in a co-evolutionary dynamic of permanent exchange with environments for continuous innovation (Hou & Shi, 2020; Ma et al., 2018). From a systemic perspective, ecosystems are complex and adaptive systems with the capacity to evolve, where cooperation with external actors for complementary innovation resources can contribute to cultivating nascent innovation (Geels, 2002; Gu et al., 2021). Eventually, as disruption evolves in the ecosystem, there may be a transition from a closed ecosystem with little interdependence to a more open ecosystem, spilling over into other members. Disruptions usually do not comply with existing regulatory norms, technological standards and infrastructure; therefore, they can affect the entire value structure of an ecosystem (Chan & Fung, 2016). To this end, the value proposition of the disruption business model can lead to competition in the core market, or it can create a new market and, consecutively, a new ecosystem. In this way, companies 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 disruption within the ecosystem (Dedehayir et al., 2017).

2.2. Disruptive Ecosystems

As disruptive innovations are usually developed and commercialized in ecosystems and not in isolated companies, fundamentally, the two themes intersect (Palmié et al., 2019). Palmié et al. (2019) presented the concept of the disruptive innovation ecosystem. The concept combines the definitions of disruptive innovations and innovation ecosystems so that an ecosystem develops and grows around an innovation. When disruptive innovation enters an ecosystem, complementary innovations from ecosystem members can increase the innovation's appeal and emphasize the disruption's potential to dominate the market. Thus, business models draw the perspective of inserting the disruption of the innovation ecosystem and become an essential tool for the demand for the co-evolution of business strategies (Kumaraswamy et al., 2018; Rabin et al., 2020).

In this proposal, an existing ecosystem can be shaken by a disruption, causing creative destruction of the existing ecosystem to generate a new ecosystem based on the value proposition and the disruption business model (Dedehayir et al., 2018; Palmié et al., 2019). In this way, the destruction of the existing ecosystem based on a new technology can lead to the entry of new operators in the emerging market (Adner & Kapoor, 2016). The competition between companies for market share, a dominant design or better partnerships is part of the business models that design the new ecosystem. Thus, due to disruption, new products or services are targeted at a different audience than the traditional one, creating new markets and new customers (Markides, 2006) and shaking the entire existing ecosystem. 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).

2.3. Disruptive Ecosystem Prediction

This perspective of innovative trajectory change suggests conditions to explore the circumstances in which disruption may occur. Christensen (2006) provides some ex ante examples of how the disruption model organizations should pay attention to: (1) a technological concept of a product that has not yet been developed or is under development; (2) a new technology that starts to be manufactured and commercialized; (3) the threat of an innovation that has not yet affected the mainstream market; and (4) the possible future strategy to respond to the possible ongoing disruption. In all cases, the predictive model aims to contribute to a disruption.

Nicolaï and Faucheux (2015) present some characteristics that can lead to a disruption: (1) the emergence of new technological waves; (2) the introduction of new technology by marginal or non-market actors; and (3) the introduction of a new learning curve from the new technology. According to the authors, for the creation of new markets, there must be a virtuous circle of demand for the new possibilities of the new technology and the technological impulse provided by the new products.

To disrupt dominant ecosystems, it is necessary to introduce more advanced technologies with the potential to break the established bonds of complementary ecosystems and prospect technological leaps (Ozalp et al., 2018). Blume et al. (2020) suggest that an ex-ante idea of performativity and disruption must follow an evolutionary path. Thus, the probability of a disruption materializing with high impact is more significant if the favourable conditions of the context in which the market operates meet a specific gap in the market (Klenner et al., 2013).

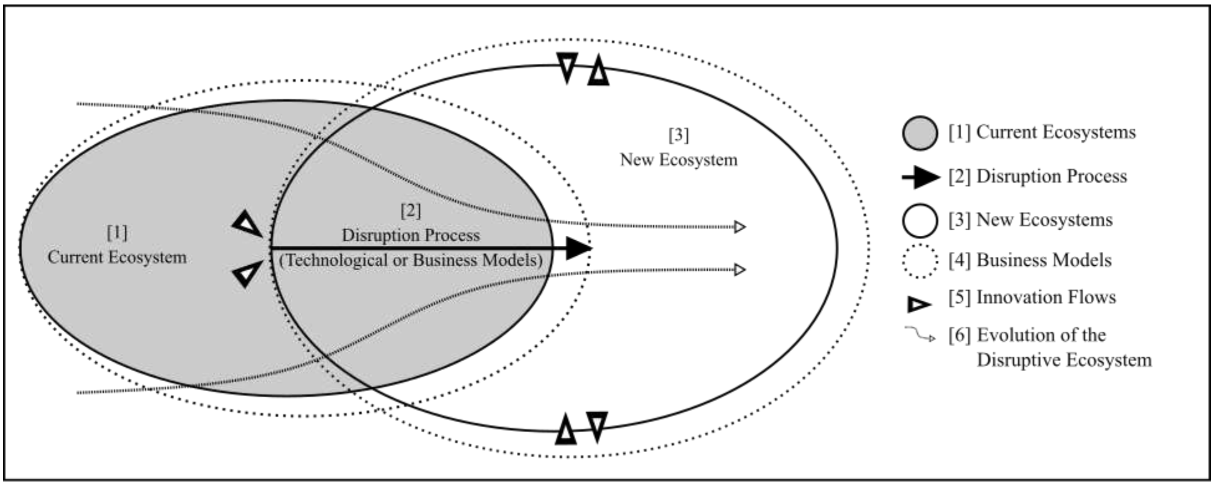
These perspectives allow exploring the complexity of disruptions that cannot be fully predicted or understood. According to Christensen et al. (2018), this would require the identification of factors that shield some markets and factors that are underexploited by the main market and that make specific sectors vulnerable to disruptions. However, adopting a performative perspective of predictability is more likely to learn, take action, and adjust activities in the face of a disruptive phenomenon (Kumaraswamy et al., 2018). In this sense, when disruption drives the rapidly changing business environment, the actors of disruption must not neglect the power of the forces that build and transform ecosystems. Invariably, this disruptive innovation will affect the entire ecosystem, affecting the disruption's development.

2.4. Evolution of the Disruptive Ecosystem

Although different authors have discussed the ex-ante perspective (e.g. Blume et al., 2020; Chen et al., 2016; Govindarajan & Kopalle, 2006; Keller & Hüsig, 2009; Klenner et al., 2013; Müller & Kunderer, 2019; Schoemaker & Mavaddat, 2000; Sood & Tellis, 2011), they present the technology or innovation already inserted and in some degree of market maturity (S-Curve). Therefore, it is not as effective in cases of technologies, ecosystems and markets in the early stages of development and projection. To this end, the proposal by Silva and Grützmann (2022) considers the creation of an innovation or potentially disruptive technology to shake up the entire ecosystem. The authors' proposal makes it possible to present the potential for disruption of technologies at a more embryonic stage and with an impact on internal and external factors of the ecosystem of technologies that are still being developed.

