To Diversify or to Specialise? How to Strike a Balance in a Cluster Profile: A Case Study of the Hamburg Aviation Cluster (HAv), Drawing on Related Variety and Blending Processes[1]

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Abstract

The motivation for this paper comes from the recognition that our understanding of specialisation might be too simplistic and that the dichotomy of specialisation and diversification could be outdated not reflecting the richness of real complex economic and technological relations among industries. Drawing on a qualitative study of the Hamburg Aviation (HAv) cluster, this paper discusses the peculiarities of a cluster profile in the digital time – the age of Industry 4.0 (I4.0), touching upon the issues of cluster structure and the complexity of production, synchronising specialisation with diversification, branching, and bridging, and the I4.0 attributes facilitating complementarity. The final research proposal, which is empirically embedded in the studied context, states that related variety encompassing both 'specialisation in diversification' and 'diversification within specialisation' can be further developed by a blending process. This can lead to branching and is modulated by the universal character of the I4.0 and a problem-solving attitude. It takes the form of an additive (new entries) or multiplicative (spinoffs) evolution, and, ultimately, owing to the complementarity, it can provide sustainable competitive advantages.

Keywords

cluster, specialisation, diversification, digital transformation, Industry 4.0, Germany

Introduction

Inspiration for this research comes from the fact that the interrelations between clusters and the Industry 4.0 (I4.0; digital transformation; the Fourth Industrial Revolution) remain uncharted (Pagano et al., 2021). A co-evolutionary perspective and a dynamic approach to studying clusters (Johansen et al., 2020) stress, even more so, the need to unpack these dependencies (Denney et al., 2021). This motivation is further strengthened by the recognition that the understanding of specialisation and diversification could be outdated and not reflecting the richness of real complex relations due to the growing popularity of transversal technologies, which are developed and applied in different sectors (Giannini et al., 2019) and compound the accurate measurement of relatedness.

So far, most of the papers on clusters have perceived them as local concentrations of specific industries, not as groups of related industries (Ketels & Protsiv, 2020). Yet, as stressed recently by Lazzeretti et al. (2019), more attention is paid to the role of diversity than to that of specialisation as the determinants of clusters' performance and competitiveness. "*Clusters evolving into platforms of diversification may come as a surprising insight (…), but cluster defined by the entrepreneurial process is far more complex and flexible and, in some ways, more fragile"* (Engel, 2014, p. 385). Far-reaching consequences of the I4.0 imply that the industry's borders are becoming more blurred; competitive advantage – only transient, whereas the eco-system, not a single firm – is becoming a new unit of competitive analysis (Lanteri, 2021). This certainly affects the cluster's existence and requires the re-alignment of the existing knowledge, with new external knowledge

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as well as the transformation of sectoral specialisations, business networks, supply relations, and institutional support (Bellandi et al., 2020). In the face of new technological challenges, such as digital transformation, the cluster needs mechanisms of robust transition (Martin & Sunley, 2015). They encompass factors, such as local, secondary industries with specific know-how; traditional producers supporting the development of new domains due to skill-updating programmes; local leadership, triggering the plasticity within the institutional frame or experience of local actors within multi-territorial networks (Bellandi & Santini, 2017). As demonstrated by Pagano et al., (2021), the complexity of the I4.0 requires a combination of traditional and innovative mechanisms, with the emergence of new players, activities, and resources. The I4.0 upgrading in clusters shows blurred sectoral and geographic boundaries, and the dissemination of the I4.0 knowledge requires the undertaking of deliberate initiatives of 'collective' cooperation.

This paper aims to explore the changing cluster profile in the digital era by drawing on the case study of the Hamburg the Aviation cluster (HAv) and concepts of related variety and blending, which are helping to analyse the need of synchronising specialisation with diversification. It seeks to characterise the nature of a cluster and describe how it strikes a balance between specialisation (a focus on specific activities, usually limited to one industry) and diversification (a wider range of activities, extending to a narrowly defined sector) in the I4.0 realms. Thus, the focus of the conducted study is digital transformation, which presumably modifies the relationship between cluster specialisation and diversification. The study aims to identify the cluster profile (balancing specialisation – in this case in aviation – with more diversification, i.e. openness to new sectors) in digital time by exploring the related variety and blending processes. After embedding the research in a conceptual framework, this paper proceeds with presenting the methodology and the case of the selected cluster. The extended discussion section combines the main findings stemming from the carried-out study and the critical analysis of the emerging pattern of cluster profile. This paper closes with conclusions, including a brief outline of limitations and a way forward.

Conceptual framework

The motivation to frame the discussion on a cluster profile in the I4.0 age in the concepts of related variety (understood in terms of diversified specialisation) and blending (defined in terms of sectoral/scope expansion) processes stems from the recognition that the specialisation–diversification dichotomy may not adequately capture complex relationships, particularly in a digital time, where boundaries between sectors are becoming blurred and transversal technologies hamper accurate measurements (Szalavetz, 2022; Lanteri 2021; Content & Frenken 2016; Gancarczyk 2019)[2]. It reflects the dynamic approach to study clusters, where the concept of the 'life cycle' explicitly foresees diversification (more diversified profile) as the final phase in the evolution of the mature cluster (Fornahl & Hassink, 2017; Smith et al., 2020).

