PEGIS

Papers in Economic Geography and Innovation Studies

2022/02

Change agency and path creation toward future transport systems: A case study of the emerging urban air mobility in Germany

Tim Fraske

University of Vienna | Vienna University of Economics and Business | Austrian Academy of Sciences | University of Agder | Kiel University

Change agency and path creation toward future transport systems: A case study of the emerging urban air mobility in Germany

Tim Fraske[1,2]

[1] Department of Geography, Kiel University

[2] Digital City Science, HafenCity University Hamburg

E-Mail: tim.fraske@posteo.net

ORCID: http://orcid.org/0000-0002-9360-6460

Abstract: The transformation toward the fourth industrial revolution leads to multi-scalar changes for existing socio-technical systems. "Smart mobility" innovations, such as autonomous vehicles or the Internet of Things, challenge existing transport regimes. This raises questions regarding the embeddedness and accessibility of these innovations and the interdependence of practices and structural change. The goal of this paper is to gain deeper insights into the interplay of change agency and path creation in early Mobility 4.0 evolution. The academic debate on the geography of transitions has gained much attention in recent years, but the role of new emerging industries in the context of digitalization remains understudied. This case study investigates the emerging urban air mobility sector in Germany, including qualitative insights from companies and five regional cluster initiatives. This paper finds that cross-sectoral and institutional dynamics toward the creation of use-cases challenge the socio-technical integration of this new mobility form and create an ambivalent environment of insecurity and high expectations. A few innovative entrepreneurs play a pioneering role in technological development. While EU proposals guide the creation of formal institutions, place-based leadership emerges alongside existing regional preconditions. When analyzing the interconnection between structural change and agency, geographers must emphasize the necessity of a more technologically differentiated and actor-centered approach.

Keywords: evolutionary economic geography, Industry 4.0, urban mobility, regional development, opportunity spaces

This is a pre-print version of a paper that will be submitted for publication to a journal.

1. Introduction

The academic debate about the role of actors and agency for regional development has gained increasing attention in recent years (Boschma, 2017; Grillitsch & Sotarauta, 2020; Steen, 2016). While evolutionary economic geography (EEG) assumes that regional capabilities and structural preconditions impact future path development, there is a growing interest in understanding how activities on the micro-scale of spatial change, such as individual decision-making and practice change, influence the directions of path creation. As path creation toward the generation of novelty is a dynamic and irreversible process (Boschma & Martin, 2007), understanding micro-level phenomena is crucial to explaining the spatial dimension of structural change as well. Grillitsch and Sotarauta (2020) propose the concept of the trinity of change agency, which relies on three distinct theoretical approaches to understanding entrepreneurial activities, namely innovative entrepreneurship, institutional entrepreneurship, and place-based leadership. This paper builds on recent contributions to the topic of emerging industries, institutions, legitimacy, and agency (Gong et al., 2022). I examine the case of the evolving urban air mobility (UAM) in Germany, using the proposed trinity of change agency as a conceptual framework for the analysis. The article strengthens the role of actors and agency for early path creation in the context of Mobility 4.0 innovations that challenge existing socio-technical regimes. Digital technologies enforce the emergence of new industries as well as the recombination of existing knowledge bases. Thus, spatial relationships, both technological and societal, change alongside these transformations. Regarding fundamentally new solutions like artificial intelligence (AI) or the Internet of Things (IoT), it has become a growing challenge for geographers to understand the interconnections between technological characteristics and regional development (Fraske & Bienzeisler, 2020; Gherhes et al., 2022; Njøs et al., 2020). Until now, there have been few empirical studies that provide insights into these developments. Instead of considering the overarching narrative of Industry 4.0 only, geographers need to develop a more differentiated understanding of the specific technologies, their evolutionary background, and their use case scenarios (Fraske, 2022). Therefore, this study addresses the following question:

How can the trinity of change agency contribute to the understanding of path creation toward urban air mobility?

As evolutionary economics generally focuses on historical processes (Geels, 2002; Henning, 2019), it is important to not run short of understanding fast-paced innovations, especially considering digitalization. So far, the literature on path creation pays little attention to the question of time-specific dimensions of agency (Grillitsch et al., 2022; Micek et al., 2022,). However, this gap offers an important linkage to ongoing debates about windows of opportunity for socio-technical transitions and their spatial dimension. Moreover, it is crucial to examine multi-scalar and cross-sectoral factors of socio-technical change. Industry 4.0 is often not characterized by single industries but by strong spillover effects. This aspect touches frequent debates among economic geographers, such as regional diversification (Boschma et al., 2017), practice change in socio-technical transitions (Fastenrath & Braun, 2018), or co-

evolution (Gong & Hassink, 2019). Besides, a perspective on multi-system interactions across seemingly unrelated sectors encourages a more differentiated understanding of transitions and pays attention to the multi-scalar qualities of socio-technical systems (Rosenbloom, 2020).

Geography has a historical interest in the analysis of innovations and their linkages to structural change. Socio-technical transitions come along with new industrial formations and spatial arrangements. The geography of transport systems covers several conceptual dimensions, including but not limited to networks, urban transportation, and environmental impact (Rodrigue, 2020). Transport systems have a historical impact on industrial paradigm shifts and vice versa, as they not only adapt to new innovations but also build the foundation for new value chains, infrastructural upgrading, and social change. Future transport systems comprise different solutions and narratives alongside the overlaying transformations toward digitalization and sustainability, such as e-mobility (Späth et al., 2016), hydrogen fuel (Ahmed et al., 2016), or automated vehicles (Milakis et al., 2018). The evolution of UAM joins this continuous change in mobility and offers the potential to be one of the central paradigm shifts for transport in the coming years. Thus, the development requires system-building activities that address multilevel lobbying and regulatory change (Uyarra & Flanagan, 2022). As cities seek solutions that relieve ground-based transport and environmental issues, technological developers push the idea of new business cases for both cargo and passenger transport. Entrepreneurs must use multi-scalar approaches to fulfill different roles of entrepreneurial activity to provide space for experimentation, address the policy discourse, and position their solutions within an existing socio-technical regime.

The paper is structured as follows: In the second chapter, I provide an initial overview of the current development and definition of UAM, including use case scenarios and descriptive insights from the sector in Germany. In the next chapter, I will describe the theoretical framework of this case study, based on the trinity of change agency and path creation from an evolutionary perspective. Chapter four gives an overview of the methodological approach. Subsequently, chapter five provides a comprehensive analysis and discussion of the examined case. Finally, I will conclude with the findings of this case study.

2. Urban air mobility – toward a new form of transport?

Urbanization and sustainability transitions 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 UAM. The various use case scenarios can be divided into two core aspects: the transport of goods or materials with cargo drones and passenger transport with air taxis.

The academic literature on the topic is primarily techno-centric or business-oriented with several open research agendas (Straubinger et al., 2020; Sun et al., 2021), while only few contributions address urban studies or explicit socio-technical research (Mavraj et al., 2022). Early concepts and imaginations of air taxis or flying cars go a long way back until the early 1910s. However, they never reached commercial

viability or sufficient market creation in the last century (Cohen et al., 2021). The topic greatly re-emerged in the last decade, starting with a strong focus on cargo drones and quickly expanding its narrative and experimentation to passenger transport. These various use case scenarios create a fragmented landscape development, with expectations, objectives, and visions differing significantly among the actors involved. Besides, regulations and expectations also vary spatially, which makes it important to understand the territory and societal context for tackling the long-term risks (Nneji et al., 2017).