The Disruptive Ecosystem Evolution Model is based on the impact of Disruptive Technology (Christensen et al., 2018; Christensen & Raynor, 2003) on the Ecosystem (Adner, 2017; Granstrand & Holgersson, 2020; Moore, 1993; Palmié et al., 2019) and Business Models to interweave this dynamic (Christensen et al., 2018; Palmié et al., 2019; Petzold et al., 2019). According to the proposal, disruptive innovation has the potential to transform the entire ecosystem, and it is up to actors, innovations and value to co-evolve through business models (Silva et al., 2023 – Article 4).

Figure 1 - Theoretical Evolution of the Disruptive Ecosystem Framework.



Source: Silva e Grützmann (2022).

In the model (Figure 1), the forces interact with the impact of disruption on the evolution of a new ecosystem. Thus, when a disruption occurs in an existing ecosystem, it can evolve into an innovation ecosystem around the disruption. A new market emerges based on the new technology, which requires a new business model configuration. The model presents this disruption process as the destruction of existing technologies and business models for the evolution of ecosystems.

3. Methodology

According to Christensen (2006) and Christensen et al. (2018), it is possible to use a disruptive innovation as an ex-ante model for developing an innovation in the market. In this sense, the strategic analyses developed for a disruptive technology scenario seek to identify opportunities and threats that can reconfigure the business model and the existing market (Petzold et al., 2019). To this end, a perspective of adopting scenarios and performative prospecting of possible business models can help organisations' learning, decision-making and flexibility (Kumaraswamy et al., 2018).

According to the objective, this study is characterized as inductive and exploratory (Bohnsack et al., 2015, 2021; Eisenhardt & Graebner, 2007; Ozalp et al., 2018; Yin, 2009). As a research strategy, we apply the case study based on the technology of eVTOLs in the transportation mobility market. We justify the analysis of this case because the theory of disruption has many dimensions. The analysis of cases shows rich data, making the theory more profound and practical (Christensen, 2006).

This method is proper when existing theories do not answer the existing question and when the question relates to a process or evolution over time (Hannah & Eisenhardt, 2018; Langley, 1999). Finally, we apply the exploration of scenarios since they will be used to understand the future AAM ecosystem. This method was used as an analytical lens to capture the disruption's evolution and build scenarios (Blume et al., 2020). It also allows answering the research question based on the technological changes that are happening and that will have the potential to happen in the market.

3.1. Data Collect

Under the light of ecosystem and disruptive innovation theories, this study analyzes the ecosystem factors, the disruption process, business models, innovation flows, the evolution of the disruptive ecosystem, and the possible arrival of a new market. We followed the example of previous studies (Bohnsack et al., 2015, 2021; Holgersson et al., 2018; Ozalp et al., 2018) to select the bases for data collection.

We use secondary data as an empirical basis for the case, which can contribute to the triangulation of a wide range of sources regarding the development of the disruptive ecosystem of eVTOL technology. The data includes 17 reports provided by technology development companies and 31 reports by specialized consulting companies. A total of 48 reports with 2,427 pages of documents for analysis (Holgersson et al., 2018; Langley, 1999; Ozalp et al., 2018). We also use the eVTOL Insights podcast, which specializes in the eVTOL ecosystem and interviews several CEOs and Directors of large companies and startups in the sector. A total of 77 podcasts containing 29 hours and 54 minutes were analyzed.

We used the list of the largest companies in the world pointed out by Silva et al. (2023 – Article 2) to list the companies that develop eVTOL technology. Following the example of previous studies (Bart, 1998; Campbell, 1991; Lynn & Akgu, 2001; Raynor, 1998; Waddock & Smith, 2015), 10 commercial websites of technology development companies were analyzed. Complementarily, we use the TNMT Innovation Hub list, which points out the leading players in the Aviation sector (6), the Automotive sector (7), the Technologies sector (5) and the main Startups (11), and the list of the top 20 companies in the total amount of technology patents (Lufthansa Innovation Hub, 2021). In total, we collected information from 46 websites of companies related to the development of technologies. A total of 171 documents that could contribute to the technological development and the eVTOL ecosystem were analyzed.

We propose using the Disruptive Ecosystem Evolution tool to model the innovation ecosystem by identifying the relevant constructs and relationships to represent the ecosystem of the current technological world, the impact of disruption and the constitution/evolution of the new disruptive ecosystem. Data analysis will be carried out to describe the potential disruptive process caused by the new technology in an existing ecosystem.

3.2. Data Analysis

The analysis of this article focuses on the insertion of new technology in the existing ecosystem. The concept of Disruptive Ecosystem Evolution tries to assess the impact of disruptive innovation on an ecosystem even before the new technology of eVTOLs is introduced in the market. After analyzing the structure of the existing ecosystem through the collected documents from an ex-post perspective, we apply the collected data to the model. The study is an illustrative case for applying an actual model of inserting new technology into an existing ecosystem and, therefore, a perspective view of disruption. This is the first evaluation of the Disruptive Ecosystem Evolution Model from a prospective perspective.

The focus was on understanding the insertion of disruption in the ecosystem and the consequent evolution of the new disruptive ecosystem. After collecting the data, we performed a content analysis where the emerging patterns of the case studied were identified (Yin, 1994). We follow up on individual cases to verify emerging patterns (Eisenhardt & Graebner, 2007).

The concentration of information corroborates with the multiple data sources. The results were categorized into the categories predetermined by the Disruptive Ecosystem Evolution Model to identify the evolution of the existing ecosystem and the disruption insertion logic.

4. Results and Scenarios

The following results will be presented based on the Disruptive Ecosystem Evolution Model and the analysis carried out. The first step contextualizes the researched case, and for each step of the model (Current Ecosystem, Disruption Process, New Ecosystem, Business Model, Innovation Flows, Evolution of the Disruptive Ecosystem), the possible evolution of the ecosystem in the face of disruption and possible scenarios of construction of this ecosystem. We approach a discussion of the current context and point out the possible ex-ante scenarios of disruption in the ecosystem. Some quotations from the research were used to present the results and are marked in parentheses. The complete table is presented in Annex I.

4.1. Technology Case Background

Many prototypes and projects of "flying cars" were part of the historical development of this technology (61; 4; 60; 70). Despite numerous attempts, there was no technological and market maturity to take on this change nor an ecosystem that allowed the technology to grow (14). However, with frequent problems related to combustion and congestion problems, among others, eVTOLs have become a proposal for new market demands (72; 67; 16; 30; 32; 42; 70; 18).