The literature review shows a wide array of understandings of **related variety**. The measure of related variety (**RV**), usually draws on the hierarchical structure of the official classifications of industries (e.g. NACE; Sedita et al., 2015; Fratesi & Rodríguez-Pose, 2016). Whittle and Kogler (2019) propose three approaches: co-occurrence matrices, industrial hierarchy, and resource similarity. In the line of Grillitsch et al. (2018), RV implies the potential for diversification, resulting from similarities in the knowledge base between industries. Frenken et al. (2007) as well as Content and Frenken (2016) draw attention more to dynamic, complementary externalities, stressing that regions can benefit from the production of a variety of products and services, as more diversity can lead to more cross-sectoral knowledge spill-overs. Aarstad, et al. (2016), define RV as the deployment of complementary factors. The concept of RV assumes knowledge-sharing (Cainelli & Ganau, 2019) or the re-combination of technologies by various sectors within a region, which can

[2] I fully recognise and agree with Reviewers' remarks concerning clusters as economic phenomena – which cannot be reduced to specialisation in one industry – which are undergoing structural changes that require reflection and to some extent reconceptualisation, and that the evolution of clusters has been recognised as driver of industrial upgrading. Nevertheless, it seems beyond the scope of this paper to dwell in details on this issue. However, the processes of blending discussed in this article, particularly as induced by the digital transformation, can be interpreted in terms of cluster evolution.

contribute to the success of certain clusters (Gaschet et al., 2017). Since neither pure specialisation (the production of a narrow range of goods or services, commonly defined by reference to the NACE statistical classification of economic activities)[3] nor pure diversification (encompassing various sectors from industrial classifications such as the NACE – the more digits share two industries the more closely related they are) guarantees the prosperity of the local economy, harnessing the concept of related variety, understood here in terms of "diversified specialisation", seems to be the promising compromise option. Related variety was introduced in an attempt to resolve an empirical question of whether regions benefit most from being *specialised* or being *diversified*. This 'controversy' is commonly referred to as 'MAR versus Jacobs', referring to the theories of Marshall, Arrow, and Romer, suggesting spillovers to take place primarily *within a single industry* versus the theory of Jacobs, who argued that 'the greater the numbers and *varieties of divisions of labour* in an economy, the greater capacity for adding still more kinds of goods and services' (Content & Frenken, 2016). RV may be also associated with the idea of smart specialisation (McCann & Ortega-Argilés, 2011), which is based on the concept of kinship. It assumes that owing to the relatedness of embedded industries, the resilience and growth of the local economy can be enhanced (Elekes, 2014). Though, as argued by Hassink and Gong (2019), despite the growing popularity, there are several inconsistencies in the fashionable concept of smart specialisation strategy. Ingstrup and Menzel (2019) stress the system's property and the role of institutions, whereas Kuusk and Martynovich (2018) perceive RV as a dynamic category with a „best before" date. This unstable characteristic of RV is addressed in this research by drawing on the concept of blending.

The **blending** strategy, defined by Njøs et al. (2017) as scope expansion, whilst cluster evolution is another interpretation (Fornahl & Hassink, 2017), aims to enhance the cluster and strengthen the innovative capacity of cluster firms by facilitating the combination of different but related skills. This strategy implies extending the industrial reach of cluster projects by encouraging co-operation between companies in related sectors, and even with those with different but related knowledge. This strategy, as many pundits suggest, emphasises the regional dimension of diversity, as noted by some authors (Boschma & Frenken, 2011; Cooke et al., 1997; Uyarra, 2010). Blending aims at fostering knowledge spill-overs between related industries, endorses cross-sectoral innovation (Enkel & Gassmann, 2010), and facilitates the fusion of different competencies. Blending should lead to an extension of the cluster's industrial reach by facilitating co-operation and learning between companies from related industries. When it is perceived as a counter-balance to classic rigid specialisation, this implies a re-definition of the cluster by prescribing that it is an agglomeration of the representatives of related industries (Cooke, 2012). The traditional thinking sees clusters as vertical, sectorally specialised 'silos' (James & Halkier, 2016), but nowadays clusters can span sectoral boundaries and are based around common markets and/or technologies (Delgado et al., 2016; Puig, 2019). James and Halkier (2016) stress the necessity to identify novel directions of industrial knowledge flows in the region, bypassing these specialised 'silos', to horizontal and combinatorial 'platforms' (2016, p. 832).

This paper framed in the above-mentioned concepts of related variety and blending is supposed to provide a contextualised explanation (Welch et al., 2011; 2022) of the changing cluster profile in the digital era by drawing on the case study of the Hamburg Aviation cluster (HAv). It seeks to characterise how cluster strikes a balance between specialisation (understood as specific activities usually limited to one industry sector) and diversification (seen as a wider range of activities extending one distinct sector) in the realms of digital transformation (defined also as the Industry 4.0).

The method applied – the qualitative approach

As this study focuses on the nature of the phenomenon, not its frequency, the qualitative method seems to be the most suitable one (Karafyllia & Zucchella, 2017; Vanninen et al., 2017; Eisenhardt, 1989). It can produce rich descriptions, explanations, and interpretations of phenomena (Ryan

[3] Grillitsch et al. (2018) suggest defining specialisation as resting on traded and untraded interdependencies of economic activities, as it is the only useful interpretation of specialisation in a knowledge-based economy, whereas related variety captures the potential for diversification resulting from similarities in the knowledge base.

et al., 2020), allowing the emergence of a good theory from even strongly idiosyncratic contexts (Michailova & Mustaffa, 2012). It can also be justified, as it is suitable for phenomena that are not well-studied in the existing literature (Eisenhardt, 1989). The adopted hybrid approach of the grounded theory method combines the 'spontaneous grounding in empiricism' with the 'rigorous systematisation' (Glaser & Strauss, 1967; Strauss & Corbin, 1990), and is useful in developing context-based, process-oriented descriptions and explanations of phenomena, as well as is appropriate for developing theories in areas where prior knowledge is scarce and pre-formulated hypotheses are rare, such as the Industry 4.0 (Magnani & Gioia, 2023; Charmaz, 2009; Eisenhardt, 1989; Yin, 1984; Urquhart et al., 2010; Grashof et al., 2020).

