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Legitimation strategies in emerging ecosystems: The case of advanced air mobility in Hamburg

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ABSTRACT

This study provides insights into the legitimation process of emerging ecosystems and strengthens the conceptual link between entrepreneurial ecosystems and economic geography. It examines existing theoretical frameworks on legitimation strategies in emerging entrepreneurial ecosystems by inquiring into advanced air mobility (AAM), an area in which innovation faces exceptionally high legitimation challenges. The initial integration of drones for logistics and air taxis for passenger transport is surrounded by ambiguous future visions that range from high expectations to concerns about developing a mobility form that is neither sustainable nor socially acceptable and affordable. Empirically, this article offers an analytical understanding of the collective legitimation strategies within the emerging AAM ecosystem in Hamburg, Germany. For this, we used multiple qualitative methods and data sources: (1) a contextualizing network analysis, (2) semi-structured interviews with 22 representatives of tech and policy development, and (3) participatory observation from applied research projects. Based on the empirical material, we find that the current conceptual debate underestimates the public sector's role in ecosystem emergence and legitimation. As AAM depends on fundamental regulatory change, authorities and state-owned companies in the aviation sector have a decisive influence on the emergence of the ecosystem. Furthermore, our findings highlight how global discourses shape local practices and expectations. By combining cross-sectoral knowledge, entrepreneurs and policymakers aim to identify feasible use cases for their place-specific context. Nevertheless, the lack of a collective identity within the ecosystem, which comes largely from the uncertainties of AAM, poses numerous challenges for ecosystem participants addressing their liability of newness.

1. Introduction

Integrating emerging technologies into existing physical infrastructures, technological landscapes, economic constellations, and social contexts is challenging. New technologies face various organizational, legal, and social barriers, which we call the *liability of newness*. Initially, the term refers to the greater risks that young organizations face in comparison to established organizations and why they are more likely to fail due to their lack of stability, legitimacy, and access to crucial resources (Freeman et al., 1983; Singh et al., 1986; Stinchcombe, 1965). More recently, the liability of newness also includes disbelief and a lack of evidence regarding the viability of the innovation, its value proposition (Aldrich & Fiol, 1994; Dattée et al., 2018), and doubts in the long-term sustainability (Ansari et al., 2016). Overcoming this liability of newness represents a core challenge for new technologies (Binz & Gong, 2022; Gong et al., 2022) and for emerging entrepreneurial ecosystems using them for new value propositions (Thomas & Ritala, 2022; Kuratko et al., 2017).

Entrepreneurial ecosystems are "communities of interdependent yet hierarchically independent heterogeneous participants" (Thomas & Ritala, 2022: p. 515), that rely on collective actions among diverse participants to generate a joint value proposition (Autio & Thomas, 2021; Thomas & Ritala, 2022). The emergence of a novel ecosystem and its value proposition hinges on the successful development and deployment of the innovation itself. While this general connection of entrepreneurial ecosystems and technological novelty is not new (Bouncken & Kraus, 2022; Drucker, 1985; Kuratko et al., 2017), the collective processes that structure their emergence remain

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under-researched (Thomas et al., 2022). This includes the research on the reasons for ecosystem emergence, their distinctiveness from other forms of governance, and how multilateral dependencies are addressed (Jacobides et al., 2018). Ecosystems are not isolated or limited to the action of the actors within, but a major input is rooted in the exchange of people, ideas, or resources across geographical distances (Schäfer & Mayer, 2019; Malecki, 2011). Therefore, emerging ecosystems respond to challenges that exceed their spatial, sectoral, and administrative scope, such as uncertainties regarding the technology or the feasibility of a regulatory framework that enables market creation and pursuing ventures. While researching emerging technologies and affected industries might offer sector-related insights into industry-specific legitimation strategies, entrepreneurial ecosystems are "industry-agnostic" (Autio et al., 2018: p. 88), ideally offering more generalizable insights. This is particularly important when analyzing technologies that stem from different industrial backgrounds with varying expectations or understanding of the innovation. Hence, they can be poorly understood across entrepreneurs and external actors (e.g., public agencies, customers), causing them to lack legitimacy. Studying the aforementioned elements of entrepreneurial ecosystems can enhance the understanding of micro-scale developments (i.e., the collective action of its participants) that lead to the successful legitimation of innovation (Schäfer & Mayer, 2019). However, despite an increased attention from economic geography on entrepreneurial ecosystems (e.g., Alvedalen & Boschma, 2017; Haefner & Sternberg, 2020; Malecki, 2018; Schäfer, 2021), and the first conceptualizations of their legitimation strategies (Kuratko et al., 2017; Thomas & Ritala, 2022), the collective efforts of overcoming an ecosystem's liability of newness still largely remain untested and uncontextualized.

In this article, we thus aim to test and contextualize the initial conceptualizations of ecosystem legitimation strategies by confronting existing theoretical contributions to our case study. More precisely, our case study aims to contribute to the scholarship of entrepreneurial ecosystems by empirically investigating the case of an emerging ecosystem in the context of a technological novelty, the development of advanced air mobility (AAM). We do this by discussing *how participants of an emerging entrepreneurial ecosystem reduce their liability of newness*. This research question is further disentangled into the sub-questions of *(1) how an emerging ecosystem is structured, (2) what are the major liabilities that the ecosystem faces,* and *(3) how entrepreneurs strategically address these liabilities.*

We find the mobility sector to be particularly suitable to empirically research legitimation strategies for overcoming a technology's liability of newness. Transport systems have a historical impact on industrial paradigm shifts and vice versa, as they not only adapt to innovations but also build the foundation for new value chains, infrastructural upgrading, and social change. The evolution of AAM joins this continuous change in mobility and potentially represents a central paradigm shift for both cargo and passenger transport. Impacting core public goods, the innovation in the mobility sector requires system-building activities that address multilevel lobbying and regulatory change (Uyarra & Flanagan, 2022). Entrepreneurial ecosystems that attempt to test new solutions for the mobility systems of the future in a specific location must therefore always strike a balance between societal feasibility and economic viability. AAM development has received an enormous investment push in recent years, which has been driven primarily by companies in China, the US, and Germany. The primary goal was to reach the milestone of certifying the first air taxi for commercial operation, which is linked to many years of continuous evaluation, adaptation, and several pilot projects. In October 2023, the Chinese company EHang was the first to achieve this ambitious benchmark (EHang, 2023). They aim to establish air taxis as an element of urban mobility and launch them in several major Chinese metropolitan areas by 2024. Within this global competition for pioneering these new mobility solutions, aspects such as national legislation, bureaucracy, and the co-involvement of civil society become critical success factors for the legitimacy of this novelty.

Empirically, we investigate the legitimacy-making of emerging technologies by studying the participants of the emerging entrepreneurial ecosystem engaged in AAM in Hamburg, Germany. As a forerunner city regarding AAM operation, Hamburg has successfully launched the first certified drone control center in Europe in June 2024, enabling numerous autonomous drone operations beyond the visual line of sight in the port area simultaneously (HHLA Sky, 2024). Methodologically, this study uses qualitative research methods with an exploratory research strategy that allows analyzing the emerging ecosystem in Hamburg. The empirical research draws on three types of primary sources. Initially, we conducted a network analysis to identify relationships among ecosystem participants. We then used expert interviews and participatory observations from applied research projects to gain deeper insights into the legitimacy-making strategies employed in the ecosystem's emergence.