With the rise of electric batteries to power vehicles, eVTOLs would become cleaner, more economical and cheaper technologies (53; 36; 37; 25; 39; 27; 76). Vehicle automation technology has also contributed to air vehicles, allowing them to become safer, faster, and more efficient, without noise and pollutant emissions, to work intelligently, to seek new transport routes that are flexible, accessible and entirely on demand from users (60; 11; 67; 16; 39; 43; 62). An evolution of the innovation ecosystem in search of the development of eVTOLs technology (11; 14; 71). That provides new ways of delivering goods and services and can deliver new transportation mobility solutions (60; 72; 18; 9).

The eVTOL will combine electric propulsion, autonomous navigation, vertical lift and other communication and navigation features, and user input is limited to commanding the desired trajectory. Combined with electrification and automation technologies, the vertical propulsion of vehicles could propose the exploration of airspace as a new route for AAM. Without the need for runways, passengers and goods will depart from take-off and landing platforms positioned at different locations in the city, and aircraft, including drones, will be able to coexist safely and quickly (60; 72; 18). Compared to other forms of urban transport, eVTOLs can develop travel routes in real-time airspace by shortening the distances travelled at much higher speeds and shortening the duration of trips compared to land transport (8; 67; 43). With the advent of the potential disruption of eVTOLs, there may be a reduction in the need for roads, maintenance costs and congestion, allowing the construction of take-off and landing stations (60; 36; 15; 72; 18). The focus of eVTOL is to offer a new class of aircraft that will revolutionize inter- and intra-city movement, providing fast, direct and clean mobility (70).

While introducing eVTOLs to the market has brought gains, some concerns are considerable. Certification and regulation processes will be necessary to adapt to the new reality (67; 31; 24). New traffic control rules will need to accommodate eVTOL routes in the airspace close to large aircraft and smaller drones. Cybersecurity issues also concern new technology (16; 14; 13). A structural change needs to be made to the transport infrastructure to suit the construction of vertiports, eVTOL take-off and landing bases (66; 46; 72). Other important factors are vehicle reliability and demand for transport via eVTOLs, where this mode of transport needs to become competitive to reach public acceptance (60; 66; 23; 24; 34; 35; 40; 41; 44). All these barriers are part of the ecosystem impacted by new technology. As these barriers are overcome, the AAM industry has the potential to offer transportation mobility solutions and economic, social and environmental opportunities. For the development of this future, intelligent, connected, sustainable and publicly accepted traffic management solutions will only emerge through the collaboration of the entire ecosystem (1; 6; 28; 65; 60; 18; 9; 50; 58; 67; 55; 59).

For eVTOLs integration into the market, aircraft need to be equipped with information to navigate safely through the airspace, share information and deal with the airspace's large and diverse population density. Several companies, especially startups, are developing eVTOL technology to make it a reality. From incumbents in various markets such as Boeing, Airbus, and Embraer in the aviation sector, Toyota, Porsche and Hyundai in the automobile sector, to startups such as Volocopter, Joby Aviation, and Ehang, among others (8; 1; 19; 71; 64; 50; 76; 55; 16).

However, it is important to understand that eVTOLs will not compete in range with conventional cars, trains, helicopters or planes. eVTOLs should offer an alternative form of air transport that complements the Transportation Mobility System (66; 60). In this perspective, considering that eVTOLs are a technology that can change and even create a new business model in the transportation mobility market, this is a technology with the potential to create a new ecosystem of disruptive innovation (74; 33; 62; 29). The AAM ecosystem is taking shape. This embryonic market is now open to potential participants from various backgrounds. It can attach importance to different aspects, such as the production of technologies, infrastructure development, navigation, air traffic management systems, among others. As technologies mature, they require collaboration between governments and businesses to create new regulatory and infrastructure frameworks to facilitate future development (1; 17; 6; 28; 65; 60; 18; 9; 50; 58; 67; 55; 59). The picture of eVTOLs ecosystem potential disruption emerges with the relationships between its different stakeholders and their challenges to overcome. This disruption can create a new AAM ecosystem based on eVTOLs with a focus on air mobility as an on-demand service, transform the entire transportation experience and become the solution to many environmental, economic and social problems generated by current ICE technology.

4.2. Current Ecosystem

The current Ecosystem is the one in the actor coexist and are affected by the disruption. The current innovation ecosystem in the transportation mobility sector is formed by ICE manufacturing companies that are evolving towards the entry of EVs, such as Toyota, Nissan, Hyundai, among others, and by companies entering the sector, such as Tesla (71; 63; 50; 69; 10; 57; 57; 57; 75). The sector also focuses on the production of batteries for electric vehicles. On the other hand, the innovation ecosystem in the air mobility sector is made up of aviation manufacturing companies, such as Embraer, Boeing, and Airbus, and helicopters, such as Honeywell, Bell, and Leonardo (19; 8; 1; 49; 7; 58; 48; 50; 64; 1; 8; 61; 60). Ecosystems have their limits well separated from each other, with companies distinguishing in the production of technologies and the exploration of markets. The scenario of the new technology of eVTOLs points to a disruption in the existing innovation ecosystem in both markets. Specifically, for the innovation ecosystem, the technology of eVTOLs tends to encourage an evolution of established actors and the insertion of new actors to accompany the evolution of the Ecosystem itself and the creation of the new market (55; 21; 76; 56; 5; 60; 70; 58). For the business ecosystem, both sectors will have a new competitor for short and medium-distance transport that complements the transportation mobility ecosystem (66; 22; 60).

4.3. Disruption Process

The disruption process occurs when a new technology and a new business model affect the existing ecosystem. The disruption in the current ecosystem occurs when combining transportation mobility electrification and automation technologies with air mobility propulsion technologies, opening up space for the development of the new AAM ecosystem (55; 21; 76; 56; 5; 60; 70; 58; 72; 18). Due to the growing movement of actors seeking to leverage this new technology, eVTOLs have a disruptive impact on the current innovation and business ecosystems in the terrestrial mobility and aviation sectors. For the innovation ecosystem, due to the need to master the different technologies required (e.g. electric batteries, automation, propulsion, connectivity, artificial intelligence, cloud computing, big data, 5G), where companies do not have to master all skills necessary for the development of the eVTOL. This scenario points to the maturation of the new technology, accompanied by several actors from the automotive and aerospace sectors and several new actors from other sectors (66; 60; 70; 12; 74; 6; 67; 16). Due to the need to master the wide range of necessary skills, many companies are establishing partnerships to explore these technologies.