This paper applied the case study method, as the scientific discipline, without a number of thoroughly executed case studies, is ineffective (Flyvbjerg, 2006). Following Welch et al. (2011; 2022) with their classification, this research seeks to develop a contextualised explanation, which assumes that social phenomena require some integration of explanation and understanding. Contextualised explanation utilises the main strength of the case study, as it reconciles a causal explanation that ensures the internal validity of reasoning, and a context that provides a full description of the case, which is particularly vital as the I4.0 – encompassing digitalisation, connectivity, and automation – is bound to context-specific variations (Culot et al., 2020). Inspired by Tsang (2022), this study can be seen as an identification of empirical regularities, with the context not being a 'hindrance', but having explanatory power (Welch et al., 2022). In the line of relational research design, this research aims at generating transferable insights while acknowledging the contingent conditions of the given setting (Bathelt & Glückler, 2018).

This study followed an inductive coding procedure (Gioia, et al., 2013; Magnani & Gioia, 2023). This enabled new concepts to emerge and prevented certain restrictions of pre-defined hypotheses (Graebner & Eisenhardt, 2004), which is of particular importance, given that research on the I4.0 is still in its infancy. Inductive coding allows the identification of consistencies and patterns in the collected data (Edmondson & McManus, 2007; Greening et al., 1996).

The case study of Hamburg Aviation cluster (HAv)

HAv – basic facts

The Hamburg Aviation cluster (HAv) represents the world's third largest aerospace cluster, (Bräuninger et al., 2010; Buxbaum Conradi, 2018). Hamburg Aviation satisfies the cluster criteria, as it is both a spatial agglomeration of related industries as well as a functioning cluster organisation (CO). HAv e.V., as a registered association with corresponding cluster management, was established in 2011, succeeding the 2001 Initiative Luftfahrt Hamburg. HAv sees itself as an "international centre of expertise for 'new flying'". Three main actors comprise: Airbus, Lufthansa Technik, and Hamburg Airport. The HAv profile encompasses aviation, aeronautics, and aerospace. The cluster population constitutes more than 300 small and medium-sized enterprises with approx. 40,000 highly-qualified employees, as well as research institutions – universities, laboratories, and scientific centres, representing the entire aviation value chain and life cycle of an aircraft: from development, to repair, and recycling. The table below (Table 1) briefly scrutinises the performance of HAv against Breznitz's (2021) four fundamentals of the successful cluster; hence, it also provides a glimpse into the ongoing evolution of its core elements.

Table 1. HAv four fundamentals, according to Breznitz (2021)

Breznitz (2021) fundamentals	HAv position	Examples
Flows of local-global knowledge	Strong – well-documented, with a long tradition, institutionalised with knowledge flows, particularly fostered with external actors.	The European Aviation Cluster Partnership (EACP), created in 2009 co-ordinated by HAv; the international expansion comprises diversified channels – partnerships with Canada, Portugal, and Brazil, within the framework of the ministerial project (Interspin – 2015-2020, BMBF).

Table 2 (continued)

Breznitz (2021) fundamentals	HAv position	Examples
A steady supply and creation of public and semi-public goods (qualified workforce, testing and prototyping facilities, collaborative public spaces, etc.)	Strong – various formats provided, due to a diversified pool of actors.	Multiple entities with a diversified portfolio of activities and services provided, acting as interface epitomising Triple Helix elements, e.g. Hanse-Aerospace; the Hanseatic Engineering & Consulting Association, HECAS; Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V BDLI; Deutsches Zentrum Für Luft- Und Raumfahrt DLR; Hamburg Centre of Aviation Training-Lab HCAT+ and Zentrum für Angewandte Luftfahrtforschung, ZAL.
A local eco-system that supports the firm-level benefits from the first two fundamentals (financial and legal services, etc.)	Strong – wide range of facilitators, in line with the concept of '*clusterspace'* – intersectoral intra-regional collaborative learning (Fromhold-Eisebith 2017).	Co-learning spaces, roundtables, Fora, "bridging" by HAv officials and at the metropolitan level – Hamburg selected as the European model region for a modern cluster policy, with all eight clusters involved in cross-clustering.
The co-evolution of public policy, with the previous three fundamentals, to fit the needs of the eco-system.	Emerging – initiatives suggesting certain corrections of action.	HAv 55th Forum (June 2019) – the revision of strategy aiming, among others, at diversification. Re-orientation from aviation towards mobility; HAv sees itself as an „international competence centre for the „new flying, integrated into the global civil aviation network. A selective and adaptive approach to internationalisation (few MoU signed).

Source: Author's own judgements based on conducted research and gathered material.