UAM encompasses different concepts, vehicle types, functionalities, and use case scenarios. A comprehensive examination of the technological definitions would be out of scope in this case study. Unmanned aerial vehicle (UAV) refers to the actual vehicles that are developed for operations, such as drones or air taxis, whereas unmanned aircraft system (UAS) refers to the overall systems that enable the operations, such as communication, AI, IoT, or big data applications (Cohen et al., 2021). Generally, drones or air taxis concepts differ in their propulsion, design, technology (e. g. vertical or short-runway takeoff), capacity, range, autonomy, and compatibility with existing infrastructure and operational systems (Cohen et al., 2021; Thipphavong et al., 2018). The technological characteristics closely co-evolve with the associated use case scenarios. The smaller cargo drones primarily address the necessary payload for specific types of logistics, while air taxis aim for an efficient combination of reach, energy management, and passenger seats for commercial viability. However, only a few technological configurations ultimately lead to practical use. New propulsion forms like battery electric or hydrogen expand the technological possibilities and revive some of the older approaches (Thipphavong et al., 2018). Today, over 200 different concepts for passenger drones exist, with twelve prototypes for upcoming certification (VUL, 2021). In Germany, there are three leading air taxi companies: Airbus Urban Mobility, Volocopter, and Lilium. So far, these companies account for the highest media coverage on a national level, e. g. Volocopter is planning the first European air taxi routes for the Olympic Games 2024 in Paris.

A recent industrial market research study by the German Unmanned Aviation Association (VUL) identifies quantitative characteristics of the German UAM market (VUL, 2021). Today, over 430.000 drones are in practical use, with a total market volume of 840 million €. The commercial market only accommodates 10% of the drones but creates nearly 90% of the sales. There are around 400 companies focusing on UAM technology with a strong start-up culture. In terms of industrial applications, it becomes apparent that transport is only a small fraction so far (5%), with measuring and inspection being the most frequent application fields.

Besides, high volumes of venture capital mark the UAM sector, especially in air taxi development. In 2020 and 2021, investors put over 5 billion $ in the nascent sector. Six companies alone account for 4.6 billion $ of the investments including Volocopter and Lilium. This is ten times as much as in the ten years before and stresses the risk that the valuation runs out technological maturity too fast

(Shaposhnikov, 2021). Subsequently, air taxis greatly accelerated the discourse and development toward UAM, raising the question of whether this development overwhelms smaller drone developers, or whether they can potentially benefit from it.

Despite the hype that surrounds this new mobility form, the sector is still rather small. Since surveillance, maintenance, or photography have lower entry barriers and socio-technical regime structures in transport are way more complex, most companies address the transport sector only partially or in a specified way. Practical integration is so far hindered by capacity problems (compared to cargo vans), social acceptance, demand, and primarily the lack of regulations in Germany and Europe. The European Union Aviation Safety Agency (EASA, 2021a) highlights noise, safety, privacy, community or self-benefits, visual annoyance, and environmental impact as the most critical societal acceptance factors. Therefore, companies with a cargo focus shift their perspective from UAM as a solution for last-mile city logistics to different use cases, e. g. critical-time logistics (healthcare, maintenance & repair), regional logistics (urban-rural connections), or business to business deliveries. Figure 1 provides an overview of potential transport use case scenarios for UAM.

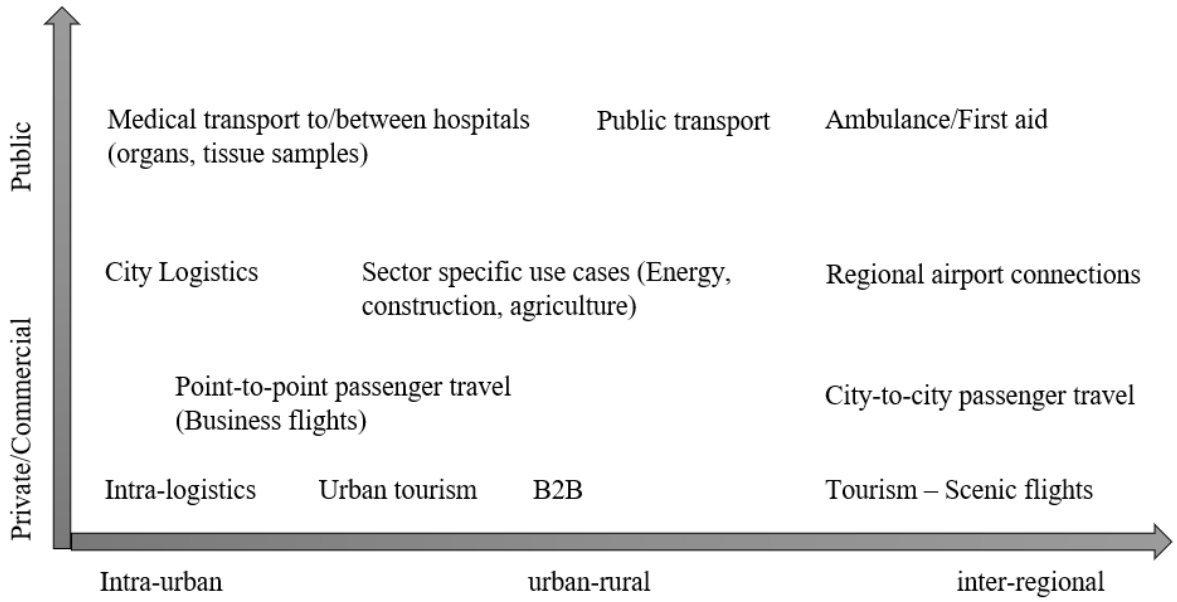

Figure 1: UAM use case scenarios for transportation, own elaboration

The spatial dimension of the specific use cases also defines the competition with other mobility forms. Private intra-urban passenger flights would therefore primarily compete with taxis or the subway, while regional or city-to-city flights would challenge (high-speed) trains or intercity bus services. Moreover, UAM can create fundamentally new business models, like air taxi tourism or sector specific logistics operations. The opportunities for different use cases are also dependent on the societal, political, and topographic conditions of a region. Aside from acceptance and business cases, UAM requires ground-based infrastructures for maintenance, take-off, and landing (so called vertiports or vertihubs), which presents urban planners with the challenge of efficiently integrating this new mobility form. UAM enters

an urban space that is already characterized by existing fields of conflict, such as sustainability issues, additional land sealing, social inequality, or demographic change.

The financial, societal, and environmental risks of this new mobility form underline the necessity of a careful and participative approach by the involved actors. UAM will have to justify its ambiguities and highlight its usefulness to a broad range of different stakeholders and civil society if it ultimately aims to contribute to the pluralistic mobility of this century. This unique challenge of forming a new paradigm of transport places enormous pressure on all involved actors, both commercial and societal, in defining a common sense, a sufficient balance between technology and societal needs, and legal frameworks for an efficient operation system.

3. Theoretical background

Gregory et al. (2011) define human agency as "the ability of people to act, usually regarded as emerging from consciously held intentions and resulting in observable effects in the human world." While reproductive human agency tries to maintain the status-quo, transformative agency tries to break with existing paradigms and establish novelties in existing development paths (Coe & Jordhus-Lier, 2011). Insights from research on ecosystems and agency stress the fact that, besides innovative economic activities, there needs to be a stronger emphasis on behavioral and cultural dimensions of agency to strengthen entrepreneurship that leads to transformative renewal (Huggins & Thompson, 2019). Therefore, we need to deepen our theoretical understanding of how a more differentiated perspective on entrepreneurship and the initiation of new breakthrough technologies can explain path creation. This encompasses the role of geography and the time-, place-, and scale-specific dimensions. This case study draws from recent conceptual debates in EEG and specifically refers to the trinity of change agency (Grillitsch & Sotarauta, 2020) as a conceptual framework.