The paper is organized as follows: Chapter two reviews the understanding of entrepreneurial ecosystems and introduces our framework regarding the emergence of legitimacy. Chapter three provides details on our methodological approach and the empirical sources. Chapter four introduces the empirical case of advanced air mobility. In the following, chapter five highlights the empirical findings focusing on network analysis and the legitimation dimensions of AAM in Hamburg. Subsequently, we discuss our findings and conclude with the critical contributions of this study.

2. Legitimacy emergence in entrepreneurial ecosystems

Entrepreneurial ecosystems are organic constellations of a set of interdependent actors that collectively work towards system-level outputs associated with benefits for individual stakeholders (Autio & Thomas, 2021; Stam, 2015). While ecosystems share certain principles with other organizational or spatial concepts like clusters, they are not necessarily being spatially anchored, but rather centered around knowledge flows and collective action to advance a co-dependent value proposition (Bouncken & Kraus, 2022). Entrepreneurial ecosystems are led by entrepreneurs themselves, in distinction to the top-down/policy perspective of clusters or regional innovation systems (Autio et al., 2018; Autio & Thomas, 2021; Stam, 2015). Thus, ecosystems should encourage entrepreneurs and other participating actors to take risks for funding and venture creation (Spigel, 2017). Rather than emphasizing the resources that a specific network or company contains, entrepreneurial ecosystems establish common interests and allow members to access resources (Spigel & Harrison, 2018).

Crucially, four characteristics distinguish ecosystems from other organizational concepts (Autio & Thomas, 2021): (1) Ecosystems aim at a ***system-level output*** that all participants collectively agree with. This outcome can be in the form of products, services, business models, or knowledge production. Moreover, participation is based on motivation and persuasion rather than formal contracting. (2) The ***heterogenous participants*** are hierarchically independent and fulfill separate roles within the ecosystems. Unlike in value chains, the participants are volunteers without a predefined agreement on their specific role. (3) They are linked through ***interdependencies***, such as physical interconnection, spatial proximity, or network effects. (4) The ***coordination*** mechanisms of the ecosystem must find a balance between change and stability. This process of coalignment also reflects the power relations between the participants. Moreover, entrepreneurial ecosystems are "industry-agnostic" (Autio et al., 2018: p. 88), relying on entrepreneurial knowledge beyond industry-specific knowledge (Spigel & Harrison, 2018). This knowledge notably includes experiences in building up an organizational culture, interacting with policymakers, or stakeholder management. This entrepreneurial knowledge becomes imperative in the emergence of new technologies within existing industries, as the ecosystems seek to obtain legitimacy through and within new formal and informal institutions (Lange & Schmidt, 2021).

The lack of legitimacy is a core problem for emerging ecosystems,

that require social acceptance, plausibility of value propositions, and credibility of actors as much as material resources and capabilities (Suchman, 1995). While the liabilities of new ventures (e.g., while developing technological novelties) might lessen if they enter an ecosystem to improve the legitimacy evaluation of their audience (e.g., potential partners and supporters), insights on how ecosystems can influence the performance of new ventures are rather scarce (Bouncken & Kraus, 2022). By nature, new value propositions are not widely known or well-understood and challenge incumbent practices leading to a limited acceptability by (possible) ecosystem partners and supporters (Kuratko et al., 2017).

Initial conceptualizations of legitimation strategies in emerging ecosystems exist. For instance, Zimmerman and Zeitz (2002) suggest that there are four basic legitimation strategies available to emerging ecosystems in relation to existing and established ecosystems: (1) conformance (following the existing rules and particular social structure), (2) selection (locating in a favorable environment), (3) manipulation (attempting to make changes in the current ecosystem environment), and (4) creation (creating a new social context by establishing new rules, norms, values, beliefs, and models). Kuratko et al. (2017) and Johnson et al. (2006) describe the emerging ecosystem's pursuit of legitimacy as a phased process beginning with innovation, diffusion, and then local validation. Once the innovation exists, entrepreneurs engage in legitimation strategies during the diffusion phase to garner legitimacy for the upcoming venture. Thomas and Ritala (2022) conceptualize ecosystem legitimacy emergence as a collective process composed of two different ecosystem legitimation processes: (1) *discursive legitimation* processes, which promote ecosystem acceptance and comprehensibility, (2) *performative legitimation* processes, which demonstrate the viability of the ecosystem. Emerging ecosystems must therefore be perceived as legitimate not only by the ecosystem participants but also by other actors in the broader environment that entangle the development. Both discursive and performative legitimation processes mutually work towards creating an ecosystem identity (Thomas & Ritala, 2022).

While all three conceptualizations are valid, we draw most intensively from Thomas and Ritala's (2022) conceptualization as it draws attention to the collective nature of legitimacy-making by assigning different roles to the ecosystem's participants. As ecosystems consist of diverse types of legitimating actors, analyzing the collective action for legitimacy emergence in ecosystems, the key actors within a given ecosystem must be identified and disentangled. The *orchestrator* is the focal point of the ecosystem and advocates its value propositions and provides crucial resources for other actors (Autio, 2022; Thomas & Ritala, 2022). An orchestrator thus shapes an ecosystem's goals, identity, and design (Gulati et al., 2012). *Complementors* provide complementary products, services, or inputs that contribute to the value proposition (Jacobides et al., 2018; Shipilov & Gawer, 2020) and must build legitimacy for their own contributions within the ecosystem (Thomas & Ritala, 2022). *Users* legitimize ecosystems through their adoption of the value proposition, especially large and powerful users who can contribute to the legitimacy of an ecosystem (Thomas & Ritala, 2022; Tushman, 1992). *External actors* in the ecosystem can be the media, financial analysts, competitors, or regulators. Especially regulators can play a vital role in enforcing standards for new technological settings (Garud et al., 2022). Based on the understanding of Thomas and Ritala (2022) an ecosystem identity promotes legitimation for both the ecosystem participants and the external environment. Legitimacy thus emerges through two processes, which are intertwined and mutually complementary as collective action in one process influences the other.

Firstly, ***discursive legitimation*** processes drive cognitive legitimacy and the generation of a shared meaning (Thomas & Ritala, 2022). They describe activities that should motivate and convince actors in the broader environment to accept and participate in the value proposition of the ecosystem (Phillips et al., 2004). For instance, this involves the framing of the ecosystem by the orchestrator to make the purpose of the ecosystem comprehensible and engage complementors in sensemaking of the value proposition. Moreover, users can help to position the ecosystem in the broader discourse (such as spreading information about successful pilot projects) and external actors, such as regulators and the media, can have a decisive influence by recognizing the emergence of the ecosystem (Thomas & Ritala, 2022).