Sample analysed and the scenario of interviews

Semi-structured expert interviews form the backbone of collecting data (Yin, 2009), with an interview scenario informed by literature, but flexible enough to allow novel topics to arise (Kasabov, 2015). The selection of HAv was phenomena-driven as the Hamburg Aviation cluster officially represents the Industry 4.0 and has been categorised by the Cluster Platform Deutschland as one of more than 400 officially recognised clusters and one of 41 German 'I4.0 clusters' (https://www.clusterplattform.de/CLUSTER/Navigation/DE/Home/home.html). The 26 interviews in the HAv cluster were conducted in mid-February 2019 and March-June 2019 in person, on the premises of companies or institutions, as well as through telephone conferences. They lasted between 45 minutes and half-day sessions. These talks have rather taken the form of guided conversations than structured interviews (Buxbaum Conradi, 2018, p. 114). The concrete questions were oriented towards the listener and were supposed to stimulate narration. The interviewees included representatives of the HAv office – the team of managers involved in co-ordinating the cluster's activities, the Hamburg City Economic Authority, research institutions, and managers or directors of various companies, especially small and medium-sized ones, often newly-founded firms, as well as scientists – researchers from the Helmut Schmidt University and the University of the Federal Armed Forces. Besides, this study benefited from consultations with the Kiel Institut für Weltwirtschaft IfW experts and the insight got during the 55th Hamburg Aviation Forum. The interviewers were anonymised and classified as cluster representatives (CR) or cluster HAv experts (CE), cluster companies (CC), cluster officials (CO), and cluster scholars (CS), respectively. The sample of companies which took part in this study is pretty heterogeneous and comprises start-ups, SMEs, and subsidiaries of large multinational companies, representing different tiers of the supply chain.

Table 2. HAv sample – cluster representatives (CR), cluster experts (CE), cluster companies (CC), cluster officials (CO), cluster scholars (CS)

Cluster member	Role	Date of interview	Additional information
CS1	PhD researcher at HSU	14-15.04.2019	Sample structure:
CS2	PhD researcher at HSU	15.02.2019	The interviewed firms (CC) are suppliers of avionics,
CO1	Ministry of the Economy HH	17.04.2019	consulting firms in aerospace quality and process management, producers of plastic parts, providers
CR1	CEO of HAV	14-15.02.2019	of aircraft propulsion systems, and integraters of
CR2	junior manager at HAV	14-15.02.2019	aircraft engine nacelle systems. They offer integrated
CR3	senior manager at HAV	14-15.02.2019	consulting for aviation; lighting solutions to reduce jet
CR4	senior manager at HAV	14-15.02.2019	lag, and electronics for aircraft; specialise in the control
CR5	junior manager at HAV	14-15.02.2019	of vibration and noise into the cabin. They produce
CR6	senior manager at HAV	14-15.02.2019	high-precision and safety-related components for the
CR7	senior manager at HAV	14-15.02.2019	aviation industry, offer collaborative robotics: context-
CE1	PhD, senior manager at aviation institute/agency	14.05.2019	sensitive assistance, and AI for aircraft, as well as aircraft systems' technology and system architecture, and provide recruitment, and technical training services
CE2	HSU/company/military	04.05.2019	to the aviation industry.
CE3	manager at aviation institute/ agency	15.05.2019	This stratification ensures a diversity of research participants, implying that also competing explanations are included, which is essential for internal research
CE4	senior manager at aviation institute/agency	15.05.2019	validity (Billing & Bryson, 2019). Selected issues raised in semi-structured interviews: HAv belongs apparently to I4.0 clusters: do you
CC1	CEO of SME	08.05.2019	share this opinion? Which technologies of I4.0 are
CC2	senior manager at SME	14.05.2019	here applied/used by your company? Would you
CC3	CEO at SME	09.05.2019	agree that digital transformation (I4.0) promotes
CC4	senior manager of MNE	06.05.2019	cluster diversification (less sectoral specialisation),
CC5	PhD, senior manager at consulting firm	07.05.2019	and requires a more inter-disciplinary approach? What about the external relations, do you feel that the cluster is becoming spatially/geographically
CC6	CEO at SME	13.05.2019	less concentrated? Would you support the view that
CC7	senior manager at MNE	10.05.2019	digital transformation necessitates more international
CC8	senior manager at SME	09.05.2019	openness of the cluster?
CC9	manager at consulting company	27.05.2019	For facilitating I4.0, which of these three cluster features are most important, from your point of view: business relations (customer ties; supplier linkages);
CC10	junior manager at SME	14.05.2019	knowledge environment (competencies, know-how,
CC11	manager at MNE	16.05.2019	skills); or policy support (institutions, professional
CC12	senior manager at SME	17.05.2019	management), or all are equally important, and should be provided simultaneously? Do you see that the cluster is becoming more cross-sectoral? Would you agree that digital transformation (I4.0) requires a more inter-disciplinary approach?

Source: The author's data collected.

The main findings

To make the presented claims robust and substantiated, Table 3 summarises selected findings of interviews conducted in HAv. Quotas are collected in notes and memos during interviews, and verified with recorded versions of interviews. In the process of drafting the paper, the interviewees' names were anonymised for confidentiality reasons. Data analysis encompasses iterations enabling the identification of first-order codes, next establishing second-order constructs, and, finally, the aggregate dimensions (Cao et al., 2018). In particular, this process was guided by the procedure proposed by Gioia et al. (2013), which increases the methodological rigour of qualitative research design. In the initial step, informant-centric constructs – quotations – were developed. Secondly, these citations were grouped into first-order constructs – codes. In the third stage, they were systemised and distilled into the major categories of the analysis. Manual coding permitted the narrative integrity of transcripts and conversation-contextualised interpretation of text (Owens et al., 2018; Cao et al., 2018). The risk of prejudice from informants and retrospective sources was prevented by selecting reliable and competent experts, ensuring full anonymity and confidentiality for all respondents. Internal credibility was ensured by repeatedly asking interviewees to confirm their previous statements.