3.1 The role of agency in evolutionary economic geography

There is a growing interest by evolutionary economic geographers to broaden their perspective toward a more sophisticated analysis of the micro-scale of structural change. EEG puts a strong emphasis on sectoral relatedness, unrelated variety, and path-dependency in industrial development (Boschma & Frenken, 2006; Frenken et al., 2007), but it runs short of explaining how innovations emerge and enter existing socio-technical regimes (Njøs et al., 2020). Boschma (2017) points out that EEG often ignores micro-level phenomena regarding path creation and why some regions are more successful than others despite similar preconditions. Moreover, Njøs et al. (2020) criticize EEG for the lack of theoretical and analytical clarity regarding technological characteristics and how they shape new paths for industrial development. Research on Industry 4.0 reflects this criticism, as there are few forerunners who create novelty, and new digital technologies often require a vast amount of co-learning between civil society, entrepreneurs, and other policy actors. This highlights the relevance of an evolutionary geographic perspective that does not remain on a superficial level of micro-level analysis but puts a stronger

emphasis on purposeful and meaningful decisions by actors that create both intentional and unintentional outcomes (Grillitsch & Sotarauta, 2020). Cities can become powerful promoters of technological transitions, as they provide crucial resources for successful innovation processes (Truffer & Coenen, 2012). Such examples of urban tech or urban living labs cluster primarily in specialized regions that are tied to the innovation capabilities of metropolitan areas (Florida et al., 2017). One question that remains is to what extent such local experiments can scale and leave their initial geographic context (Turnheim et al., 2018).

The role of agency and its relation to structure is still regarded as a "blind spot" (Grillitsch & Sotarauta, 2020), that results in an insufficient understanding of how technologies evolve geographically. While some authors criticize EEG for a lack of understanding of green industries and path creation toward sustainability (Grillitsch & Hansen, 2019; Trippl et al., 2020), the same shortcoming emerges for the innovation development toward Industry 4.0 and digital technologies. While neighboring disciplines account for most of the empirical research on that topic so far, there is also a strong leaning toward quantitative approaches and a lack of sector-specific research. This perspective falls short of explaining technological differentiation and its impact on regional development (Fraske, 2022). Therefore, a comprehensive perspective on micro-scale actions is important to better understand the impact of new technologies on structural change.

3.2 The trinity of change agency for path creation

To bridge the theoretical understanding of regional development and transformative agency, Grillitsch and Sotarauta (2020) propose the trinity of change agency as a holistic approach to study human agency from a geographical perspective. It relies on the understanding of three different approaches to understand entrepreneurship: innovative entrepreneurship, institutional entrepreneurship, and place-based leadership. The idea of innovative entrepreneurship goes back to the initial works of Schumpeter (1911), who was the first to highlight the role of intentional actions by individual actors for path-breaking economic development and how actors combine knowledge resources in novel ways. Generally, this type of entrepreneurship aims toward the discovery and exploitation of opportunities to create value and work toward new industrial specializations, also including unexpected outcomes of actions (Grillitsch & Sotarauta, 2020). Entrepreneurs therefore need to provide the willingness to create something fundamentally new (Schumpeter, 1911). Schumpeter distinguishes between economic actions that, firstly, are based on past experiences and rely on market and technological knowledge and, secondly, those that are driven by a belief in future opportunities (Grillitsch & Sotarauta, 2020). Digital innovations often rely on both incremental and radical types of innovations, as they combine existing structural preconditions with breakthrough approaches that ultimately create new business models and technological settings. This reflects in the development of autonomous cars by combining existing knowledge from the automotive sector with robotics, AI, and IoT.

However, economic actions are not limited to a purely innovative outcome but contain a mutual connection to institutional change (Granovetter, 1985). Therefore, institutional entrepreneurship defines the second type of agency, referring to actions toward transforming or creating formal and informal institutions that are crucial for regional development (Grillitsch & Sotarauta, 2020). Institutions refer to the question of how social practices shape the entrepreneurial environment. In terms of regional development and economic geography, this addresses rules and regulations as well as economic, political, social, and educational organizations (Grillitsch & Sotarauta, 2020; Storper, 1997). Moreover, institutions can be divided into formal or "written" institutions as well as informal institutions, which can be described as "specific legitimate patterns of interactions displayed at the localized level of agency" (Glückler & Bathelt, 2017). The importance of institutions becomes apparent with a perspective on mobility in general, as technological infrastructures, social practices, and traffic management intertwine in various ways and create a unique but sensitive environment for innovation. New transport systems reflect this institutional change. Firstly, formal institutions like legal frameworks for system integration need to be adjusted. In terms of UAM, this includes legislative redefinitions of airspace, rules for operation and certification of new vehicle types, as well as rules for integration alongside existing infrastructures. Secondly, new forms of transport enter a sensitive and complex environment where several actors are embedded in the same place and must address new practices that come with the use of a new mobility form. In the initial development, this especially accounts for the legitimacy, social acceptance, and how entrepreneurs can enforce an integration that highlights the potential benefits instead of strengthening existing inequalities or pessimistic expectations.

Finally, the role of place-based leadership refers to the role of key actors and how they can benefit from regional preconditions and vice versa. This type of agency aims at efficient networking, bringing competencies, powers, and resources together and therefore strengthening the individual and regional objectives (Sotarauta, 2016). Besides regional preconditions, some authors highlight the importance of global linkages to access extra-regional knowledge (Isaksen & Trippl, 2017; Saxenian & Sabel, 2008). Besides accessing collective resources on a regional level, it is crucial for innovative entrepreneurs to address regional disadvantages or build up missing resources (Grillitsch & Sotarauta, 2020). The evolution of new industries is often tied to new policy initiatives, which try to bundle competencies in proactive networks and accelerate the development of industrial clusters, research, and forerunner projects.

The interplay of this trinity of change agency provides a holistic understanding of how new path creation can evolve and bridge novelty with existing structural patterns. A common concept is the idea of opportunity spaces, which bridge the socio-technical niches with the regimes and enable a novelty to enter new systems (Perez & Soete, 1988; Tyre & Orlikowski, 1994). Grillitsch and Sotarauta (2020) understand opportunity spaces as mediators between the trinity of change agency and structure, as actors

are embedded in specific opportunity spaces. They define three different dimensions of opportunity spaces:

(1) Time-specific opportunity spaces are defined by the knowledge, institutions, and resources at a specific moment in time.
(2) Region-specific opportunity spaces are determined by the regional preconditions.
(3) Agent-specific opportunity spaces are provided by the capabilities of individual agents to make a change.

When analyzing agency empirically, researchers must consider some methodological challenges to ensure a clear definition of the aim and scope of the research (Grillitsch et al., 2021). This case study wants to put an emphasis on the emerging UAM sector in Germany. As empirical studies on the micro-level level of human agency focus down to the actual individuals, it is also crucial to acknowledge the importance of organizations, groups, or networks (Grillitsch & Sotarauta, 2020). UAM illustrates this circumstance, as the embedding of new legal frameworks is tied to the competences of certain authorities in planning and mobility policy. Besides, many governments enforce these mission-driven innovations by defining urban agendas and funding programs to provide a beneficial environment for path creation. Small groups of cooperating actors often initiate pilot projects that shape business models as well as the early perception of society. Therefore, it is crucial to identify both key actors at the individual and organizational level and highlight the interplay between these two scales of human agency. This perspective also includes an understanding of the social acceptance of modern technologies, especially if they are embedded in the everyday lives of a population. The next chapter will provide an overview of the methodological approach and sources of information for this case study.