In this new AAM context, startups dominate technology development and drive market development. Joby Aviation, Volocopter and Lilium are examples of startups pioneering the technology and market of eVTOLs (71; 50; 55; 59; 76; 7; 58; 60; 13). The entry of new players into a new ecosystem accentuates the impact of disruption. The number of patents and investments related to the development of technologies has grown a lot in recent years, and startups and their partners have dominated this expansion. Ehang and KittyHawk are two startups with the highest patent filings growth rate (71; 50; 55; 16; 56; 60). Due to this technological diversity, as there is no dominant design or a defined exploration business model, many new entrants seek space for a slice of the market. The scenarios point to constant collaboration between incumbent operators from the various technological segments with startups for developing eVTOL technology and the AAM market (6; 28; 65; 60; 18; 9; 50; 1; 58; 67; 55; 59). Another scenario is the pull of the disruptive process due to the massive collaboration of so many companies from various sectors, creating a participatory network effect in search of technological maturity.

For the business ecosystem, scenarios point out that eVTOL technology tends to complement the transportation mobility ecosystem, where transport technologies will coexist, and an integrative experience between air and land transport should occur (66; 22; 60). eVTOLs tend to be used for medium and short trips, coexisting with aeroplanes for long trips and with cars for short trips. The cars will complete the eVTOL route, being responsible for the first and last miles of the trips. While technology coexistence scenarios are relevant opportunities for all participants, the risks are greater for traditional helicopter companies. The eVTOLs will be more sustainable technologies, with low noise emissions and competitive cost with traditional cars, and will create the on-demand short and medium-haul air transport market. This approach tends to incorporate the high-cost market for helicopter travel, which points to an imminent disruption of this market. In preparation for this disruptive trend, many manufacturers like Honeywell, Bell, and Leonardo are engaging in developing eVTOLs to keep up with the disruptive process (49; 7; 58; 1; 60; 11; 37; 38; 26).

4.4. New Ecosystem

The new ecosystem emerges based on the interaction of actors and technologies to create disruption. With the arrival of automation software technologies, connectivity, 5G, the internet of things, artificial intelligence, cloud computing, big data, among others, the transportation mobility ecosystem was taken over by companies from different sectors. Traditional car manufacturing companies like Toyota, Nissan, Hyundai; and new entrants to the automation sector like Tesla and Uber; and aviation giants like Embraer, Boeing and Airbus; helicopter manufacturing companies like Honeywell, Bell and Leonardo; in addition to technology companies such as Google, IBM, Tencent and Intel; and retail companies such as Amazon and the Alibaba Group, join startups such as Joby Aviation, Lilium, Eve, Volocopter, Ehang, among others, to develop technologies (71; 63; 50; 69; 19; 8; 49; 7; 51; 68; 52; 3; 55; 59; 21; 76; 16). These companies joined the traditional vehicle manufacturing ecosystem and co-evolved through coopetition for the development of the electric and autonomous AAM sector.

To reach the business ecosystem, the new technology support ecosystem is critical to AAM's success. The infrastructure is necessary for the operation of eVTOLs and creates a bottleneck for ecosystem actors to interact in the operational development of the technology (66; 46; 72). Companies like Embraer/EVE partner on all continents to develop the necessary infrastructure for operations (18; 21). Failure to develop the right infrastructure can create bottlenecks and impede AAM's growth. Linked to infrastructure, service flows are an important point that will ensure the safety and efficiency of transport activities. Many new startups seek to benefit from this growing infrastructure to have space in the market. Another critical point is the advancement of regulations that legalize and encourage the technology commercially (67; 31; 24). The Uber Elevate project carried out regulatory-friendly development mates (72). Finally, public acceptance, presenting the benefits of speed, economy, and a safe, pleasant, and environmentally green integrated mobility experience, will directly influence market demand (60; 66; 23; 24; 34; 35; 40; 41; 44). For this, the AAM business ecosystem must bring together stakeholders from various sectors, constituting an ecosystem composed of companies, government agencies, research and technology organizations, academia, professional institutions, local authorities, social scientists, and consumers (17; 6; 28; 65; 60; 18; 9; 50; 1; 58; 67; 55; 59).

The scenarios for the innovation ecosystem are certainly related to collaboration between the various stakeholders for technology development. Not far away, due to the diverse technologies needed to realize the objective of eVTOLs and AAM, scenarios also point to different designs dominating different markets (6; 28; 65; 60; 18; 9; 50; 1; 58; 67; 55; 59). Different technologies can take the lead and develop the various available markets from the various specifications and relationships of governments, companies, legislation, and infrastructure. These multiple constitutions can occur to the detriment of the dominant technological design. Everyone who best integrates into existing transportation mobility will have a chance to grow in the market.

4.5. Business Model

Business models create the alignment of actors and technologies within the ecosystem. With the arrival of electrification and automation technologies, the technologies and markets of the transportation mobility and aviation ecosystems began to have points of intersection. The scenarios point to collaboration between incumbent operators from various sectors and new entrants to develop an innovative ecosystem. Joby Aviation acquired Uber Elevate (responsible for Uber's UAM sector) and has partnerships with Hyundai and Toyota to develop the technology (55; 73; 50; 71). Embraer created EmbraerX and EVE as spinoffs for technology development and market exploration (19; 20; 21). Google acquired KittyHawk to leverage its technologies in favour of the AAM market (2; 56). Kittyhawk teamed up with Boeing and created a joint venture (Wisk) to develop the Cora (56) aircraft. In addition to their "isolated" developments, many of these companies collaborate. This new, complex, and sophisticated ecosystem will take years of planning to develop, and collaborations seem to be the most direct path to technology and ecosystem success.

Due to the ease of diversification of startups, incumbent operators and giants of the various markets do not seek to be the first in developing eVTOLs and AAM. Large companies know that the market needs to be mature for the new technology (60; 13). Vehicle development, infrastructure networks, regulation, and public acceptance, need to be in place. That is why many of these companies choose to encourage the ecosystem through partnerships, acquisitions, mergers, and joint ventures. Startups tend to be more malleable, faster, and more susceptible to the changes that the development of new technology demands from companies.

While actors cooperate in the collaborative innovation ecosystem to develop eVTOL technology, the exploration of the ecosystem still needs to be defined by the lack of a dominant design and a clear business model (1; 60; 66). Within the market, the business ecosystem runs into problems with the legislation, strong restrictions from traditional markets, lack of investment (even at low growth), and difficulty in accepting customers.

4.6. Innovation Flows

The innovation flows of a business model are part of the process and can interact with the disruption in changing the ecosystem. Another characteristic of the business model that emerges is the model of open innovation and closed innovation. Companies like Hyundai invest heavily in a complete line of eVTOLs for different needs and markets. The company takes a holistic approach, looking at all aspects of the market, from development, manufacturing, and infrastructure, as a strategy to shape and influence ecosystem directions. Hyundai prioritizes partnerships with other companies and avoids direct investments in startups to build a robust and comprehensive approach to developing technologies, infrastructure, and business models (60; 70; 4; 50; 42).