Table 3. Selected quotations and emerging categories concerning the RV and blending

Quotes "….."	1st order constructs – codes	2nd order constructs – categories
CR1 – A broader perspective is needed to assure the quality of the final product – all stakeholders' partners, and suppliers should be involved in the "production process", which might resemble the idea of co-creation. What matters in aviation is TCO – total cost of ownership – the price when you buy, but also the cost of future maintenance, fuel consumption, all next expenditures, and how much over the next few years, the owner would spend on aircraft. To calculate this TCO, one needs to know, not just the price of purchasing, but the whole life cycle, to include all the following costs, which needs insight from users. It is crucial to have all stakeholders under one roof, to account for all aircraft stakeholders. The saying in HAV goes: "Airbus knows all the strengths, and Lufthansa Technik knows all the weaknesses".	the uniqueness of aviation, co-creation, broader involvement, ownership of the process	cluster structure; complexity of production synchronising specialisation with diversification; complementarity for sustainable competitive advantage
CE3 – three big players, and a lot of smaller companies, and contractors. HAV covers nearly the whole value chain with the large contractor, and various first, and second-tier suppliers. So, the activities comprise different technical specialisations, but also for services like human resources, consulting, etc. there are different highly specialised entities, and many accompanying services. That is ok, there is no contradiction, and that is still an aviation cluster. *Aircraft is an extremely complex product, which requires the co-operation of various areas, and input from many fields.* *There are some[digital] technologies, which are not specific to one industry, but they are horizontal, and 'cross-cluster'. For these technologies and processes, it could be very valuable if one cluster learns from another, for instance, in system engineering.*	collocation, value chain, product complexity reconciling specialisation and diversification; benefits of cross-clustering	
CC – In fact, the diversification depends on who you are in the hierarchy, if you are a system integrator. First or second-tier companies can afford diversification, while if you are a 3rd,4th, or 5th-tier supplier, you simply need to be focused, to specialise in some narrow area.	hierarchy, perspective, cluster diversification as a function of members' decision of how to balance specialisation with diversification	
CC12 – You need to find a fine balance. On the one hand, you need to be careful of staying too focused, to limit your focus on too few subjects, on the other hand, you should not spread it too widely, because you may end up fragmenting your attention, spreading resources too wide. Clusters are well advised to focus on a certain industry, but within that scope, try to cover as many different subjects as possible.	striking balance, the proportion of diversification/ specialisation depending on the perspective	synchronising specialisation with diversification
CC2 – it makes sense to get insight from other fields, and have a general overview from other sectors, but we should stay focused.	limited benefits, auxiliary role	
CC12 – digital transformation also implies changes in business models; you are moving away from manufacturing simple pieces of hardware to adding services, data processing, and other features.	balance, modification of manufacturing, role services triggered by digital transformation	
CS2 – In Stade, there is an Airbus spin-off cluster – a CFK [carbon fibre composite cluster]. It originated from HAV, though, and is now an emancipated, independent cluster active in I4.0, establishing links with the US, and Korea. Processes of slicing up, previously promoted and implemented thanks to modularisation, brought certain negative results, in this complex industry, like aviation inter-operability, which of all components, is critical and fragmentation causes problems with smooth integration. Hence, a tendency to re-integrate, to synthesise these dispersed activities.	spin-off processes within the cluster, the emergence of new sub-fields, need of re-integration	branching; multiplicative evolution; complexity of industry
CS1 – You can see [thanks to digital transformation] not only the development of truly new, innovative products, such as new landing possibilities (no under-carriage), but also the stretching into related areas, like air urban mobility and unmanned air vehicles.	pioneering and venturing into new areas	

Table 3 (continued)

Quotes "….."	1st order constructs – codes	2nd order constructs – categories
CC3 – it seems that earlier, HAV was more specific and focused, but now is getting more diverse, which is positive. Also, foreign firms are entering the arena, and new companies bring their competencies. Each firm needs to be concentrated and focused on its own field, but there is a need to integrate more from outside … it helps to increase efficiency, adapt to market requirements, to be more competitive in the future.	integrating new areas, market efficiency, assuring competitiveness	additive nature of evolution; I4.0 attributes facilitating complementarity – allowing the sustainability of competitive advantage
CE4 – beyond the cross-clustering activities, which have a good tradition in Hamburg, we have got recently, a new firm – a robot company – coming from the automotive industry. So, they offer solutions proven in the automotive world, and also useful in our sectors, like a new machine learning type, or AI. Opening up to new industry is good, as it helps development, especially in aerospace.	new industries, beneficial opening-up	
CR1 CR3 CR5 CR6 – *Projects with Saxony or a chemical cluster in Bayern, have officially been completed, with some follow-up co-operation taking place, most likely. There are numerous hurdles to co-operation, due to the aviation sector's nature – qualification, standardisation, certificates, etc; it is like this in the medical sectors, where others are afraid of co-operating, and are discouraged. Though indeed, more players come, thanks to digitalisation, than it would have been in the past, more digital companies enter the aviation cluster. Digitalisation is a possibility – new business ideas and strategies come up, and they force companies to look internationally, to connect with the outside world.*	the uniqueness of aviation, hurdles, barriers to co-operation, more digital players, implying openness and collaboration	
CO1 – Specialisation or diversification? – we need both; to master excellence in some specific fields, and yet co-operate with other industries. Aviation has been developing for centuries, and we cannot further advance it, when ignoring the past decades of achievements. Rather, we may need to re-define the concept of mobility due to digital transformation, for SMEs, it will be important to cope with the digital process and challenges, no matter if by itself, or thanks to outsourcing, or buying ready solutions, or thanks to leasing or something else. Codification of knowledge and modularisation processes, as implemented by Airbus, has influenced relations with local firms. They found themselves in need of fitting into the structure of first-tier or second-tier suppliers. Some decided to focus on a particular field of expertise, others decided to venture into new areas, and spread their expertise.	evolution from aviation towards mobility, daily balancing specialisation and diversification, challenges of digital transformation	I4.0 attributes facilitating complementarity; complementary competencies for sustainable competitive advantage; synchronising specialisation with diversification
CR1 CR3 CR5 CR6 – *The need for a more diversified local portfolio may seem top-down induced. Though, it answers the many needs of local firms, in particular, those who are simultaneously members of both the Aviation cluster, and other Hamburg-based clusters. Such dual membership makes them prone to more cross-sectoral co-operation. Also, the topic of co-operation matters, as for more general issues [digital technologies] and problems, there is always more interest among members representing different clusters, to join forces. The more universal the topic or aspect of potential collaboration, the higher the chance of success. SMEs might appreciate this top-down assistance … large firms recognised the need and benefits of more diversification a time ago, and have been enriching their portfolios, by searching for solutions for their problems in related sectors; they seem less interested in such assistance.*	conditions, modalities of diversification, top-down initiatives, universal nature of I4.0 technologies as a bridge for more variety; more diversification, size matters – small versus large firms	
CE2 – There are three areas: CFK valley with lightweight specialisation in Stade, the main production facility in Hamburg Finkenwerde, and EcoMat in Bremen (Centre for Eco-efficient Materials & Technologies) focusing on material nano-technology or AI, and covering all stages of an aircraft's life cycle, from research in new materials, to certification and production. All three techno-centres originated from Airbus. This provides some heterogeneity, and some diversification, and might turn critical for cluster coherence, and sustainability in the future.	division of tasks, diversification for the sustainability of competitive advantage, the role of the anchor tenant, need to mitigate and neutralise direct competition	