4. Methodological approach

The case study follows a qualitative research approach. Table 1 summarizes the sources of this methodology. The primary sources of empirical work have been materialized by conducting expert interviews with companies and cluster initiatives that are involved in the development of the UAM sector. The interviews were conducted between March and May 2022. The included companies must fulfill at least one of the following criteria: (1) produce, develop, or operate transport drones or air taxis, (2) create necessary hard- or software platforms or associated technologies for UAM, (3) participate in UAM research projects or living labs. The interview partners were either CEOs or in a leading role within the company, like business managers or strategic developers. Most interviews were held in German and were subsequently translated. Due to the early development of the sector, it is crucial to gain insights from different perspectives of the emerging value chain, the respective actors, and their knowledge backgrounds. I identified potential interviewees through existing networks, public documents, search engines, and snowball sampling during the interviews.

Source	Scope
Expert interviews	22 interviewees from 19 organizations - 14 companies: five UAV/UAS developers, seven system- and service- providers, two consulting companies - Five cluster initiatives from different regions
Project involvement	Insights from a project dealing with scenario development for UAM in the Hamburg metropolitan area. Insights include primarily: - Exchange with various actors, e. g. municipality, local networks, and research and development (local universities, German Aerospace Center) - Review of existing literature and own previous work on the topic
Public documents	Policy agendas and legal frameworks from European, national, and municipal authorities and industrial market research
Media coverage	Articles on current developments, emerging use cases, and press interviews

Table 1: Sources of the case study

Moreover, I am part of a project that deals with scenario development for UAM and have conducted previous work on the topic, including but not limited to two systematic literature reviews regarding ground-based infrastructure for UAM (Mavraj et al., 2022) as well as the geographies of Industry 4.0 (Fraske, 2022). Secondary sources are accessible public documents and press releases that provide insights on policy agendas, legal frameworks, and current developments in the evolving sector. Publications that deserve special mention are the latest agendas provided by the EASA, especially the proposal for the implementation of U-spaces in Europe (EASA, 2021b), social acceptance studies (EASA, 2021a), policy guidelines (UIC2, 2021), as well as industrial market research (Reiche et al., 2018; VUL, 2021).

5. UAM path creation - The case of Germany

In the following, I analyze the current socio-technical development of UAM in Germany based on the theoretical framework of change agency and path creation. Firstly, I provide insights on the market creation process from an innovative entrepreneurship perspective and how developers try to enter and create opportunity spaces for UAM. Secondly, I discuss the institutional dimension with an emphasis on multi-scalar dynamics for framing rules, laws, and legitimacy toward the new mobility form. Thirdly, I identify place-based leaders for path creation with a focus on five regional cluster initiatives.

5.1 Innovative entrepreneurship – Emerging markets and opportunity spaces

The nascent topic of UAM forces companies to fulfill several requirements across the value chain. Thus, most companies have a clear understanding of their primary goal or sectoral identification, but they often must provide additional serves or operational tasks since there are no established external partners available yet. The qualification of the entrepreneurs often defines the self-image of the company. In general, most interviewees describe the market as very untransparent yet, both referring to competitors as well as potential partners. Many firms conducted their own initial market research to sharpen their

focus and understanding of the solutions. However, there is a fundamental distinction in the background of the companies involved in the development of UAM. While one group of actors has their background in the traditional aviation sector, the other addresses the topic from a mechanical engineering perspective, primarily from the automotive sector but also Industry 4.0 robotics like AI and IoT. At first glance, this difference becomes apparent in the pure definition of what UAVs are. While actors with an aviation background understand them basically as another form of aircraft, entrepreneurs from robotics highlight significant differences in these understandings:

"Basically, we consider drones as one more sensor in the industry that is not wired. […] How do we break the existing "encrusted" structures of manned aviation that they can arrange with these new IoT devices as well? […] Our aim is to make flying itself a minor thing. Many people from aviation have so much fun flying that they sometimes forget that it is only a means to an end."

(Business developer, Interview 6, 2022)

This statement also reflects a common criticism that companies without linkages to aviation highlight, as the sector is regarded as locked in conservative approaches and a lack of innovative creativity. Actors with a background in automotive strongly refer to the flying car narrative and share grand expectations for UAM in the context of individual transportation:

"In the modal split of the future, UAM 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. […] In the aviation industry, they are used to subsidies, but there will be none for UAM. […] As for economies of scale, only automotives are self-sustaining today, aviation has never accomplished that."

(CEO, Interview 10, 2022)

Besides the argument of cost-efficiency and being commercially viable without state-funding, actors highlight knowledge spillovers regarding automation and E-mobility from the automotive sector as very supportive for the development of UAVs. In general, entrepreneurs agree that software for automation is the key aspect in terms of technological development. It provides scalability of the solution and the possibility to transfer an idea to different use cases, even those that may still be unknown. However, it also poses the greatest risk to young companies, as they experience that an insufficient automation system is one of the strongest selection criteria in the current market.

In contrast, actors from the aviation industry also highlight several critical issues regarding the development of UAM outside of the traditional boundaries of the sector. Aviation engineers point out the lack of technical detailing, consideration of certification, and understanding of the aerospace context. They criticize concepts by new UAM developers as generic and emphasize the general criticism that the hype outruns the practical advancements:

"The use case is sometimes counteracted when one applies the external constraints and tries to provide solutions for them, e. g. overflying sensitive areas, noise, safety. […] And suddenly, when these factors are considered, the time savings are lost as the main driver. […] To align the expectations with the realistic opportunities could lead to the fact that concepts then no longer appear to be as great as they did on paper." [COO, Interview 9, 2022)

This statement underlines the necessity and benefits of intermediary actors, who support the technological development from the outside. Consultants and service providers seem to benefit most from the knowledge gap between these two approaches, as they can provide crucial networking activities and initiate co-learning practices. As networking, certification, and basic understanding of the stakeholder environment are crucial tasks for entrepreneurs, they seek for external knowledge sources. Actors from automotive are particularly interested in understanding the value chain and institutional activities, which will be even more important in the case of mass production.

Although this diverse environment provides a great source for new cooperation and technological recombination, there is also a critical stance by aviation actors on the hype surrounding the development of UAM:

"The challenge I see here, is that a lot of market players are not from aviation. That's good in one way, but they don't have the sensitivity to the probability of failure. Everyone wants to make a car fly. […] The most critical inexperience in this market comes from the huge hype of advanced UAM. […] Promise the impossible and take the money for it." (CEO, Interview 11, 2022)

This highlights the second apparent distinction between the expectations and advancements of the sector, namely between cargo drone focused companies and air taxi developers. Since logistics has the lower entry barrier, most air taxi developers also address cargo use case scenarios. The interviewees have a differing opinion on how cargo and passenger transport developments are related in terms of actors and innovation. At the interface of the aviation and robotics background, they ultimately share the same operational constraints, legal frameworks, and service providers. On the contrary, they differ in the actual markets, the initiating actors, and the socio-technical environment, which is often described as fundamentally different:

"Air taxis and transport drones are two different planets, with completely different players and customers. […] As a car manufacturer, it is en vogue to deal with air taxis. […] I see this topic very critically: Let´s assume they can´t keep their promises in ten years. Then we have a Wirecard case. […] I see the danger of a bubble bursting […] when Silicon Valley and venture capitalists withdraw because they lost a lot of money. Then the whole industry, including our sweet small drone industry, will have a problem." (CEO, Interview 1, 2022)

Despite their technological specifications and own network environment, both use case scenarios share the same narrative and, therefore, are also dependent on the perception of each other. The most crucial questions for scenario building for most companies are, therefore: What can we accomplish? What are we allowed to do and where? And what are the viable solutions?