Secondly, ***performative legitimation*** processes refer to normative legitimacy by demonstrating the viability of the ecosystem. Hence, it is an ongoing process that should promote and prove the performance of the ecosystem and its value proposition. (Thomas & Ritala, 2022). Orchestrators can provide strategic actions (such as governance or technological design) to initiate changes and engage complementors in providing required resources for the value realization (such as infrastructure or crucial operational software). Users drive the ecosystem emergence by adopting the value proposition, which is closely tied to the question of social acceptance and trust in new technology and how to overcome the hurdle of reaching early adopters of an innovation. External actors, such as regulators or venture capitalists, may affect the ecosystem emergence by providing investments for market creation (Thomas & Ritala, 2022). This aspect becomes even more critical in cost-intensive sectors such as transport, where the integration of a new vehicle is tied to infrastructural changes and new modes of operation to align with the existing mobility system.

We refer to this distinction throughout our empirical analysis to identify the key challenges that entrepreneurs face at the early stage of the ecosystem and how they address these challenges. Nevertheless, we emphasize the importance of interdependencies between these two legitimation processes and identify conceptual and empirical implications for future research in our discussion and conclusion. While we draw heavily on Thomas and Ritala's (2022) conceptualization of legitimacy emergence in entrepreneurial ecosystems, we do not seek to replicate the results but rather aim to contextualize and critically advance this existing framework by confronting it with other literature and our empirical investigation outlined below.

3. Methodology

This study is based on an empirical investigation which is based on the following methodological steps. Firstly, we conducted a network analysis to delimit the entrepreneurial ecosystem and contextualize our case study. We identified the actors in Hamburg's AAM ecosystem through desk research based on project websites and documents.

Secondly, we interviewed 22 experts who are related to the development of AAM. The interviewed entrepreneurs involve a heterogeneous set of unmanned aerial vehicle (UAV) developers, system- and service providers, and consulting companies. Moreover, we addressed public-related actors like operation agencies, networking organizations, and municipalities. The interviews were conducted between March and May 2022. Table 1 provides an overview of all interviewees. Most actors are either based in Hamburg or directly tied to AAM development in Hamburg by participating in networking activities or research projects. As the AAM technology development in Germany is still emerging and some specific fields only contain a handful of actors (e.g., air taxi development), we also included insights from actors outside of Hamburg to broaden our view on the overall development. Due to this young development that stems from different industrial backgrounds (primarily robotics and aviation), there is a lack of joint data on investments or start-up numbers in specific places. Our attempt was therefore also to shed some light into the current structures and provide a comprehensive overview of the emerging ecosystem. In a first step, we identified interviewees through a document and website analysis, that also set the basis for our network analysis. Some actors were already familiar to us due to our work in applied research projects. We contacted the organizations that were known to us based on this preliminary groundwork to identify suitable interview partners. Because of our focus on entrepreneurship and strategic development, we focused on leading roles such as

Table 1
List of interviewees.

#	Hamburg relation	Role/affiliation	Background and focus	Linkages to transport and AAM
1	Local actor	CEO *Private company*	UAV developer Start-up- aviation background	Focus on critical time logistics
2	Local-related	Business developer	Service provider Aviation and IT background	Management of air traffic
3	Strong ties to HH	Product manager *Public-private*		Legal framework Data operation
4	Local actor	CEO *Private company*	Systems developer Start-up - aviation background	Ground-based infrastructure Passenger tr. and logistics
5	Local-related Ties to HH	CEO *Private company*	Software and UAV developer Start-up – IT background	Automation and routing software
6	Local actor	Sales manager *Private company*	Software developer Major company – IT background	Broad activities in transport AAM an experimental niche
7	Non-local actor	CEO *Private company*	UAV manufacturer Start-up – automotive background	Passenger tr. and logistics
8	Local actor	CEO *Private company*	Consulting Start-up – aviation background	Supporting certification
9	Local-related actor Ties to HH	CEO *Private company*	UAV manufacturer Start-up	Software platforms Focus on logistics
10	Local actor	CEO *Private company*	Service provider Start-up – aviation background	Data operation Safety & route planning
11	Non-local actor	COO	Consulting	Trainings
12	Ties to HH	Project manager *Private company*	Start-up - aviation background	Supporting certification
13	Local actor	Project lead *Private company*	Software developer Medium-size – IT background	Operation software
14	Local actor	Technical dev.	Systems and service provider Aviation and IT background	Hardware for drone operation Supporting certification
15		Project manager *Public-private*		
16	Non-local actor	Business developer *Non-profit*	UAV developer	Focus on medical logistics
17	Local-related actor Strong ties to HH	Project manager *Public actor*	Service provider Aviation background	Management of air traffic Legal frameworks
18	Local actor	Cluster manager *Public actor*	Networking organization	Industry networking Focus on pilot projects
19	Local-related actor Ties to HH	City administrative *Public actor*	Networking organization	Industry networking Focus on research & development
20	Local-related actor Ties to HH	Cluster manager *Public actor*	Networking organization	Industry networking Focus on logistics
21	Local-related actor Ties to HH	City administrative *Public actor*	Networking organization	Industry networking Focus on IT & AI
22	Local-related actor Ties to HH	City administrative *Public actor*	Networking organization	Industry networking Focus on aviation

CEOs. In major companies or public-private organizations, we focused on business, product, and technical developers who could provide sufficient insights on the overall development of the company. Ultimately, we also use snowball sampling in the form of suggestions or mentioning from the previous interviews to identify further potential interviewees (especially within the public sector). The average length of the interviews was 1:00:19, with the longest interview lasting 1:28:32 and the shortest 49:16. The interviews were semi-structured and afterwards coded and analyzed with the software Maxqda based on the categories of the theoretical framework.

Thirdly, we draw on internal insights from three AAM research projects in Hamburg via participatory observation including our own research during the project running time. Each project has a different thematic focal point and provides a specific understanding of the local stakeholder network. The project "Medifly" deals with critical logistics by using cargo drones for medical transport between hospitals, such as organs or tissue samples. The second project "i-LUM" (innovative airborne urban mobility) analyzes the development from an interdisciplinary perspective to evaluate the feasibility, create a holistic simulation tool, and ultimately describe future scenarios of AAM in Hamburg. The last project, "LUV", addresses the u-space proposal of the EU Commission. It provides recommendations for enhancing the current legal state and how the ideas can be transferred into the local and national context.

4. Advanced air mobility: toward a new form of mobility

Urbanization and sustainability issues put an increasing strain on existing urban transport systems. Innovations associated with Industry 4.0 foster the creation of new automated forms of mobility, such as AAM. The various use cases can be divided into two core aspects: (1) transporting goods or materials with cargo drones and (2) passenger transport with air taxis. Besides this distinction, AAM encompasses different concepts, vehicle types (vertical or short-runway take-off), and functionalities that differ in their propulsion, design, capacity, range, autonomy, and compatibility with existing infrastructure and operational systems (Cohen et al., 2021; Thipphavong et al., 2018). While small drones generally have a lower entry barrier regarding their socio-technical integration compared to air taxis, the discourses, limitations, and legal obligations of both technological strands share several similarities. In October 2023, Chinese air-taxi developer EHang successfully obtained the first certification for a passenger UAV worldwide, which is considered to be a milestone for the market creation (EHang, 2023). This success has several implications for global competition, as companies from other countries are struggling with slower regulatory processes or a longer bureaucratic act of testing the technology in a real-world scenario. Hence, it emphasizes the importance of a transnational perspective on legitimacy emergence, as milestones like those of EHang in China can have a decisive influence on the strategic actions of ecosystems in Europe or North America.