Table 3 (continued)

Quotes "….."	1st order constructs – codes	2nd order constructs – categories
CS1 – These 8 clusters, located in Hamburg metropolitan area, have their own specific path development, but the regional Ministry of Economy decided to bridge them and set up a platform of co-operation, which seems critical in the digital revolution. The co-learning space might prove critical in the I4.0 era, as it encourages co-operation across clusters – solutions applied in aviation, are also used in health, maritime, etc. I4.0 instruments and technologies facilitate bringing them together, acting like a glue which binds them, a common thread of interest for representatives of various clusters.	digital transformation/I4.0 a common topic, a glue that binds different actors' consolidation, co-learning, solving problems, bridging – cross-clustering; *clusterspace* – intersectoral and intra-regional learning	
CO1 – Co-operation takes place formally in an agreed format, via a weekly meeting of middle and lower-level officers, and monthly, when higher-ranking representatives like CEOs and directors meet and discuss. Different formats aim at opening the minds of local clusters. They aim at strengthening this cross- fertilisation through brainstorming sessions, world coffee roundtables stimulating creative thinking. So, when groups are seated at different tables dedicated to certain topic-problems, and they rotate, they think about what the previous group came up with, they change and modify it, and in this way are jointly learning, as revision brings fresh new life into certain problems. It is not simply a discussion detached from real problems; it is about solving these challenges.	problem orientation helps, integrates naturally, and fosters cross-collaboration, intersectoral and intra-regional learning	
CC1 – it is beneficial to diversify, in terms of bringing new skills, and new complementary competencies on board. This is particularly important for small firms like us. The bigger the diversification, the bigger the chance you will find someone with complementary capacities. HAV also recommended setting a development platform, a useful tool for collaboration among members. This was welcomed with much suspicion and scepticism; however, it proves to be the right way to increase efficiency, and we can see the progress. It is of utmost importance for small and medium firms. We met and spoke for two days on some topics, but this close exchange allowed better intervention, and early correction, if necessary, to improve efficiency. This development platform somehow fits into the concept of system engineering and co-operation along the V pattern – first, we develop the requirements the client needs, and then we work to validate them.	complementarity, integrative tools (also digital) enable collaboration cross-clustering; *clusterspace* – intersectoral intraregional learning efficiency	
CC3 – New incoming companies are close to this I4.0. We see this process going on; before, there were very specific aerospace companies and products, but the new ones joining are very diverse and bring capabilities from other industries. It is positive … On the one hand, you need to focus on core activities and specialisation, on the other hand, to integrate new activities, which creates a competitive advantage in the future.	Enrichment -positive, complementarity for competitive advantage, diversification for future competitiveness	

Source: Own elaboration based on verbatim expressions and own field notes.

Discussion

This section discusses the emerging peculiarities of a cluster profile in the digital time – the age of the Industry 4.0 (I4.0), touching upon the issues of cluster structure and the complexity of production, synchronising specialisation with diversification, branching, and bridging, and the I4.0 attributes facilitating complementarity.

Cluster structure and the complexity of production

The NACE divisions, groups, and classes, which are present in HAv (manufacture of aircraft, spacecraft and related machinery; repair and maintenance of aircraft and spacecraft; aerospace; telecommunications; programming, consultancy and related activities, information services;

architectural and engineering activities; technical testing and analysis; scientific research and development) are various, implying a certain degree of diversification. The HAv profile covers, indeed, a wide range of the aviation industry, with members active in technology and engineering, design, and production, as well as related services. The particular need for co-operation, including that of related sectors, is due to the complexity of the final product of aviation, and since producing aircraft means much more than simply manufacturing, it rather needs to be seen in terms of the intelligent technical production system, rich in complementary services and data processing.

Synchronising specialisation with diversification

Cluster members and experts agree that the adequate proportion of specialisation and diversification is different at each level, depending on the perspective and position of the company in the value creation hierarchy. One may speak about a specific, conditional balance. The tendency of clearly defined specialisation corresponds to the diagnosed trend of providing a broader portfolio of products and services, and implies that "diversification within the specialisation" co-exists with "specialisation in diversification". Dual membership in Hamburg clusters makes companies susceptible to cross-sectoral co-operation, which is particularly likely. When possible, co-operation is more universal.