On the other hand, more open business models allow companies to use partners' expertise to advance innovation. For example, the collaboration between Toyota and Joby Aviation, where Toyota offers all the production capacity, quality and cost control experience, and market exploration, while the startup presents its innovative and agile capacity for technology development (71; 55; 6070; 45). 75wagen and Leonardo, companies in the automotive and aerospace sectors, respectively, cooperate with several laboratories, universities, and innovation centers in several countries to make local connections and gain regional knowledge for the development of technology in the Deep Tech area (75; 58; 60; 70). Innovation centers in various regions aggregate local knowledge and experience and provide the many partners with the ideal infrastructure to derive global solutions to regional challenges and needs.

4.7. Evolution of the Disruptive Ecosystem

Disruptive Ecosystem Evolution occurs when actors leverage new technologies and evolve into a new ecosystem based on disruption. The technologies and markets of the transportation mobility and aviation ecosystems were well-defined and separate. This is the initial ecosystem and the basis of transportation mobility. The disruptive process begins with the arrival of electrification, automation, and connectivity technologies developed by incumbent operators in the two sectors, and by new entrants to the technology sector, the sectors have come together. The companies participating in these initial ecosystems evolve with the new participants in the new ecosystem of eVTOLs (11; 14; 71; 47). For the development of the entirely new ecosystem to occur successfully, the major players join new entrants to collaborate in technology development (48; 50; 64; 1; 8; 61; 60). At this point, open innovation flows prevail to mitigate risks and increase the chances of success.

In the development of eVTOLs technologies, ecosystems mixed and formed an ecosystem cluster with actors and technologies transiting between several different ecosystems. For example, the manufacturing capabilities of automobile companies such as Toyota, Nissan, Hyundai, and Volkawagen; the aerospace sector such as Embraer, Boeing, Airbus, and Bell; which have partnerships with many startups such as Joby Aviation, Lilium, and Volocopter; and which use the same software as technologies developed by Google, IBM, and Amazon (71; 63; 50; 75; 19; 8; 1; 7; 55; 59; 76; 2; 51; 3). Companies such as Toyota or JetBlue, among others, invest in eVTOL startups to gain access and learn about new technologies potentially relevant to their core businesses (71; 54). Meanwhile, for technology companies like Tencent or Intel, eVTOL commitments unfold a whole new business segment where they can leverage many existing software capabilities in the future (68; 52). In this accumulation of partnerships, a biome of innovation for eVTOLs and the AAM market emerges (It will be better discussed in topic 5).

The scenario here points to the growth in the number of participants in the ecosystem, greater investments in development and consequent technological maturation. Many collaborative projects attempt to mature the technology and explore the market (48; 50; 64; 1; 8; 61; 60). Because they are more dynamic and agile, startups tend to accelerate the development of technologies. Incumbent companies tend to use their resources, encourage the development of technologies and infrastructure, and collaborate with startups to mature the field (71; 50; 55; 59; 76; 7; 58; 57; 75; 56; 60; 70). Many collaborations between manufacturers, operators, infrastructure providers and regulators are needed for the technology to be pushed into the market (6; 28; 65; 6018; 9; 50; 1; 58; 67; 55; 59).

For the business ecosystem, adaptation to environmental, economic and social needs is part of the selection process of technologies to dominate the market and the consequent public acceptance in the AAM market (6; 28; 65; 60; 18; 9; 50; 1; 58; 67; 55; 59). After reaching the biome's peak, the ecosystem becomes complete and operational. When the eVTOLs technology maturity is reached, the main scenario points to the beginning of the competition to the detriment of collaboration (14; 30; 60). eVTOLs will be a technology that will create a new form of transportation mobility as an on-demand service and will integrate the broad existing mobility system (66; 60; 11; 67; 16; 39; 43; 62). At that point, the AAM business ecosystem becomes the focus more than the innovation ecosystem.

5. Discussions of Scenarios with the Literature

The AAM ecosystem is at an early stage, creating and developing distinct characteristics from the current transportation mobility system. Characteristics such as ways of producing technologies, infrastructure development, regulatory structures, connectivity systems, artificial intelligence, and navigation, air traffic management systems, new ways of providing services, creating environmental, economic, and social solutions, and transforming the experience of transport, among others, which become part of the AAM system. This finding is in line with the literature where disruptions have a set of characteristics different from the dominant technologies in the market (Bower & Christensen, 1995; Christensen, 1997, 2006; Christensen et al., 2018; Petzold et al., 2019) and has the potential to reshape the way companies and industries operate (Christensen et al., 2018; Kumaraswamy et al., 2018). This ecosystem change is an indication of a disruption that can create a new AAM ecosystem based on eVTOLs and is in line with the literature where disruptions create demand for new customers, break existing market linkages and, consecutively, create space for new markets (Adner, 2002; Christensen, 1997, 2006; Christensen et al., 2018; Christensen & Raynor, 2003; Markides, 2006; Palmié et al., 2019). In this way, research was carried out on the impact of disruption on the transportation mobility ecosystem, which is also in line with the literature where disruptions are developed and marketed by ecosystems (Ansari et al., 2016; Kumaraswamy et al., 2018). Also in line with the literature, in this researched case study, we see the impact of the development of a technology on the innovation ecosystem (Ansari et al., 2016; Sandström, 2016) and the environment to which companies must monitor and react as an ecosystem of business (Li, 2018).

The current innovation ecosystem in the transportation mobility sector is being affected by new technologies, specifically eVTOLs, which could create a new AAM market. eVTOLs tend to encourage the evolution of established actors and the insertion of new actors to accompany the evolution of the ecosystem itself. This result corroborates the literature where innovation ecosystems are collaborative arrangements so that companies can jointly make major innovations in the market (Adner, 2006; Holgersson et al., 2022; Yaghmaie & Vanhaverbeke, 2019). For the business ecosystem, eVTOLs are a complementary tool in the current transportation mobility ecosystem. This result is in line with the ecosystem literature, where changes are an environment in which the company must monitor and react (Li, 2018) to adapt to the development of emerging technologies and business ideas (Adner & Kapoor, 2010).

The disruptive process brings electrification, automation, and air propulsion technologies together and opens space for developing the new AAM ecosystem. These results also corroborate the literature where the occurrence of disruption can transform the entire structure of an ecosystem (Ansari et al., 2016; Christensen et al., 2018; Kumaraswamy et al., 2018; Lee & Shin, 2018; Palmié et al., 2019; Rabin et al., 2020; Salvador et al., 2019; Zalan & Toufaily, 2017). Due to the need to integrate different technologies, many technology operators integrate eVTOL development. This entry of new participants into a new ecosystem accentuates the process of disruption. The scenarios point to constant collaboration between all actors for the technological development of eVTOLs. These findings also corroborate the literature where disruption tends to cause an evolution dynamic (Holgersson et al., 2022), replacing current standards with new technologies (Gu et al., 2021). For the business ecosystem, the scenarios point to the coexistence and integration of technologies in urban transport. This same finding is in line with some disruption theories where technologies can create a new market (Christensen et al., 2018; Kumaraswamy et al., 2018) and is in line with other disruption theories where technology tends to supplant current technology (Bower & Christensen, 1995; Christensen, 1997).