Regarding the liability of newness of this new mobility form, certain issues become apparent. The value proposition of this new mobility form is still unclear, as there are few established business cases yet, and the existing start-ups are heavily dependent on venture capital. The development of AAM is still strongly dependent on the actual application scenario in which it should operate. Moreover, the integration into the existing airspace (Bauranov & Rakas, 2021), modal split and welfare aspects (Ploetner et al., 2020), ecological and noise emissions (Vascik & Hansman, 2018), as well as the social acceptance (EASA - European Union Aviation Safety Agency, 2021a) are crucial factors for a broad integration. Far-reaching scenarios, such as the use of drones in last-mile logistics, have become unlikely due to these barriers. Therefore, companies increasingly expand their urban perspective to more specific use cases, e. g. critical-time logistics (healthcare, maintenance, and repair), regional logistics (urban-rural connections), or business-to-business deliveries.

Nevertheless, only a few applied projects and practical experiences exist. Thus, the long-term sustainability of this innovative development remains unclear, both economically and socially (Cohen et al., 2021; Biehle, 2022). Regarding passenger transport, in 2020 and 2021, investors put over 5 billion $ into the emerging air taxi sector. Six companies alone account for 4.6 billion $, including the German companies Volocopter and Lilium (Shaposhnikov, 2021). As an industrial report reflects, this is ten times as much as in the ten years before and stresses the risk that the valuation runs out the technological maturity too fast (Shaposhnikov, 2021). Moreover, the air taxi discourse accounts for higher media coverage, including the plans of Volocopter to initiate the first air taxi routes in Europe at the Olympic Games 2024 in Paris. Subsequently, air taxis greatly accelerated the narratives toward AAM, raising the question if this development overwhelms smaller drone developers, or whether they can potentially benefit from it.

In the European context, the regulatory embedding of AAM accelerated with the publication of two proposals by the European Union and the European Aviation Safety Agency (EASA): Firstly, a proposal that should motivate municipalities to engage in the development of AAM and organize the necessary socio-technical changes on a local scale (UIC2, 2021). In Germany, Hamburg was the first city that adopted this idea in 2017 and founded a network organization to bring companies, researchers, and city representatives together. Secondly, the EU provided a proposal for the integration of "u-spaces" which should enable the practical connection of manned and unmanned aviation in defined air space and provide platforms for the management and operation of automated flights (EASA - European Union Aviation Safety Agency, 2021b). While the EU is pioneering in formulating legal frameworks, practical competencies are deliberately shifted to the national and local scale. Table 2 provides an overview of the system agencies that are involved in managing advanced air mobility in Europe.

The national government can create a conducive economic and social environment for entrepreneurship, for example, by adjusting laws and regulations (Stam & Spigel, 2016). Innovative technologies must adhere to specific rules or policies (Harris, 2021), which becomes a primary challenge for AAM development as its integration is tied to several aviation policies. However, what if these regulatory frameworks are not defined yet, and how do ecosystem participants address and impact the development of these frameworks themselves? In this regard, ecosystem literature often regards regulators as external actors, there are only a few insights on how the emergence of ecosystems is mutually tied to the development of new regulatory frameworks (Alaassar et al., 2022).

Table 2
Scales of system agencies for advanced air mobility, own elaboration.

Policy Scale	Important actors and agencies	Primary objectives for formal engagement with AAM
European	European Union Aviation Safety Agency and Eurocontrol	Providing legal frameworks and guidelines for initiating national policymaking. Forerunner and most important agency for standardization and certification.
National	Federal Ministry for Digital and Transport Deutsche Flugsicherung (DFS)	Primary national agency for promotion, rulemaking, and management of AAM. Air traffic control: Reorganize airspace for autonomous operations and define safety standards.
Regional	State aviation agencies Cluster initiatives	Aviation and airport administration. Project initiation, networking, represent regional interests to the national agencies.
Local	Municipality	Decision-makers for local embedding (social acceptance) and use cases; Integration of ground-based infrastructure.

5. Emerging AAM ecosystems in the case of Hamburg

Hamburg was the first region in Germany to address the EU initiative for AAM (UIC2, 2021) when it formed the first German AAM model region "Windrove'' in 2017. Windrove is part of an aviation cluster organization and is closely linked to the existing knowledge base of the aviation industry in Hamburg. Today, the networking initiative has over 50 members, with more than 90 % of them located within the metropolitan region of Hamburg. While Hamburg has a broad regional background in associated sectors like aviation and logistics, most key players in the emerging air mobility market are located in the south of Germany, such as Airbus Urban Mobility, Volocopter, or Lilium. Therefore, start-ups and small and medium-sized companies represent the AAM development in Hamburg. Moreover, local research facilities engage with the topic increasingly.

In the empirical analysis, we focus on two aspects: Firstly, describe and structure the AAM ecosystem in Hamburg based on social network analysis. Secondly, analyze the performative and discursive legitimation processes based on the theoretical framework.

5.1. Mapping and identification of the ecosystem

As our ecosystem analysis (Fig. 1) is initially centered on Windrove it naturally gives this network organization a relatively high prominence in the collaboration network. Nevertheless, the network graph reveals other key characteristics of Hamburg's emerging AAM ecosystem.

For one, the collaboration network highlights the decentralized character of the ecosystem. Even if the network highlights the assembling (and potentially orchestrating) role of large project consortia, and of network organizations and clusters, such as Windrove, the ecosystem has no hierarchical structure. While some projects and network organizations, such as Hamburg Aviation, connect numerous actors to each other, the projects of the ecosystem are connected to each other via government agencies and research actors. These include Hamburg's Authority for Economics and Innovation (BWI), the port authority (HPA), and all of Hamburg's major universities (TU, HSU, UHH, HTW and HCU). The Authority for Economics and Innovation (BWI) is the actor with the most widespread participation by being directly part of eight of the 20 projects in the ecosystem. Only 3 companies figure among the 10 most engaged organizations despite over 60 % of the ecosystem's organizations being companies (HHLA Sky; Lufthansa, and Workplace Solutions). Key companies at the national scale (e.g. Lilium or Volocopter) do not directly engage in the projects of Hamburg's AAM ecosystem. The network graph (Fig. 1) visualizes the central role of government authorities, universities, and industry representatives such as industry interest groups as central stakeholders in the emerging ecosystem.

For another, while the majority of actors in the ecosystem are Hamburg-based, over 40 % of involved organizations come from other parts of Europe. Of the 89 distinct organizations that participate in 20 projects of the ecosystem, 51 organizations (57 %) are Hamburg-based.[1] However, while a large proportion of organizations in the ecosystem is not from Hamburg, the most well-connected organizations are Hamburg-based. While Hamburg-based organizations have an average of 2.04 connections in the network, organizations from outside Hamburg only have 1.26 connections on average. Nevertheless, organizations from outside Hamburg include key regulating bodies such as the DFS (i.e. Germany Flight Security Agency).