Digitalisation undoubtedly poses a challenge for aviation. Cluster experts see this trend as a horizontal, cross-industry issue, and it is the task of the cluster authorities to exploit it in a way that does not simply seek excellence in a narrowly defined industry, but fosters co-operation across sectors. HAv companies agree that diversity is something beneficial in general. Each company should concentrate on its area of expertise, but there is a natural need to integrate more activities and competencies from the outside, as this increases efficiency, adaptation to market requirements, and competitiveness in the future.

Branching and bridging

The HAv case demonstrates more than the tendency of cluster enrichment by units representing related sectors; it also outlines the rise of related sub-specialisations owing to branching and the emergence of new areas, such as urban air mobility (UAM), including unmanned aerial vehicles (UAV). Companies originating in other sectors can valuably enrich the HAv composition, as their solutions can also prove useful in the aviation industry. Digital transformation provides the possibility of combining components in new ways. New sub-sectors, building on local expertise, can emerge as the case of light industry emancipation and the spin-off cluster, as the CFK Valley e.V. shows. In the light of digital transformation, the concept of mobility must be re-defined. In the future, it will not be possible to cope with new challenges only within one industry – the need for a broader perspective is evident.

As Hamburg clusters have their own path of development, the Ministry of Economic Affairs decided to facilitate cooperation among them by establishing a platform, which seems to be crucial in the digital revolution. The Co-Learning Space (https://www.co-learningspace.de) stimulates collaboration by advancing the joint use of technologies or developing specific solutions to common future problems. I4.0 tools and technologies facilitate clustering. They act like an adhesive that binds together a common thread that is of interest to representatives of different clusters.

I4.0 attributes facilitating complementarity

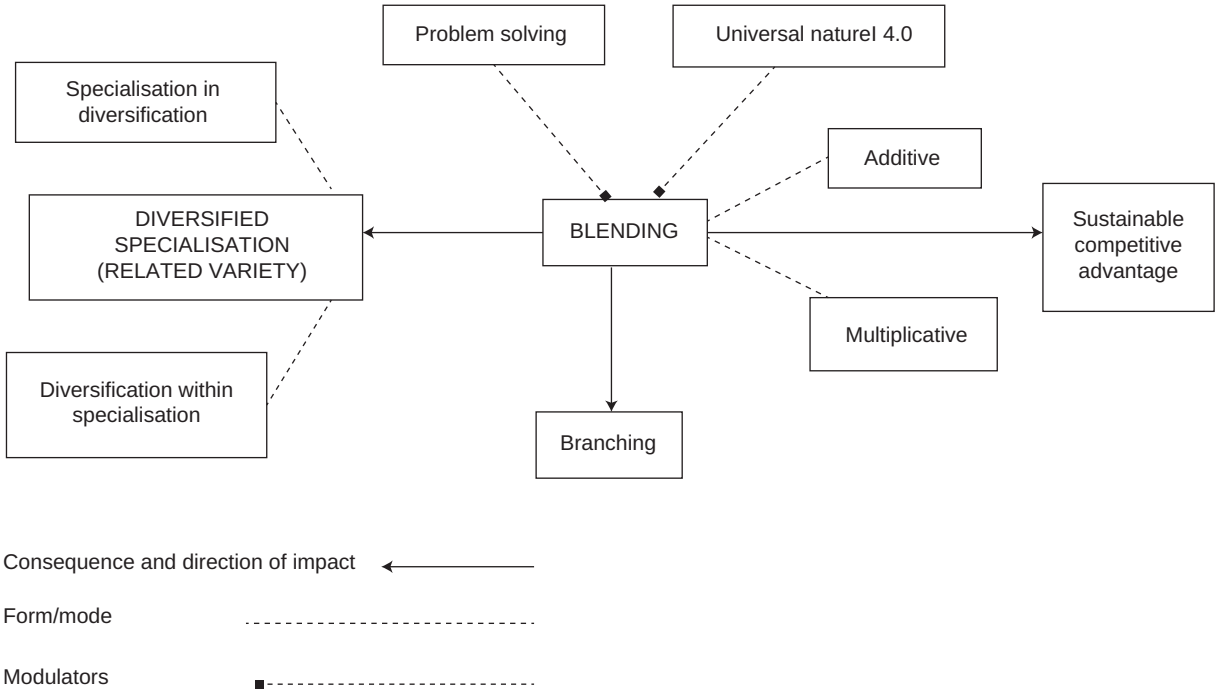
As recently re-iterated by Kourtit (2020), clusters do not rely merely on industrial linkages, but also on access to information, trust, and multiple connections to a wide array of actors. The sectoral expansion would benefit more from a more problem-oriented approach. Bringing members together around certain common challenges facilitates co-operation, which can be further augmented owing to the universal nature of many I4.0 technologies (Pagano et al., 2021). Certain HAv innovative solutions can be seen as general-purpose technologies (GPTs), stimulating extension in related areas. As cluster experts have stressed, the best method to encourage local actors to joint

work is to bring them together around the need to solve a specific challenge. The problem-oriented approach helps, because when actors face similar difficulties, they tend to seek common solutions. Various formats can facilitate cross-fertilisation, e.g. brainstorming sessions or worldwide coffee roundtables stimulating creative thinking.