As the entry barriers also differ greatly, innovative entrepreneurs need to constantly review current market developments and new emerging application fields. Their economic activities need to be aware of public perception and fast-paced market dynamics to successfully create or enter windows of opportunity and accelerate commercial adaptation. Most applied projects are "*driven by the opportunity itself*" (CEO, Interview 8, 2022) rather than by strategic planning or clear intentions, which highlights the importance of networking and force encounters to uncover unknown capabilities. The development of UAM use cases stresses the importance of co-evolution and multi-system interactions for path creation, since all embedded stakeholders are dependent on co-learning from each other to unveil the full potential – both societal and technological.

Another mentionable knowledge source for innovative entrepreneurs are linkages to the arms and defense industry, as a lot of technological concepts started in a military context first before they were transferred to civil use cases. However, there is also a current demand for transport related use cases for armed forces. Some companies maintain ongoing contact to military development, but they address this in a very cautious manner, as they know about the potential drawbacks in an already sensitive debate.

Most interviewed companies started their UAM development between 2015 and 2017. The time windows of the opportunity spaces are strongly reliant on EU guidelines and funding programs. They define the temporary dimensions of the development and when to expect viable use case scenarios. System-providers take this into account when developing operational systems for traffic management:

> *"There is the milestone 2023 when it comes to the first U-Space integration. Then we must be ready with certification and everything that goes along with it. […] The objectives move with the political side."* (Product manager, Interview 2, 2022)

Moreover, most actors highlight the Covid-19 pandemic as a disruptive element. Especially the aviation industry suffered under the lockdowns, and UAM projects were among the first to stop to absorb the negative impacts. In addition, the war in Ukraine provides a challenge for UAV manufacturers, as some supply chains have been significantly delayed, which ultimately slows down prototyping enormously.

In the current socio-technical development, the availability of venture capitalists and cooperation to initiate pilot projects define agent-specific opportunity spaces. Forerunners on a micro-level as well as big players are crucial to bringing the topic forward. However, there is a discrepancy about how small actors can address bureaucratic issues in comparison to established actors who already have the internal structures for legal development. Moreover, patents play an important part for young companies, as solutions are often very specific, and software is the key aspect of a unique selling proposition:

"As a small company, patents are, of course, a good way to distinguish yourself from the big players. […] So far, they (big player) are doing their thing. If they realize that they may need additional solutions as well, there is still potential for cooperation before this hype fades away."

(CEO, Interview 3, 2022)

Opportunities spaces are also highly place-specific, primarily depending on the different legal frameworks and corporate cultures on a national level. Different preconditions, therefore, also impact the way entrepreneurs approach their innovation. While the US is heavily tech-driven by private companies, the development in the EU primarily draws from inputs of the EASA. While practically all actors are in favor of the growing engagement by EASA and other agencies, there is also an awareness of the slower technological development and socio-technical integration in Europe. As market creation is much more regulated than in other spatial contexts, there is a concern that the next digitalization step cannot grow to its full potential in Germany:

"First there was e-commerce, then cloud technology that we have "overslept", and now comes the third thing. […] With our laws and regulations, it is not that easy to get something going. […] For testing and experimenting, we switch to other countries."

(Business developer, Interview 6, 2022)

Use case scenarios in China operate on a totally different scope, e. g. mass use of drones in agriculture, which is less interesting for western companies, as they put a stronger focus on specific use cases. Other rapidly emerging markets that the interviewees highlight are India and Oceania, as topography-related use cases like island-to-island transportation provide additional space for experimentation.

Conclusively, UAM combines both ideas of Schumpeterian innovative entrepreneurship. On the one hand, it relies on existing knowledge about the aviation sector while bringing fundamentally new technological concepts and use cases to the evolving market. This duality is not without conflict, since expectations, business models, and technological approaches differ between the two sides. Therefore, UAM provides a good example of how past experiences and beliefs in future scenarios mutually co-evolve. Besides the potential novelty created in this ongoing process, it also shows how the alignment challenges economic activities and innovative entrepreneurs – not only in a technological but also in an institutional and spatial context.

5.2 Institutional entrepreneurship and system agency

The institutional dimension of the current UAM development can be divided in three core aspects: The evolution of legal frameworks, formal rulemaking, and legitimacy. All involved actors share the same insecurity when it comes to changed practices due to new policy guidelines. The most important aspects that need to be standardized in this regard are "*the technical networking, operational procedures, and security*" (Business developer, Interview 13, 2022). So far, the most important legal framework for UAM operations is the U-Space proposal by the EASA (EASA 2021b). U-Spaces are geographically

defined areas that should work as a guideline for UAS operators to manage drones in an airspace. They should work as a complementary element to existing aviation guidelines and provide a first step to the combined integration of manned and unmanned transport. These frameworks must ensure one central balancing act: On the one hand, they need to provide sufficient information for certification and rules for practical operations, on the other hand, they need to be flexible enough to not interfere too much with innovative development or hinder the evolution of possible scenarios:

"U-Spaces cannot exclude existing flights, like sailplanes. This will not work out. […] Air taxis will ultimately have to fit into aviation specifications, and the structural and operative embedding of this is the real challenge." (Business developer, Interview 13, 2022)

While the interviewees saw no necessity for standardization in terms of the vehicles, the major concern is with the surrounding associated system environment for operation and management. One criticism highlighted in this regard is the strong federal bureaucracy in Germany, as responsibilities are often not clear, especially for new market players. The primary challenge for legal rulemaking is to bundle interests and bring together different stakeholders to create a common basis for the establishment of a clear distribution of competencies. Table 2 summarizes the key system agencies that institutional entrepreneurs need to address to developing UAM.

Policy Scale	Important actors and agencies	Primary objectives for formal institutions
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 UAM. Air traffic control: Reorganize airspace for autonomous operations and define safety standards.
Regional	State aviation agencies Cluster initiatives	Aviation and airport administration. Project initiation, industrial 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.

Table 2: Key system agencies, own elaboration

Legitimacy for UAM evolves in two dimensions: Firstly, within the sector itself; and secondly, toward society. Within the emerging sector, the debate about legitimacy refers primarily to the aspects of the distribution of venture capital and the definition of use cases. While some actors highlight the lack of honesty by air taxi developers, others emphasize the need for positive synergies or the early development state of the value chain that is dependent on an open-minded innovative approach. Social acceptance is probably the most frequently discussed topic of UAM, both in social science literature and policy. There exist some preliminary case studies and surveys that attempt to provide insights on the public perception, however most of them only cover a small scale or are limited to a specific well-perceived context like healthcare. The most striking problem, however, is that most approaches remain on an abstract level because there are simply no UAVs to observe. The evaluation of the social acceptance therefore often

relies on pure imagination. Some projects try to include virtual reality technologies in their participation to outline a realistic scenario.