The new disruptive ecosystem is based on the interactions between actors and technologies. The different connectivity technologies, 5G, the internet of things, artificial intelligence, and automation, among others, encouraged the entry of several technology providers into the transportation mobility industry. These companies are co-evolving with the traditional ecosystem to develop the AAM sector. Various government relationships, companies, legislation, and supporting ecosystem infrastructure are critical to creating the framework for the growth of the AAM market. This result corroborates the literature where, in the ecosystem, the development of a market and an economy around innovation occurs (Hou & Shi, 2020; Ma et al., 2018). The literature also points out that support factors are critical for the development of ecosystems. Thus, as the literature points out, ecosystems are complex and adaptive systems with the capacity to evolve, where cooperation with external and complementary actors can contribute to cultivating innovation (Geels, 2002; Gu et al., 2021). This fact is necessary for the development of the eVTOL ecosystem.

Business models link all the different actors, technologies and business models in each market. The most evident business model is the collaboration between all participants for technology and ecosystem development. This finding corroborates the literature where business models draw the perspective of inserting the disruption of the innovation ecosystem and becoming a tool for the co-evolution of companies' strategies (Kumaraswamy et al., 2018; Rabin et al., 2020). Many companies encourage the ecosystem through partnerships, acquisitions, mergers and joint ventures. Startups tend to be more malleable, faster and more susceptible to the changes that the development of new technology demands from companies. Incumbents utilize their resources and provide efficiency, productive capacity and market experience to the growing market. This finding also corroborates the literature on disruptive ecosystems, where an ecosystem shaken by disruption can generate a new ecosystem based on the disruption's value proposition and business model (Dedehayir et al., 2017; Palmié et al., 2019). Part of the process is to unite ecosystem actors for successful disruption (Kumaraswamy et al., 2018).

Open innovation flows are another feature of the business model that interacts with disruption in the evolution of the ecosystem. More open business activities allow the use of partner resources to develop innovation. This open relationship between actors corroborates the literature on technology, ecosystem and market development (Chan & Fung, 2016; Rabin et al., 2020). This openness also corroborates the literature where companies that integrate the ecosystem are a value ecology and must align their strategies for ecosystem success (Bers et al., 2012; Moore, 1993; Zalan & Toufaily, 2017) for the development of disruption within the ecosystem (Dedehayir et al., 2017; Palmié et al., 2019).

Lastly, the evolution of the disruptive ecosystem occurs when actors and technologies evolve into a new ecosystem based on the disruptive technology. The new ecosystem will only evolve and become disruptive if the initial ecosystem is changed. Thus, the disruptive process begins with the arrival of electrification, automation, connectivity and air propulsion technologies, and the actors of the initial ecosystems evolve into the new ecosystem of eVTOLs. These results corroborate the literature to help understand how existing ecosystems are affected by disruptive innovations (Ansari et al., 2016; Oghazi et al., 2022; Ozalp et al., 2018) and how it evolves into the new disruptive ecosystem (Dedehayir et al., 2017; Palmié et al., 2019; Silva & Grützmann, 2022). This study also supports an understanding of the potential of disruptive innovations to disrupt existing ecosystems (Christensen et al., 2015; Oghazi et al., 2022; Palmié et al., 2019; Silva & Grützmann, 2022). The actors and technologies of eVTOLs and ecosystems mixed and formed an ecosystem cluster in search of maturing the technology and exploring the market.

Digging deeper into this ecosystem innovation cluster, inspired in the biologic concepts (Keith et al., 2022), we suggest the concept of the innovation biome, where all actors with different ecosystem focus come together to collaboratively develop eVTOL technology, and with is the set of different technological and non-technological ecosystems involved to develop demand for the AAM market. The results of this research corroborate the proposal of the biome concept and the theory that the new disruptive ecosystem obtains access to resources from all the actors responsible for the ecosystem they disturb (Kumaraswamy et al., 2018). The innovation biome creates space for complementary businesses from all ecosystems based on different technologies to grow the core technology ecosystem. In this study, the leading technology is eVTOLs, and the different technologies (e.g. automation, connectivity) are necessary parts of the biome. The technologies needed for the core technology have their ecosystems but are part of the eVTOL innovation biome. The success of the eVTOL disruptive biome depends on the success of each technology ecosystem within its own biome. Thus, our results also propose an evolution of ecosystem theory (Bers et al., 2012; Moore, 1993; Zalan & Toufaily, 2017), where the success of the disruptive biome depends on the alignment of successful ecosystem strategies and the disruption within the ecosystem.

For the business ecosystem, our results point to a broader space surrounding different technology sectors in search of successful disruption. By joining the different ecosystems and after reaching the peak of the biome, the ecosystem tends to become complete and operational. When the technology maturity of eVTOLs has been reached, competition between companies will become greater than collaboration. At this point, the AAM business ecosystem becomes the focus as the innovation ecosystem, and companies' competition for market share, dominant design or better partnerships becomes part of the business models that design the new ecosystem. From the perspective of the ecosystem literature, the development of a market and an economy around innovation occurs in a co-evolutionary dynamic of innovation ecosystems (Hou & Shi, 2020; Ma et al., 2018), as well as occurs from the perspective of the biome of innovation. As complex and adaptive systems with the capacity to evolve are proposed by ecosystem theory (Geels, 2002; Gu et al., 2021), the innovation biome can also contribute to cultivating nascent innovation.

5.1. Theoretical Contributions

This study has important contributions to the literature. First, this study contributes to the understanding of the AAM concept and nomenclature as part of the development of an entire industry and emerging markets for eVTOL technology. Which fits the exploratory objective of this research to understand the insertion of the potentially disruptive technology of eVTOLs and the development of the AAM market (Reich et al., 2021; Reiche et al., 2021). To do so, this study uses the case study of eVTOLs to present the impact of a disruption in an ecosystem. To answer the research question, we conducted a case study to analyze the ex-ante disruptive potential of eVTOL technology. As the construct was based on a theoretical framework, the case study offers an opportunity to (1) apply theoretical propositions identified from the Evolution of the Disruptive Ecosystem Framework, (2) gain new insights from the technologies concerning existing propositions, and also (4) derive new propositions from improving theory building on disruption (Christensen, 2006; Klenner et al., 2013; Yin, 2009). From an analytics standpoint, disruptive ecosystem evolution evaluates ecosystems before disruptions enter the market.