Even if based on directed links, still this network graph fails to properly depict the diversity of the relationships among the actors; which can range from joint membership in a networking organization to long-term project collaboration. This graph highlights the ecosystem-

[1] We counted organizations as Hamburg-based if they have a significant office in Hamburg (e.g. Airbus)

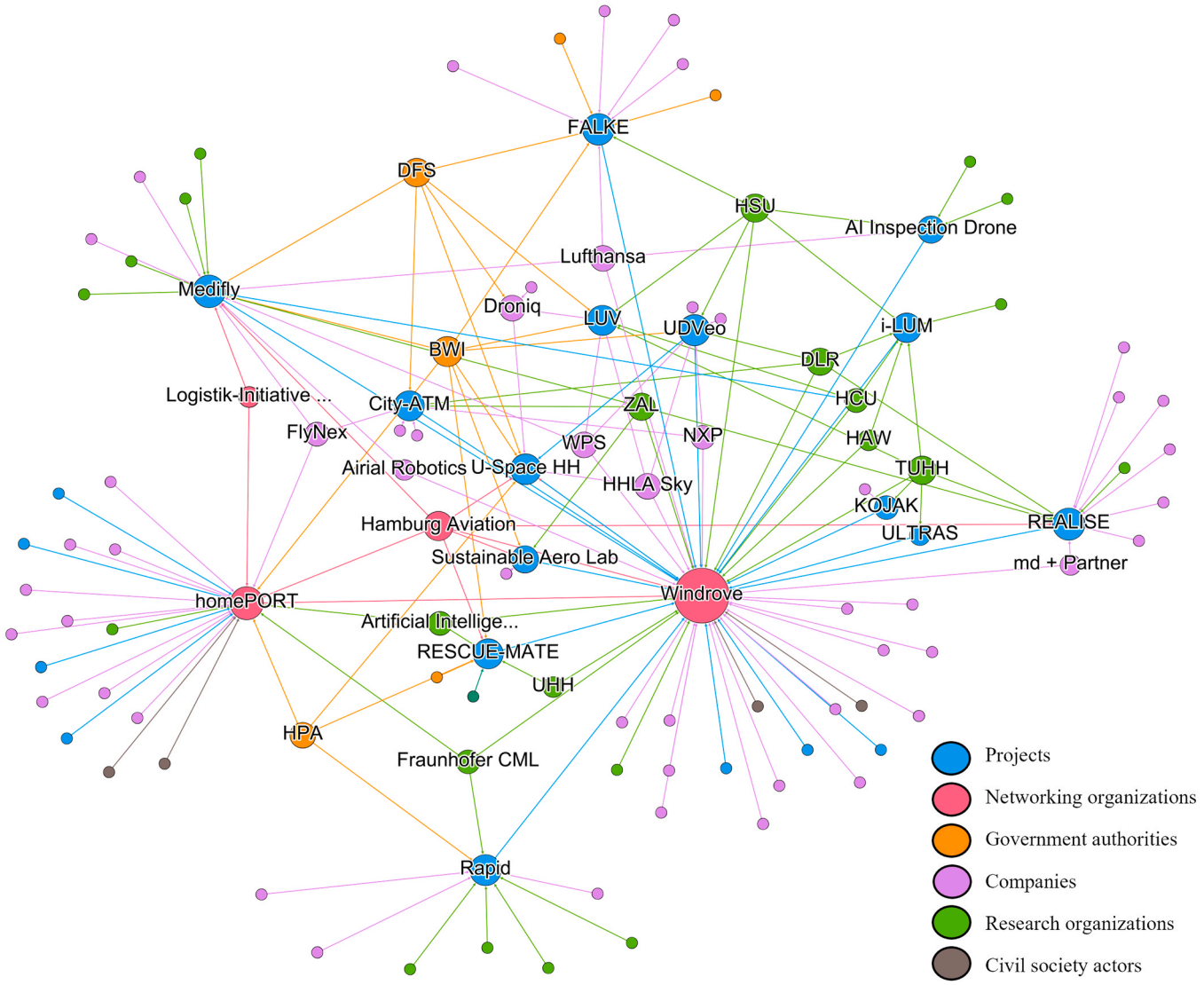

Fig. 1. Network graph of AAM in Hamburg, own elaboration.

like nature of the emerging AAM technology which is composed of heterogeneous actors who appear to be loosely coordinated. The governmental authorities (BWI; HPA), networking organizations (notably Hamburg Aviation, Windrove), researchers at Hamburg's major universities and research institutes (TU, HSU, UHH, HTW, HCU, and Fraunhofer CML), and a small group of outstandingly engaged companies (HHLA Sky; WPS; Lufthansa, FlyNex; NXP, Droniq) appear to be the key actors that coordinate in different projects to advance the AAM development in Hamburg.

5.2. *Ecosystem legitimacy emergence of AAM*

In the following, we reflect on the discursive and performative dimensions of the legitimacy emergence of AAM in Hamburg. Discursive legitimation resembles the current discourses and narratives surrounding the development of AAM to promote cognitive legitimacy and the comprehensibility of the ecosystem, both inside and outside of the metropolitan area. Performative legitimation covers the practical outcomes of the strategic actions by the involved actors to strengthen the viability of the ecosystem.

The emergent ecosystem so far lacks a clear identity, as discursive and performative actions are misaligned. This becomes apparent at the example of the drone vs. air taxi discourse. While air taxis account for the majority of venture capital and media coverage, small drone developers highlight the risk and bias of these narratives. They fear that negative experiences and non-acceptance of air taxi development may also affect the drone sector (Interview #1, #9, #13). Thus, expectations of AAM can elude technological maturity and hinder performative actions that aim at different use cases. Moreover, the perception of forerunner projects can differ greatly among different participants, as they rarely fulfill everybody's interests and intents. Hamburg, in contrast to other AAM model regions in Germany, has a strong linkage to the existing aviation industry. However, this bias also involves potential risk, as many actors clearly emphasize the importance of combining multiple knowledge bases. This makes coordinating activities along the model regions of AAM an even more important necessity to overcome a potential discursive bias within the region and exchange experiences about the outcome of performative actions.

5.2.1. *Discursive legitimation*

The discursive legitimation of AAM proves to be a highly multi-scalar process, as expectations, visions, and regulation frameworks differ greatly from a global perspective. Hence, the local ecosystem in Hamburg faces the challenge to frame the topic on a local scale while being recognizable and aware of the surrounding developments. We identify three central liabilities of the discursive legitimation process

towards an integration of AAM.