"To provide added value for society is probably the most important and difficult topic for local authorities. Address all relevant stakeholders, taking the existing infrastructure into account. Listen to all the concerns, build up communication channels. There are so many emotions involved in these projects, you must give them some space." (Business developer, Interview 2, 2022)

Besides projects that aim to reflect the potential acceptance level of UAM, unexpected feedback can also impact the perception. This is especially interesting because the developers have less impact on the actual discourse, and potential benefits can get lost in social media or media coverage of a project. One entrepreneur reflects on his experience from a project that tried to conduct cargo transport for tools and spare parts:

"Maybe you cannot necessarily take social media as a reference; comments are always devastating there anyway, but we got feedback like: "Someone is saving money or time, but it's neither my money nor my time and I'm bothered by the noise". Even if the cargo van that passes by today is much louder. But people are already used to that one." (CEO, Interview 8, 2022)

Finally, some actors observe informal behavior not only in the private but also the commercial sector for drones. Due to a lack of regulations, some companies conduct missions without formal approval beforehand. This results in an untransparent management of airspace where the exact number of drone missions remains unclear. However, these actions are limited to small operations with low payloads and will most likely diminish once the operational setting within U-Spaces is established.

"If I buy a drone today and fly it, you will not really notice it. And I am convinced that many missions today are simply flown without certification. […] I know of specific cases from real estate where such flights take place without a concept of approval, but no one notices. But this state is likely finite." (CEO, Interview 4, 2022).

In sum, the formal institutions for the socio-technical integration of UAM are in the making, but at a very different pace. Therefore, many German companies experiment in international markets, primarily the US or Asia, to pilot their ideas. So far, they don´t see the business cases on a national level, especially regarding passenger transport. However, many entrepreneurs value the engagement of the EASA as a forerunner and provide positive feedback regarding the existing guidelines and proposals for UAM in the EU. Due to the early development phase, there are no legitimate action patterns that could support UAM or provide clearer insights on how to address society. The creation of this rulemaking, both formal and informal, remains the most important aspect to be addressed by institutional entrepreneurs.

5.3 Place-based leadership and emerging clusters

To date, five cluster initiatives exist that are dedicated to UAM integration in a particular region. These clusters have formed in the context of "The Urban-Air-Mobility Initiative Cities Community of the EU´s Smart Cities Marketplace" (UIC2) and issued themselves in a memorandum as representatives of the local level to act jointly toward the national authorities. The core aspect of this project is to formally define the importance of the municipalities in the development of this new form of mobility and to position the cities in the process from the beginning. This should prevent local authorities from being insufficiently involved in decision-making and counteract possible top-down mechanisms:

"We, as a municipality, want to be regarded as a competent partner. This shouldn´t be an E-Scooter-like scenario: they were suddenly there, and the city had to deal with them. […] We want to be integrated into the process continuously, and then we can still decide whether we feel capable enough or if we want to outsource something." (Cluster Manager, Interview 15, 2022)

Table 3 provides an overview of the existing UAM clusters in Germany. *Hamburg* formed the first UAM-related cluster in Germany and the other initiatives see the city as a pioneer in industrial development as well as U-Space integration. Industrially, the existing aviation sector has a substantial influence on the cluster. In addition, the cluster clearly has the strongest local embedding and tries to enforce urban networking in the exchange of knowledge and project insights. As a federal German state, Hamburg also combines municipal and state authorities, which stands out as a salient feature and benefit for the institutional change. The *Aachen* Cluster is part of a five-city cooperation and the only one that operates on an international level. The cluster primarily aims at promoting research projects. Key actors are a heterogeneous composition of local research facilities. The objective is less geared to broad network management and regular working groups, but rather to selective calls for funding, which then lead to practical embedding at the research institutions. The cross-border aspect plays a greater role in the pilot projects, although the partner cities in Belgium and the Netherlands have so far dealt with the subject more reserved. The progress and research at the universities themselves is therefore clearly emphasized as the greatest added value. The local integration of air taxis in Aachen itself plays a rather subordinate role and is also critically discussed internally. In contrast, *Ingolstadt* forms a less spatial focus. The cluster has a much stronger emphasis on the development of individual transport with air taxis and a higher presence of robotics and AI. Although local projects exist, the members compose of very diverse companies from across Germany. The focus here is more on technology development along the entire value chain and less on a specific regional application. *North Hesse* is the only cluster that does not define itself through a central urban location. The cluster related to the logistics industry is the only one not clearly anchored in aviation or robotics. Rather, the aim is to sensitize the logistics sector itself to UAM and to promote potential fields of application. In addition, as a rural region, the cluster emphasizes the importance of considering advantages for UAM outside of urban and economic centers. *Berlin/Brandenburg is* the youngest of the clusters initiated to date. While initial thoughts on the topic

were formulated in 2019, they began to come more into focus by the end of 2021. Existing projects tend to focus on rural areas, such as fighting forest fires in Brandenburg. The theoretical implementation of air taxis in Berlin itself is still in a very early conceptual phase. Local actors are still very much part of the start-up culture, with AI playing a larger role.

Region	Embedding/Initiation	Scope and Scale	Primary objectives
Hamburg	Part of aviation cluster (one of six specialized sub-clusters) 2017	Linked to existing aviation industry 50+ members, > 90% from Hamburg Metropolitan/urban focus Combines municipality and state authorities as federal German state	Industrial development Use the existing knowledge base of the aviation industry for development of UAM
Aachen	Part of the municipality Economic development office (Promotion of science) 2018	Primarily research facilities 40+ members Cross-border/EU focus Cooperation with four cities: Liège, Hasselt (Belgium), Maastricht, Heerlen (Netherlands)	Research & Development Unique international network environment; Current focus on passenger transport and healthcare logistics
Ingolstadt	Part of the municipality Economic development office (Promotion of science) 2018	Broad sectoral and spatial network 60+ members Trans-local evolution Local key actors, but no spatial focus in terms of membership and development	Technology development Stronger focus on passenger UAM due to southern air taxi developers, also strong presence of robotics/AI
North Hesse (Kassel)	Part of logistics cluster 2018	Primarily logisticians 120+ members (whole cluster) Regional and rural focus Regional big players, but mostly not directly linked to UAM development	Sector-specific integration Integration of UAM in structurally weaker regions; Focus on cargo transport and intra-logistics
Berlin/ Brandenburg	Part of transport, mobility, and logistics cluster (Sub-Sector Aerospace) 2019	No direct membership Urban-rural perspective Few big players, primarily strong start-up culture	Project initiation Early adaptation; Focus so far on rural projects, concepts, and individual service for companies

Table 3: Overview of regional UAM cluster initiatives, own elaboration based on interviews and cluster websites

The diversity of the regions, which all focus on specific applications, underlines the intention that UAM should be viewed as holistically as possible for scenario development. All clusters clearly prioritize the cooperation for addressing formal institutions, use cases, and exchange with national and European levels. So far, there has been no opposition outside of the competition for funding of project acquisition. A central challenge for the initiatives is the next step towards use case scenario building, in particular the creation of a common basis for a commercial application. While the focus so far lies strongly on civilian applications such as in the medical sector, they see the necessity for more business-oriented approaches in the next steps and to think outside the social comfort zone:

> *"At a panel discussion, someone used the fitting term of "baby bunny" projects. […] They are, of course, socially accepted, like medical transportation. […] But in the end, these are innovation projects, and from an economic promotion and regulatory perspective, you must start thinking further."* (Cluster Manager, Interview 16, 2022)

The cross-sectoral conflict lines for innovative entrepreneurship also mirror in the everyday activities of the clusters. In their role as an intermediary actor, they act as the organizational bridge between different knowledge bases and provide a platform for the critical discussion of different approaches:

"Sometimes you sit in project meetings and realize that people talk past each other, or they realize that they meant something completely different in a proposal. This is a process of convergence. […] The automotive manufacturers want to do something, and then the aviation engineers say, "Well, if you do it like this, the thing is going to fall from the sky"." (Cluster Manager, Interview 18, 2022)

All initiatives maintain close contact with local universities. In addition to the initiation of new projects, the importance of working students plays a crucial role, especially for young companies. In the inter-regional context, the RWTH Aachen and TU Munich stand out as most companies and cluster initiatives highlight them as crucial research locations for technological development. Moreover, they provide space for early experimentation, such as student initiatives that develop cargo drones supported by the universities and their infrastructure.