In this way, we contribute to broadening the debate on the impact of disruptive innovations on ecosystems (Ansari et al., 2016; Oghazi et al., 2022; Ozalp et al., 2018) and innovate by including the impact of disruption and evolution of ecosystems. This debate goes further by presenting the insertion of new actors and technologies cooperating in the new urban air mobility ecosystem. In the disruptive ecosystem's proposed evolution/adaptation flow, companies adapt to the new ecosystem, where old and new operators can gain space. Furthermore, adding to the discussion by Silva et al. (2023 – Article 4), the new evolving ecosystem value proposition positively aggregates the ecosystem reorganization and proposition of scenarios for eVTOLs and the AAM market. Hence, disruptive innovation can generate an impact both in the innovation ecosystem and in the business ecosystem and the market.

In turn, this study contributes to the ecosystems literature by deepening the understanding of the evolution of innovation ecosystems that develop disruptive innovations and subsequently grow around this innovation (Palmié et al., 2019). A disruptive ecosystem is created when a disruptive technology and product collide with a disruptive business model. What allows us to associate the disruption of the ecosystem is the predictability found in the change technology impacts on the ecosystem. Furthermore, as far as the authors of this study are aware, no ex-ante studies have sought to understand ecosystem change based on disruption.

This study also contributes to the disruption literature proposed by Christensen (2006) and Christensen et al. (2018), where disruption may have characteristics for predicting ex-ante arrival on the market. We extend this discussion with the impact of ex-ante disruption to the ecosystem. This study raises considerations about the Disruptive Ecosystem Evolution Model (Silva & Grützmann, 2022), which is viable for designing the impact of disruption on the ecosystem. New ecosystem based on disruption. The model has become a viable tool for categorising possible disruption impact scenarios and performing the constitution of the disruptive ecosystem.

In this scenario, this study contributes to distinguishing the radical impact and the disruptive impact on ecosystems. Radical innovations break existing technological standards with the risk of a drastic disruption in the ecosystem. With every abrupt break/destruction, the ecosystem cannot adapt, where the possibility of radical technology failure and the consequent death of many ecosystem actors may occur. Differently, as in the disruptive innovation presented in this study, a change process occurs over time. Disruption only happens when one technology supplements the other, whether over a short or long time. So, disruptive innovation adapts to the ecosystem in a collaborative process between existing actors and new actors that are created, fostering an ecosystem with evolutionary dynamics of technologies, business models and value propositions. Our contribution to the literature with the proposal of an innovation or disruptive biome, where different ecosystems collaboratively develop the eVTOLs technology and where multiple technological and non-technological ecosystems are aligned with the collaborative, adaptive and evolutionary process to develop the AAM market.

This study also raises other considerations about the constitution of the disruptive ecosystem (Dedehayir et al., 2017; Palmié et al., 2019; Silva & Grützmann, 2022). Recent studies point to a change in the value proposition of the mobility ecosystem based on new technologies (Silva et al. 2023 – Article 2). These ecosystem value changes raise considerations for disruption as part of a technological leap. When a disruption impacts an ecosystem, it can evolve in the form of a technological leap for the ecosystem (Silva et al., 2023 – Article 3). This evolutionary leap of the ecosystem can be accompanied by a dynamic value proposition that accompanies the constitution of the new disruptive ecosystem (Silva et al. 2023 – Article 4). Thus, changes in the perspective of value, actors, business models and the value of new technology indicate a propensity for a new ecosystem. This way, a disruptive ecosystem is created when a disruptive technology or product is realized alongside a disruptive business model. Thus, our study presents possible scenarios for the impact of disruption and alteration of the ecosystem pattern and value proposition.

5.2. Practical and Managerial Contributions

Currently, it cannot be said from which direction a future disruptive innovation will occur, although the market is ready for future disruptive innovations (Klenner et al., 2013). Our study contributes in a managerial way so that companies and managers can prepare for possible future scenarios of the arrival of eVTOL technology and the AAM market. It is important to consider the current capacities of the actors and the opening of ecosystem exploration spaces, both for innovation and business. Actors must also pay attention to the forces that build and transform ecosystems. Invariably, this disruption must affect the entire ecosystem and the new AAM market.

Another significant contribution of our research seeks to reinforce the importance of the support ecosystem necessary for developing technology in the market. As companies invest in development and technologies mature, they require collaboration between governments and companies to create new regulatory frameworks, infrastructure, supporting technologies, and user acceptance for market exploitation. This is critical for the birth of any technology, and it is also critical for the AAM market. The technology of eVTOLs is in the early stages of development, as well as the AAM market; it is up to managers to embrace the emerging change that will shape the transportation mobility market.

6. Conclusions

This study sought to identify and to analyze the possible scenarios for the potentially disruptive innovations of eVTOLs and the Advanced Air Mobility ecosystem. It was possible to present the main scenarios for disrupting eVTOLs within the innovation ecosystem and the AAM market. The main results point to the collaboration of actors from different sectors for technology development (Adner, 2006; Holgersson et al., 2022; Yaghmaie & Vanhaverbeke, 2019).

Another significant result of this study was the coevolutionary process (Hou & Shi, 2020; Ma et al., 2018) presented based on the various necessary technologies that converge to the disruptive process of eVTOLs. Actors and technologies associate their strategies for technology success within the ecosystem (Kumaraswamy et al., 2018; Rabin et al., 2020). In this case, ecosystem strategies directed towards developing eVTOLs as a broader scope of different technologies. Thus, we proposed the innovation biome to expand the scope of technologies that involve the different technological ecosystems that are part of eVTOLs.

The Disruptive Ecosystem Model has also proved to be a valuable tool for exploring the impact of a disruption within the ecosystem (Silva & Grützmann, 2022). The tool appropriates the dynamic and evolutionary condition of the ecosystem in the face of disruption and can capture possible scenarios and impacts of the new ecosystem. It was also possible to capture the impacts of the business ecosystem in creating the new AAM market.

6.1. Limitations

Our study is subject to a number of limitations. First, the method consists of exploring the possible scenarios in the official documents analyzed within the perspective of the Disruptive Ecosystem Model. Other analysis models are suggested, and other data sources are used to search for better results. Another limitation was to derive the disruptive potential ex-ante without verifying how its effects unfold in the market. As the technology is still incipient in the market, it was not possible to follow this growth process. It is suggested to monitor the insertion of the technology in the market and make new future proposals for the design of the technology. Another limitation as the technology is in its nascent stage, and the data are a cut of the technological and business model current information, therefore it can change with the appearance of new external forces that can positively or negatively impact negatively affect the disruptive ecosystem. Therefore the information can be expanded and/or changed, which demands further research for this follow-up. It is also suggested research to deepen the universe of AAM for industry development and UAM for development of the urban market. This research has intrinsic limitations of the case study methodology (Yin, 2007) and the exclusive focus on the market and transportation mobility technologies. It is suggested to carry out multiple case studies to test the Disruptive Ecosystem Model and new research methods for eVTOLs and AAM.