(1) The current ***lack of an orchestrator*** to provide a meaningful framing of the ecosystem that reaches beyond the local scale. While the framing of an ecosystem considers the emergence of a vision and motivates others to act, the most critical issue is the lack of an orchestrator who conducts these actions in Hamburg. So far, all involved actors are primarily concerned with understanding each other's competencies and getting to know the ecosystem itself. While the interviewees agree on the importance of coordinating actors and forerunners and some actors provide orchestrating activities, particularly private companies highlight the lack of a clear framing of the local ecosystem (Interview #6, #8, #13). As a potential orchestrator, the local network organization Windrove receives ambiguous feedback. While some interviewees highlight Windroves' impact on the discursive processes as important for knowledge transfer and initiating projects, others criticize the lack of proactive engagement. One CEO stresses that he is "strongly connected to the business feeling here in Germany, but there is a lack of willingness to communicate (Interview #10)" while a software developer indicates that "Hamburg is well known for its aviation industry, but there is no label behind the whole drone topic […] there must be a main coordinator to manage all the concerns (Interview #13)." Besides connecting companies, Windrove itself is primarily concerned with advocating the interests of the municipality on higher policy scales. Rather than competing with other existing AAM model regions in Germany, it is more important to collaborate and communicate regional interests to the national authorities. Representatives of the other model regions in Germany agree on this aspect, as working towards a national legal framework remains the main task for all stakeholders involved in AAM development at its current state.

(2) The ***different perception between passenger transport with air taxis and cargo transport with drones***, which creates uncertainty among several actors and is driven by the expectations of global forerunners. Another main distinction on the discursive level is the perception of cargo and passenger transport. As the use cases and discourses differ greatly between these two main application areas, most drone developers have a critical stance toward air taxi development since it creates high expectations, media coverage, and involves a greater amount of venture capital (Interview #1, #9, #11, #12). Because of this, and due to the absence of air taxi developers in Hamburg, the local agencies address this topic more reservedly and focus instead on industrial applications, such as medical transport or port logistics. As the market is non-transparent so far, most companies stress that they have no feelings for competitors yet and are primarily focused on their internal developments, as a CEO in UAV development exemplary states: "My biggest competition is to do nothing […] many actors in the current market do not know what the others are actually doing (Interview #9)." The local agencies in Hamburg put a strong emphasis on two aspects: Firstly, screening current developments and trying to build up a diverse entrepreneurial community, and secondly, the exchange with other AAM regions in Germany and Europe. This inter-regional cooperation should help to learn from each other's project experiences as well as reflect on the current legal frameworks and adaptability of AAM from different perspectives.

(3) The creation of ***social acceptance as well as trust-building*** among policy actors and industrial partners. Probably the most-discussed issue in the AAM-related literature so far is the creation of social acceptance for this new mobility form. Actors with a background in automotive strongly refer to the "flying car" narrative and share grand expectations for AAM in the context of individual transportation: "In the modal split of the future, UAM (urban air mobility) will play a similar role like the automotive industry did in the 20th century - if it is done right. The big mistake is that many focus on a premium market. This will not be socially accepted. The image of flying has also greatly improved with cheap flights (Interview #7)." The embedding of use cases requires not only social acceptance but also growing harmonization and trust-building between the industry and involved authorities (Interview #4). The current state is still in a very early stage, as there is simply no broader user base, and most companies are dependent on funding, venture capitalists, or private assets of the entrepreneurs (Interview #1, #4, #5, #7, #9). Most use cases can be described as experimental spaces, where certain application areas are being evaluated in research projects. However, these temporary projects did not lead to long-term outcomes in terms of value proposition yet. As a local operator states, "you cannot always ask a hundred people first, AAM must be tested in practice […] you cannot sugarcoat things, you need to deliver clear arguments (Interview #15)." This also refers to the public-private nature of some key actors, as they need to set new legal frameworks and, at the same time, have a commercial interest. The companies are also aware of the uncertainty regarding their actual target group, which is why the focus in technology development often lies in providing a scalable solution that is applicable to different use cases.

Overall, the discursive legitimation is still very dependent on global discourses in the industry. Moreover, there is a gap between the perception and expectation on the political and the operational level. While Hamburg is regarded as an important industrial location by companies with many potential partners across the entire value chain, other AAM actors in Germany (Interview #19 - #22) often refer to Hamburg as a forerunner in strategic development, especially in the forethought of u-spaces as well as entrepreneurial networking. For instance, the Medifly project received critical acclaim in the local and national political discourse. However, the project was received with restraint from the economic or operational side, as it failed to actually obtain the flight license to launch a pilot project and thus did not contribute to technological or regulatory development. In this light, some companies (Interview #1, #5, #9, #10) highlight the importance of cross-sectoral embedding and global knowledge exchange as more crucial than their local embedding. As a CEO indicates, "it (the AAM development) is too imbalanced here in Germany and Europe to evolve an entire sector […] no one is going to be successful in urban air mobility thinking about their country alone, winning players are global players (Interview #10)."

5.2.2. Performative legitimation

The performative legitimation of the AAM ecosystem in Hamburg is closely tied to the existing aviation sector in Hamburg. Involved actors primarily aim at creating spaces for experimentation. We highlight four liabilities regarding the performative legitimation.

(1) The importance of ***existing knowledge bases and local capabilities*** such as the aviation sector and initiatives that provide networking activities. AAM requires both investments in resources and technology to develop scalable and unique technological solutions as well as governance design to provide sufficient legal frameworks for operation. As for technological developments, companies highlight automation as the key issue (Interview #1, #4, #9, #10). This stresses that AAM is not only reliant on conventional aviation knowledge but requires input from robotics and artificial intelligence for autonomous flying. Besides the vehicle itself, there are many start-ups that deal with associated supporting technologies for operation, such as geographic information systems for weather and route simulation, ground-based infrastructure for take-off and landing, or integration of AAM in traffic management. Most companies are also dependent on either project funding or other loose relations with big corporations like Airbus (Interview # 4, #5). However, only a few companies have long-term relationships with big corporations in AAM development from other regions or internationally (Interview #1, #6, #13). Therefore, companies focus on reducing the complexity of AAM and identifying low entry barriers for applications. Ties to other entrepreneurs in the ecosystem exist primarily for knowledge exchange and project acquisition. Windrove provides different activities to enforce this exchange, such as individual consultation or thematic working groups. The actual impact on the ecosystem is, however, hardly measurable. While there are a couple of applied projects that directly evolved out of networking activities, most opportunities are

not discovered by strategic action. As described by a CEO, "most co-operations are driven by the opportunity itself, recommendations, and informal networking […] There are some strategic components, but most of it is coincidence in the end (Interview #9)." Therefore, there is a need for intermediary actors that can bridge the different focal points and knowledge bases. These could be the state-led operators or Windrove, but sustainable and stable growth of the ecosystem has yet to evolve.

(2) The ***value realization*** of the emerging technology such as the creation of business models and local experimentation. The three main concerns regarding the feasibility of the value proposition can be summarized as follows: creating certification and safety standards, receiving funding, and raising acceptance for scalable business cases. While there is a great uncertainty regarding the overall development path of the emerging technology, all actors involved can agree on a collective system-level output: the goal to lower entry barriers and allow the practical operation of AAM within defined legal frameworks. Only a few use cases succeeded in market creation so far. Those use cases are primarily limited to individual industrial applications. As a local operator highlights, "port- and intra-logistics play a big role as potential customers, but the solutions must be adapted for every case individually […] I would say, 50 % of the solutions are standardized, the other half is use-case specific (Interview #14)." This underlines the insecurity felt by all actors that there is no clear understanding of at what point AAM applications could ultimately create revenue in both logistics and passenger transport markets. This also leads to the fact that some actors must take higher risks or engage more in practical experimentation than others (Interview #1, #5, #9). Ecosystem actors with different sectoral backgrounds, such as energy management, are more resilient to a potential failure of AAM, as it is only a minor aspect of their portfolio (Interview #6).