The perception of the clusters by the interviewed companies differs greatly based on their experiences: Some didn't know about the networks; some see them as pure communication channels; others are involved in projects that directly evolved out of cluster activities. It becomes apparent that companies that develop UAV or UAS generally have a stronger tie and more activity within the clusters. Associated companies from the wider value chain follow a more exploratory approach and, therefore, are less engaged with cluster activities so far. However, these structures are in a dynamic change, as all clusters observe a broader interest in the topic and include a growing number of members outside of the core value chain.

"What I am noticing here […] is that certain personalities and individuals push such a debate and have the necessary perseverance to position it. I think this plays a crucial part in how the topic is now perceived at national and European level." (Cluster Manager, Interview 17, 2022)

In sum, all regions use their previous strengths differently for the development of UAM. While some follow a more local-industrial or research-oriented approach, others emphasize the importance of sectoral transfer. Small and medium-sized companies constitute the largest group for cargo drone development. In contrast, few big players, primarily Airbus, Lilium, and Volocopter, as well as companies from the automotive industry accelerate the air taxi development. On the one hand, this is because the development is so far strongly dependent on big investments, on the other hand, it emphasizes on the idea of a major transformation in mobility. Cargo drones offer fields of application with lower entry barriers, whereas the transport of larger goods tends to occupy a secondary market so far.

6. Conclusion

The main objective of this case study is to analyze the interplay of the trinity of change agency to offer a better understanding of an emerging path toward future transport systems, namely urban air mobility. I identified central actors that try to combine innovative, institutional, and place-based activities and use regional preconditions to position their solutions in a broader context. The empirical results show that innovative entrepreneurs approach the development from different knowledge backgrounds and that the overarching discourse and institutional activities are primarily driven by EU engagement. Building use case scenarios is not only dependent on technological advancements but also on the time- and place-specific opportunity spaces provided by legal frameworks, legitimacy, and forerunners in promoting the new solution. Besides, it becomes clear that the inclusion of civil society is still at a weak spot. Involved actors see big pilot projects as a potential accelerator for the growing acceptance of UAM. However, they also run the risk of too early adoption in terms of technological improvement or safety standards. Moreover, there is an insecurity within the sector, which primarily evolves alongside three dimensions: the different expectations and financial capabilities of small-scale cargo drone providers and big players in air taxi development; a strong and ongoing market selection due to the efficiency of the technological solution (particularly automation) and defining sufficient business cases; and the connection to the policy-level as well as the competition for funding programs to access the opportunity for experimentation.

The paper is limited to an early socio-technical evolution toward new transport solutions. Comparisons with other future mobility transitions should be made with caution due to the unique technical and actor-specific characteristics. The article provides a comprehensive perspective on current developments, that are, however, in a very fast-paced and dynamic environment. Nevertheless, it highlights the importance of a more elaborated perspective on early developments toward Industry 4.0 and digital innovations by evolutionary economics to better understand how early entrepreneurial activities are linked to structural change. Future research should put a stronger emphasis on the interconnection of different knowledge bases in the context of Industry 4.0, local ecosystems for promoting fundamentally new ideas, and how to use participatory approaches to address the legitimacy of advanced solutions toward society and local actors.

Acknowledgements

I cordially thank all the interviewees for their insights and feedback.

I am part of the research project i-LUM, funded by the Hamburg State Research Fund as part of the HamburgX projects. The project involves the HafenCity University Hamburg, the Hamburg University of Technology, the Helmut-Schmidt-University, the Hamburg University of Applied Sciences, and the German Aerospace Center.

Disclosure statement

I declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Ahmed, A., Al-Amin, A. Q., Ambrose, A. F., & Saidur, R. (2016). Hydrogen fuel and transport system: A sustainable and environmental future. International journal of hydrogen energy, 41(3), 1369-1380.

Boschma, R. (2017). Relatedness as driver of regional diversification: A research agenda. Regional Studies, 51(3), 351-364.

Boschma, R., Coenen, L., Frenken, K., & Truffer, B. (2017). Towards a theory of regional diversification: Combining insights from evolutionary economic geography and transition studies. Regional studies, 51(1), 31-45.

Boschma, R., & Frenken, K. (2006). Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. Journal of economic geography, 6(3), 273-302.

Boschma, R., & Martin, R. (2007). Constructing an evolutionary economic geography. Journal of Economic Geography, 7(5), 537-548.

Coe, N. M., & Jordhus-Lier, D. C. (2011). Constrained agency? Re-evaluating the geographies of labour. Progress in Human Geography, 35(2), 211-233.

Cohen, A. P., Shaheen, S. A., & Farrar, E. M. (2021). Urban air mobility: History, ecosystem, market potential, and challenges. IEEE Transactions on Intelligent Transportation Systems, 22(9), 6074-6087.

EASA - European Union Aviation Safety Agency (2021a). Study on the societal acceptance of Urban Air Mobility in Europe.

EASA - European Union Aviation Safety Agency (2021b). Development of acceptable means of compliance and guidance material to support the U-space regulation.

Fastenrath, S., & Braun, B. (2018). Lost in transition? Directions for an economic geography of urban sustainability transitions. Sustainability, 10(7), 2434.

Florida, R., Adler, P., & Mellander, C. (2017). The city as innovation machine. Regional Studies, 51(1), 86-96.

Fraske, T. (2022). Industry 4.0 and its geographies: A systematic literature review and the identification of new research avenues. Digital Geography and Society, 100031.

Fraske, T., & Bienzeisler, B. (2020). Toward smart and sustainable traffic solutions: a case study of the geography of transitions in urban logistics. Sustainability: Science, Practice and Policy, 16(1), 353-366.

Frenken, K., Van Oort, F., & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth. Regional studies, 41(5), 685-697.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research policy, 31(8-9), 1257-1274.

Gherhes, C., Vorley, T., Vallance, P., & Brooks, C. (2022). The role of system-building agency in regional path creation: insights from the emergence of artificial intelligence in Montreal. Regional Studies, 56(4), 563-578.

Glückler, J., & Bathelt, H. (2017). Institutional context and innovation. In The Elgar companion to innovation and knowledge creation. Edward Elgar Publishing.

Gong, H., Binz, C., Hassink, R., & Trippl, M. (2022). Emerging industries: institutions, legitimacy and system-level agency. Regional Studies, 56(4), 523-535.

Gong, H., & Hassink, R. (2019). Co-evolution in contemporary economic geography: Towards a theoretical framework. Regional Studies, 53(9), 1344-1355.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. American journal of sociology, 91(3), 481-510.

Gregory, D., Johnston, R., Pratt, G., Watts, M., & Whatmore, S. (Eds.). (2011). The dictionary of human geography. John Wiley & Sons.