Appendix I

Nº	Source	Nº	Source
1	Airbus, 2022 (Official Website)	39	Evtol Insights, 2020 (Podcast: p. 18 – Bruno Mombrinie – Founder and CEO of Metro Hop)
2	Alphabet/Google, 2022 (Official Website)	40	Evtol Insights, 2021 (Podcast: Ep. 37 – Daniel Avdagic of AV Living Lab)
3	Amazon, 2022 (Official Website)	41	Evtol Insights, 2021 (Podcast: Ep. 47 – Yun-yuan Tay, Head of Asia Pacific at Skyports)
4	Asian Sky Group, 2021 (Report: UAM Report)	42	Evtol Insights, 2021 (Podcast: Ep. 48 – Pamela Cohn of Hyundai Motor Group's UAM Division)
5	Autoflight Global, 2022 (Official Website)	43	Evtol Insights, 2021 (Podcast: Ep. 55 – Manal Habib, CEO and Co-founder of MightyFly)
6	Bell Helicopter, 2022 (Official Website)	44	Evtol Insights, 2022 (Podcast: Ep. 68 - Bem Tigner, CEO and co-founder of Overair)
7	Bell, 2022 (Official Website)	45	Evtol Insights, 2022 (Podcast: Ep. 72 - Eric Allison, Head of Product at Joby Aviation)
8	Boeing, 2022 (Official Website)	46	Fukushima, 2019 (Report: Headed towards "Air Mobility Revolution")
9	Daimler, 2022 (Official Website)	47	General Electric, 2022 (Official Website)
10	Deloitte, 2017 (Report: Framing the future of Mobility)	48	Honda, 2022 (Official Website)
11	Deloitte, 2018 (Report: Change is in the air The elevated future of mobility What's next on the Horizon)	49	Honeyweel, 2022 (Official Website)
12	Deloitte, 2018 (Report: Horizon in the air The elevated future of Horizon What's next on the Horizon)	50	Hyundai, 2022 (Official Website)
13	Deloitte, 2019 (Report: Change is in the air The elevated future of mobility)	51	IBM, 2022 (Official Website)
14	Deloitte, 2019 (Report: Change is in the air The elevated future of mobility: What's next on the horizon?)	52	Intel, 2022 (Official Website)
15	Deloitte, 2019 (Report: Horizon in the air The elevated future of Horizon: What's next on the Horizon?)	53	Japan Airlines, 2022 (Official Website)
16	Ehang, 2022 (Official Website)	54	JetBlue, 2022 (Official Website)
17	Ehang, 2022 (Report: The Future of Transportation: White Paper on UrbanAir Mobility Systems)	55	Joby Aviation, 2022 (Official Website)
18	Embraer X, 2020 (Report: Flight Plan 2030)	56	Kittyhawk, 2022 (Official Website)
19	Embraer, 2022 (Official Website)	57	KPMG, 2022 (Report: Levelling Up China's race to an autonomous future)
20	EmbraerX, 2022 (Official Website)	58	Leonardo,2022 (Official Website)
21	EVE, 2022 (Official Website)	59	Lilium Aviation, 2022 (Official Website)
22	Evtol Insights, 2020 (Podcast: Ep. 1 - Lilium's Oliver Walker-Jones, head of communications)	60	Lufthansa, 2021 (Report: Are Air Taxis Ready For Prime Time?)
23	Evtol Insights, 2020 (Podcast: Ep. 10 – Wisk's Chief Marketing Officer Becky Tanner)	61	NASA, 2021 (Official Website)
24	Evtol Insights, 2020 (Podcast: Ep. 11 – Felipe Varon, CEO and Founder of Varon Vehicles)	62	NASA, 2021 (Report: NASA Electric Vertical Takeoff and Landing (eVTOL) Aircraft Technology for Public Services)
25	Evtol Insights, 2020 (Podcast: Ep. 12 - George E. Bye - Bye Aerospace)	63	Nissan, 2022 (Official Website)
26	Evtol Insights, 2020 (Podcast: Ep. 14 - Christoph Fraundorfer CEO of Fraundorfer Aeronautics)	64	Porsche, 2022 (Official Website)
27	Evtol Insights, 2020 (Podcast: Ep. 15 - Co-Founder and CEO of Airflow.aero, Marc Ausman)	65	PWC, 2018 (Report: Industrial Mobility and Manufacturing)
28	Evtol Insights, 2020 (Podcast: Ep. 16 – Flock's Sales and Marketing Leade, Sam Golden)	66	Roland Berger, 2018 (Report: Urban air Transpor – The rise of a new mode of Transportation)
29	Evtol Insights, 2020 (Podcast: Ep. 17 - Trancend Air's CEO Greg Bruell and COO Peter Schmidt)	67	Rolls-Royce Holdings, 2022 (Official Website)
30	Evtol Insights, 2020 (Podcast: Ep. 19 – Neil Cloughley, MD of Faradair Aerospace)	68	Tencent, 2022 (Official Website)
31	Evtol Insights, 2020 (Podcast: Ep. 2 – Skyports' Duncan Walker, founder and CEO)	69	Tesla, 2022 (Official Website)
32	Evtol Insights, 2020 (Podcast: Ep. 21 – Darrell Swanson of Swanson Aviaton Consultansy and Julian Carlson of Pascall + Watson)	70	The Business Research Company, 2022 (Report: eVTOL Aircraft Global Market Report 2022)
33	Evtol Insights, 2020 (Podcast: Ep. 23 – Thomas Pfammatter and Jasmine Kent of Dufour Aerospace)	71	Toyota Motor, 2022 (Official Website)
34	Evtol Insights, 2020 (Podcast: Ep. 26 – Marco Pugliese, Head of Institucional Relations at Walle Mobility)	72	Uber Elevate, 2016 (Report: Fast-Forwarding to a Future of On-Demand Urban Air Transportation)
35	Evtol Insights, 2020 (Podcast: Ep. 31 – Yolanka Wulff, Co-Executive Director of the Community Air Mobility Initiative (CAMI))	73	Uber Elevate, 2022 (Official Website)
36	Evtol Insights, 2020 (Podcast: Ep. 7 - Ed De Reyes, CEO of Sabrewing Aircraft)	74	UKRI, 2021 (Report: Future Flight Vision and Roadmap August 2021)
37	Evtol Insights, 2020 (Podcast: Ep. 8 – Vertical Aerospace CEO Michael Cervenka)	75	Volkswagen, 2022 (Official Website)
38	Evtol Insights, 2020 (Podcast: Ep. 9 – Dr. Yoeli of Urban Aeronautics)	76	Volocopter, 2022 (Official Website)

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