(3) The initiation of ***partnerships and temporary applied projects*** that aim at the standardization of the technology, primarily regarding automation. Companies strive for applied research projects that provide space for experimentation. This involves both the direct participation of companies to deliver specific skills or resources into applied projects, as well as acting as an associated partner to benefit from the knowledge insights. In this regard, the ecosystem participants are especially interested in exchanging with the local and state authorities, as they will ultimately be the key actors to sensitize for the successful integration of AAM in the metropolitan area. National authorities and public-private operators also play a crucial role in most projects, as they can act as a bridge between the political and commercial sides of the development. Although closely tied to the discursive positioning of the topic, most projects did not lead to a long-term outcome. However, they can provide a necessary resource for human capital and unveil important stakeholders within the ecosystem. External actors, such as authorities and research facilities, act as users in this regard and can provide crucial knowledge about the current state of the technology and potential gaps in the socio-technical embedding.

(4) The importance of ***formal lawmaking***, which is exemplified by the dominant role of key authorities on the national scale. External actors are of high importance in this early stage of development as they provide particularly relevant legitimation strategies. Three key actors that have a strong influence on the current ecosystem legitimacy emergence are the EU/EASA, DFS (German air traffic control), and venture capitalists that engage with this technology. The EU pushed the topic of AAM greatly in the past years and encouraged cities to engage with the topic. While the general perception of the EU proposals is positive, there is also criticism of the overcomplicated bureaucracy in Europe and especially in Germany (Interview #1, #8). Companies refer primarily to the certification processes and the embeddedness in the existing air traffic. As a CEO states, "the DFS must fundamentally rethink their role with the flight operations of unmanned vehicles, the management of the platforms, bureaucracy […] Then on the second level are the state agencies: the integration of pilot projects, everything is just way too slow (Interview #1)." While companies criticize the slow embedding, agencies highlight that there are still essential technological gaps (Interview #2, #3, #17). This includes safety issues such as emergency landings, but also the routing and positioning of the flight trajectories. Commercial actors would often overlook these issues or leave them out of the overlaying discourse. The liability of newness is mitigated by acquiring funding, which highlights the trust of venture capitalists in the value proposition. However, this underscores the necessity for an efficient marketing and public relations strategy, as big investors remain crucial for entrepreneurs in this emerging field (Interview #1, #4, #9).

6. Discussion: ecosystem legitimacy emergence

Our theoretical framework followed by the empirical study delved into the context in which emerging entrepreneurial ecosystem participants work to overcome the liability of newness of their value proposition. Our central research question and sub-questions examine the structural composition of the ecosystem, the significant liabilities it faces, and how entrepreneurs strategically address these challenges. Firstly, we find that the role of actors from the public sector in ecosystem emergence is underestimated, as entrepreneurs in private companies and networking organizations must reach out to external actors to fulfill their aspired system-level output: the creation of a regulatory framework for operation. To strike the balance between the development of a regulatory framework and market creation, entrepreneurs must also bridge different sectoral knowledge bases, concerning aviation, artificial intelligence, and robotics. Secondly, global discourses and practices crucially influence local practices, while not rendering the local technological evolution irrelevant, which underscores the importance of considering the geographic dimension of legitimacy emergence in ecosystems. This is exemplified in the differentiation of drones and air taxis, two areas which, although they involve different mobility visions and key actors, overlap in terms of discourses and narratives surrounding the technologies. This way, our findings add to ongoing debates in the literature on importance of legitimation for emerging technologies and how they affect industries (Binz & Gong, 2022; Gong et al., 2022) and approaching ecosystems from a multi-scalar perspective considering the evolutionary stage of the ecosystem emergence (Alvedalen & Boschma, 2017; Thomas et al., 2022).

The EU, national, and local authorities, as external actors, do not play the attributed "peripheral role" in the ecosystem legitimation that Thomas and Ritala's (2022) conceptualization ascribes them. Not only do these state and public-sector actors possess central regulatory authority, which conditions the possibilities for performative legitimation, but they also act as key discursive legitimation actors in indicating future policies. For instance, public sector actors directly engage in legitimation efforts via governmental programs and grants that enable the emergence of new ecosystem orchestrators (e.g., Windrove as an initially EU-funded venture) and other participants. The analysis of Hamburg's AAM ecosystem reveals a somewhat "dual" role of public sector actors embedded in ecosystems that maintain a regulatory function while engaging in ecosystem orchestration. This is particularly exemplified by DFS, the Germany flight security, which is engaged in the ecosystem, but holds key regulatory capacities. Hence, we emphasize the need for a more differentiated perspective on how these actors are embedded within emerging ecosystems and the impact of pre-existing hierarchies. The interplay between acting as an orchestrator and regulator raises the question of how top-down policy directives may counteract the collective and voluntary nature of ecosystems. This adds to the conceptual literature considering not only the distinction of ecosystems from other forms of governance (Jacobides et al., 2018), but also how ecosystems are intertwined with and/or dependent on other governance forms. Moreover, it emphasizes the importance of ecosystems to seek and obtain legitimacy through new formal or informal institutions (Lange & Schmidt, 2021). From these empirical findings, we draw a

twofold implication for existing theoretical frameworks on ecosystem emergence: Firstly, existing frameworks need to place more emphasis on the identification of an orchestrator itself. In an emerging ecosystem, the roles of the actors are rarely defined in advance but emerge along with the ecosystem. Therefore, we need to consider what performative and discursive legitimation processes enable the identification of an orchestrator in the first place. We observe that the absence of an orchestrator poses numerous challenges to the creation of a common ecosystem identity. Secondly, the negotiation processes and conflicts within the ecosystem need to be highlighted. As expectations of AAM vary widely among ecosystem participants, emerging technologies may have limited acceptance (Kuratko et al., 2017) within the ecosystem itself. Therefore, ecosystem participants need to combine seemingly contradictory understandings of legitimacy, such as conformance (following existing rules) and creation for new beliefs, norms and values (Zimmerman and Zeitz, 2002). Understanding the creation of the actor constellations and early direction of the ecosystem thus requires the analysis of existing hierarchies that impact or guide the development, raising future research questions: How do ecosystems co-evolve with other organizational and spatial phenomena like clusters or regional innovation systems? And can organic constellations like ecosystems establish without any hierarchical dependency beforehand? Besides, our findings point to a stronger consideration of institutionalist perspectives on ecosystem emergence, raising the following future research questions: How do regulators and external actors shape and constrain emerging ecosystems? To what extent do they provide orchestrating activities like framing or value realization?