Grillitsch, M., Asheim, B., & Nielsen, H. (2022). Temporality of agency in regional development. European Urban and Regional Studies, 29(1), 107-125.

Grillitsch, M., & Hansen, T. (2019). Green industry development in different types of regions. European Planning Studies, 27(11), 2163-2183.

Grillitsch, M., Rekers, J. V., & Sotarauta, M. (2021). Investigating agency: methodological and empirical challenges. In Handbook on city and regional leadership. Edward Elgar Publishing.

Grillitsch, M., & Sotarauta, M. (2020). Trinity of change agency, regional development paths and opportunity spaces. Progress in human geography, 44(4), 704-723.

Henning, M. (2019). Time should tell (more): Evolutionary economic geography and the challenge of history. Regional Studies, 53(4), 602-613.

Huggins, R., & Thompson, P. (2019). The behavioural foundations of urban and regional development: Culture, psychology and agency. Journal of Economic Geography, 19(1), 121-146.

Isaksen, A., & Trippl, M. (2017). Exogenously led and policy-supported new path development in peripheral regions: Analytical and synthetic routes. Economic Geography, 93(5), 436-457.

Mavraj, G., Eltgen, J., Fraske, T., Swaid, M., Berling, J., Röntgen, O., Fu, Y., & Schulz, D. (2022). A systematic review of ground-based infrastructure for the innovative urban air mobility. Currently under review in: Transactions in aerospace research.

Micek, G., Gwosdz, K., Kocaj, A., Sobala-Gwosdz, A., & Świgost-Kapocsi, A. (2022). The role of critical conjunctures in regional path creation: a study of Industry 4.0 in the Silesia region. Regional Studies, Regional Science, 9(1), 23-44.

Milakis, D., Kroesen, M., & van Wee, B. (2018). Implications of automated vehicles for accessibility and location choices: Evidence from an expert-based experiment. Journal of Transport Geography, 68, 142-148.

Njøs, R., Sjøtun, S. G., Jakobsen, S. E., & Fløysand, A. (2020). Expanding analyses of path creation: Interconnections between territory and technology. Economic Geography, 96(3), 266-288.

Nneji, V. C., Stimpson, A., Cummings, M., & Goodrich, K. H. (2017). Exploring concepts of operations for on-demand passenger air transportation. In 17th AIAA Aviation Technology, Integration, and Operations Conference (p. 3085).

Perez, C., & Soete, L. (1988). 21 Catching up in technology: entry barriers and windows of opportunity.

Reiche, C., Goyal, R., Cohen, A., Serrao, J., Kimmel, S., Fernando, C., & Shaheen, S. (2018). Urban air mobility market study.

Rodrigue, J. P. (2020). The geography of transport systems. Routledge.

Rosenbloom, D. (2020). Engaging with multi-system interactions in sustainability transitions: a comment on the transitions research agenda. Environmental Innovation and Societal Transitions, 34, 336-340

Saxenian, A., & Sabel, C. (2008). Roepke lecture in economic geography venture capital in the "periphery": the new argonauts, global search, and local institution building. Economic geography, 84(4), 379-394.

Schumpeter, J. (1911). Theorie der wirtschaftlichen Entwicklung (transl. 1934, The Theory of Economic Development: An inquiry into profits, capital, credit, interest and the business cycle). Vienna: Kyklos.

Shaposhnikov, D. (2021). Cargo Drones and air taxis – Industry report 2021. Report by Phystech Ventures.

Sotarauta, M. (2016). Place leadership, governance and power. Administration, 64, 45-58.

Späth, P., Rohracher, H., & Von Radecki, A. (2016). Incumbent actors as niche agents: the German car industry and the taming of the "Stuttgart E-Mobility Region". Sustainability, 8(3), 252.

Steen, M. (2016). Reconsidering path creation in economic geography: Aspects of agency, temporality and methods. European Planning Studies, 24(9), 1605-1622.

Storper, M. (1997). The regional world: territorial development in a global economy. Guilford press.

Straubinger, A., Rothfeld, R., Shamiyeh, M., Büchter, K. D., Kaiser, J., & Plötner, K. O. (2020). An overview of current research and developments in urban air mobility–Setting the scene for UAM introduction. Journal of Air Transport Management, 87, 101852.

Sun, X., Wandelt, S., Husemann, M., & Stumpf, E. (2021). Operational Considerations regarding On-Demand Air Mobility: A Literature Review and Research Challenges. Journal of Advanced Transportation, 2021.

Thipphavong, D. P., Apaza, R., Barmore, B., Battiste, V., Burian, B., Dao, Q., … & Verma, S. A. (2018). Urban air mobility airspace integration concepts and considerations. In 2018 Aviation Technology, Integration, and Operations Conference (p. 3676).

Trippl, M., Zukauskaite, E., & Healy, A. (2020). Shaping smart specialization: the role of place-specific factors in advanced, intermediate and less-developed European regions. Regional Studies, 54(10), 1328-1340.

Truffer, B., & Coenen, L. (2012). Environmental innovation and sustainability transitions in regional studies. Regional studies, 46(1), 1-21.

Turnheim, B., Kivimaa, P., & Berkhout, F. (Eds.). (2018). Innovating climate governance: moving beyond experiments. Cambridge University Press.

Tyre, M. J., & Orlikowski, W. J. (1994). Windows of opportunity: Temporal patterns of technological adaptation in organizations. Organization science, 5(1), 98-118.

UIC2 - The Urban-Air-Mobility Initiative Cities Community of the EU´s Smart Cities Marketplace (2021). Practitioner briefing – Urban air mobility and sustainable urban mobility planning.

Uyarra, E., & Flanagan, K. (2022). Going beyond the line of sight: institutional entrepreneurship and system agency in regional path creation. Regional Studies, 56(4), 536-547.

VUL - German Unmanned Aviation Association (2021). Quantitative Analysis of the German Drone Market. Market Study by Drone Industry Insights.

Department of Geography and Regional Research
University of Vienna

Contact person: Michaela Trippl
Universitätsstraße 7/5/A0528, 1010 Vienna, Austria
Tel.: +43-1-4277-48720
E-Mail: Michaela.trippl@univie.ac.at
https://humangeo.univie.ac.at/

Department of Socioeconomics
Vienna University of Economics and Business

Contact person: Jürgen Essletzbichler
Welthandelsplatz 1, 1020 Vienna, Austria
Tel.: +43-1-31336/4206
E-Mail: juergen.essletzbichler@wu.ac.at
http://www.wu.ac.at/en/department-socioeconomics

Institute for Urban and Regional Research
Austrian Academy of Sciences

Contact person: Robert Musil
Postgasse 7/4/2, 1010 Vienna, Austria
Tel.: +43-1-51581-3520
E-Mail: robert.musil@oeaw.ac.at
https://www.oeaw.ac.at/en/isr/home/

Department of Working Life and Innovation
University of Agder

Contact person: Arne Isaksen
Jon Lilletunsvei 3/A161, Grimstad, Norway
Tel.: +47-37-23-33-53
E-Mail: arne.isaksen@uia.no
https://www.uia.no/en/about-uia/faculties/school-of-business-and-law/department-of-working-life-and-innovation

Department of Geography
Kiel University

Contact person: Robert Hassink
Hermann-Rodewald-Str. 9, 24098 Kiel, Germany
Tel.: +49-431-880-2951
E-Mail: hassink@geographie.uni-kiel.de
https://www.wigeo.uni-kiel.de/en/