Global and national discourses regarding local technological development and regulatory conditions play a pivotal role in shaping the legitimation strategies of the local ecosystem. The international landscape and trans-local competition significantly influence perceptions of what constitutes a viable value proposition within the ecosystem. In the case of Hamburg, the ecosystem's decision to prioritize AAM for cargo transport, despite its aviation origins that could lead to the development of air taxis, exemplifies a seemingly counterintuitive approach. This choice stems from an awareness of the substantial challenges and liabilities associated with advancing AAM primarily for passenger transport that were particularly highlighted by entrepreneurs during our research. Hence, our analysis illustrates how the innovation process of local validation (Kuratko et al., 2017) and the promotion of acceptance and comprehensibility (Thomas & Ritala, 2022) is strongly affected by overlaying discourses that are not necessarily and directly tied to the local ecosystem. Authorities insist on stringent safety guarantees before certification, and air taxis are often perceived as providing tangible benefits only to the financial elites that can cover the high costs. This underscores the need for further exploration of new research questions concerning the roles of institutional players at different scales within the ecosystem. Moreover, as emphasized in our results, the discursive legitimation is strongly affected by the lack of an orchestrator in the current emerging ecosystem. While there are orchestrating activities by some key actors (such as Windrove), no local actor was so far able to cover all necessary competencies towards the development of a regulatory framework. This raises questions about the idealized central role of the entrepreneurial ecosystem's orchestrator within such a regulation-dependent context.

Ultimately, the case of advanced air mobility (AAM) underscores the cross-sectoral nature of emerging entrepreneurial ecosystems, originating from both aviation and robotics. This recombination of previously unfamiliar knowledge bases fosters a dynamic environment for research, spillover effects, and experimentation. However, it necessitates intricate stakeholder management, continuous negotiation processes that collaboratively define the ecosystem's identity and joint value proposition. Therefore, the industry-agnostic nature of ecosystems (Autio et al., 2018) can become a challenge for entrepreneurs, as it challenges existing expectations of the innovation. So far, our empirical analysis indicates that overlaps between these different knowledge bases are not fully developed and that the entrepreneurial perceptions rely strongly on the industrial background of the individual. This has significant theoretical implications, in particular a deeper understanding of legitimation processes of emerging technologies and their co-evolution with industrial path development. Further research could explore how the legitimation of emerging ecosystems reshapes socio-technical configurations (such as the influence of AAM on the aviation sector), thereby strengthening the direct link between entrepreneurial ecosystems and evolutionary economic geography. It also calls for a stronger integration of industrial characteristics (such as established regulatory conditions, labor market, or ongoing transformations) and their influence on the performative and discursive dimensions of legitimation processes. Partnerships that exceed these boundaries primarily exist in the context of applied research projects. However, this dialogue remains challenging and causes different perceptions of project outcomes, as illustrated by the Medifly project. The influence of the ecosystem on promoting new ventures and demonstrate their value propositions (Bouncken & Kraus, 2022; Thomas & Ritala, 2022) remains the main performative legitimacy challenge towards the integration of AAM. We have observed that pilot projects are crucial for shaping the field and advancing the ecosystem, as they serve as key tools in German research policy for testing and integrating new technologies. This shifts the responsibility away from purely market-driven integration and highlights the need for a better understanding, or even typology, of how public actors can orchestrate activities or take on the role of orchestrator within the entrepreneurial ecosystem. These findings call for a more nuanced and rigorous analysis of the (social, technological, and systemic) preconditions that affect the emergence of the ecosystem. This raises questions such as: To what extent can experimental settings (such as pilot projects, living labs) bridge existing knowledge bases and contribute to legitimacy emergence on a local scale?

7. Conclusion

The goal of this article is to provide insights into the legitimation process of emerging ecosystems. For this purpose, we analyze the ecosystem legitimacy emergence in the case of AAM in Hamburg. With our insights from network analysis, expert interviews, and project participation, we identify key actors of the emerging ecosystem and present the discursive and performative legitimation strategies of the involved participants to reduce their liability of newness. The case of AAM in Hamburg shows us that while there are local dynamics and an aspired collective system-level output, non-local actors and discourses greatly influence the overall development. This circumstance is reflected particularly in the dominant role of public organizations and state-owned companies, which have a decisive impact on the emergence of the ecosystem. In this regard, they serve as regulators and provide (initial) orchestrating activities at the same time. AAM is surrounded by multiple discourses and uncertainties, where independent ecosystems can potentially strengthen local and civil interests. This is exemplified in the distinction between drones and air taxis that, despite their technological differences, share many narratives, which makes it more complex to develop a collective understanding of the ecosystem identity. However, the participants wish for a leader/mediator who can fulfill this missing role of an orchestrator.

The paper is limited to a single case study. Our knowledge on ecosystem legitimacy emergence is context-specific and draws primarily from a particular economic and geographic context. Nevertheless, we point out aspects that are particularly relevant for researchers that engage with mobility transitions and new technologies that face liabilities of newness. This applies specifically to the implications of regulatory change, the global ties of local ecosystems, and the orchestrating activities of external actors such as national agencies and authorities. Therefore, our single case study on the legitimation of emerging technologies contributes to the understanding of the interdependency between (bottom-up) ecosystem emergence, entrepreneurial actions and

how they are linked to (top-down) regulatory change. There is a lack of empirical evidence on emerging technologies, such as AAM, that emerge in the context of Industry 4.0 and transcend existing industrial backgrounds. Existing conceptual frameworks remain too static in their understanding of actor roles (such as the definition of an orchestrator) to fully capture these dynamic constellations. The shift in innovation policy, where public actors take a leading role in defining goals and driving an innovation process, such as Hamburg's high ambitions for AAM, highlights the need for a more nuanced understanding of the entrepreneurs driving these developments. This entails further insights on the institutional change and power relation within but especially beyond the scope of the ecosystem, as they can fundamentally affect the evolution of the ecosystem in early stages. Overarching institutional change takes place mainly between the development of formal regulatory frameworks and the informal discourses around AAM. However, certain state-owned enterprises maintain a monopoly on the definition of these institutions, making it difficult for the ecosystem to rely on its bottom-up nature as it needs to expand its reach beyond the local level. Ultimately, these circumstances contribute to the lack of a collective identity within the ecosystem.

The developments in the Hamburg AAM ecosystem highlight the necessity of defining a clear legal framework for operation and the mediation between several actors with varying interests. As a policy and business recommendation of the present study, it becomes apparent that entrepreneurs, especially in start-ups, wish for a platform where they can raise questions and have direct contact to relevant policymakers. Agencies should therefore incorporate the wishes and concerns of the entrepreneurial side into their planning at an early stage to not treat the processes of defining a regulatory framework and market creation separately, but at best contribute to the idea of a joint co-creation. Once this legal framework is established, it is reasonable to expect that the structures, as well as the competition within and between emerging ecosystems, will be renegotiated. Therefore, the case of AAM provides a promising case for future research on the temporal and evolutionary aspects of innovation processes. This accounts for cross-sectoral interdependencies between existing sectors like aviation and growing technologies like artificial intelligence. This diversity creates a high potential for innovative development, but it also raises barriers that must be overcome for these new approaches to be adequately legitimized.

CRediT authorship contribution statement

Tim Fraske: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Filipe Mello Rose:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Conceptualization. **Niloufar Vadiati:** Writing – review & editing, Writing – original draft, Validation, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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