According to entities operating in clusters, blending needs to be seen in the context of the growing demand for complementary competencies. Sectoral expansion and greater diversification in the aviation sector should, therefore, be in line with the principle of complementarity, which results in sustainable competitive advantages. More diversification, interlinked diversity, and blending all enhance the clusters' cohesion and sustainability, as they neutralise direct competition. There seems to be some consensus that it is necessary to focus on core activities and specialisation, but also to introduce and integrate new activities that will create a competitive advantage in the future (Dalmarco et al., 2019).

Emerging profile – how to strike a balance in a cluster profile

Following the methodological guidelines and iterative data collection and analysis, a contextualised explanation (Welch et al., 2022) of cluster profile changes in the I4.0 age has been developed. The empirically embedded interpretation states that **related variety** (***diversified specialisation***), encompassing both *specialisation in diversification* and *diversification within specialisation,* can be further developed by the **blending** process. This can lead to *branching* (the emergence of new subfields of activity, new subsectors) and is modulated by the *universal character of the I4.0* and a *problem-solving attitude.* It takes the form of an *additive (new entries)* or *multiplicative (spin-offs)* evolution, and, ultimately, owing to the *complementarity*, it can provide *sustainable competitive advantages*. The final Scheme 1 encapsulates the identified pattern and shows how HAv strikes the balance in its profile (between specialisation and diversification) by developing related variety and safeguarding blending processes.



Scheme 1. Cluster profile – striking the balance between cluster diversification and specialisation in the I4.0 time

Source: Own elaboration.

Related variety (understood here as diversified specialisation) in Hamburg aviation derives from the cluster structure and the complexity of production, and reflects the need to synchronise specialisation (focus on specific activities, usually limited to one industry) with diversification (a wider range

of activities, extending a narrowly-defined sector). In HAv, it arises, because the region covers the complete life cycle of aircraft and the entire value chain of aviation; it encompasses aerospace, aeronautics, aviation, production, and assembling, as well as maintenance-repair-overhaul (MRO) services. This co-existence and co-creation ("under one roof") are facilitated by the universal nature of the I4.0 (encompassing interrelated, general-purpose technologies GPT and KET key-enabling technologies such as additive manufacturing, cobots, Big Data, and cloud computing), and are heavily impacted by the nature of the aviation industry. In HAv, it takes the form of diversification within specialisation (offloading risks to outside firms; creating dedicated sub-entities) and specialisation in diversification (a company's wider portfolio, expanding activities, and sectoral coverage).

The role of relatedness reflects the matrix approach, adopted when the silos of vertical specialisation are linked via the universal cross-sectoral topics, societal mega trends in fact, like I4.0 – the digital transformation. The emerging HAv profile (understood here as diversified specialisation) derives from the synchronisation between specialisation and diversification defined by its members. Blending builds upon solving problems. Addressing jointly shared challenges seems to facilitate this sectoral expansion, which is also influenced by the universal, horizontal, or cross-sectoral nature of I4.0 technologies. This happens not only owing to the Cluster Organisation and dedicated initiatives, such as the co-learning and bridging or cross-clustering (round table, coffee camps, bars forum), but also by the spin-outs and new-born clusters. Adding new sectors and activities, i.e. the additive character of blending (new incoming actors), is accompanied by the multiplicative nature, with emerging spin-out clusters (e.g. CFK), with branching into new areas (e.g. UAV). Blending might prove critical for sustainability, as it can provide complementary competencies defining the future competitive advantage of cluster members, and the cluster itself.

Conclusions – limitations and a way forward

This paper explores the changing cluster profile in digital time – describing the nature of cluster in the age of the I4.0 by characterising the specialisation–diversification balance and drawing on the concepts of related variety and blending processes. This paper suggests the reconceptualisation of the cluster due to evolutionary dynamics between specialisation and diversification driven by I4.0 advancements. This study builds upon a narrative literature review (Gancarczyk, 2019), observatory participation, and 26 in-depth, semi-structured interviews with cluster members. It has certain limitations, mainly due to the nature of the adopted approach of the qualitative case study. The questions arise as to generalisability, the transferability of results, or possible subjective character of interpretations. Thus, there is a clear need for further studies, which should aim at, among other things: i) replicating the one conducted in Hamburg in other settings (countries/regions – clusters); ii) refining the scope of interviews and the range of issues raised in relation to digitally-modified profiles (such as the peculiarities of concrete digital technologies or business models); or simply iii) repeating the exact analysis in order to further explore the diagnosed dynamics ("test of time"). Nevertheless, the results obtained can contribute to the still uncharted stream of research on cluster–I4.0 relations. Drawing on the HAv case, and by discussing the emerging specialisation–diversification balance (framed in the concepts of related variety and blending), this paper aims to describe the evolving cluster profile, arguably observed in the digital age. It can contribute to still scant literature on meso-level aspects of digital transformation (as most studies focus on macro-economic dimensions, such as the country's performance in digital transformation – DESI, etc., or micro-firm level issues, e.g. maturity or I4.0 readiness). It provides a diagnosis of the importance of diversified specialisation (RV) as a key dimension of the I4.0 cluster's attractiveness, and the identification of the nature of blending. It speaks to recent calls for an industrial policy, which in the I4.0 era (Bianchi et al., 2019) is place-based and works at the intersection of technology and territories (Bellandi et al., 2019). Exploring normative questions is of even more relevance in the light of cluster evolution, which stipulates that a certain level of diversity (avoidance of too-homogenous structures) is critical for a cluster's long-term existence and prosperity (Fornahl et al., 2018). Safeguarding the development of related variety (understood as diversified specialisation or synchronisation of specialisation with diversification), along with smart modelling of cluster blending, might be seen as the new transformative place-based policy (MAKERS 7.12.2018, CEPS

Brussels). Summing up the contribution of this qualitative, case-study-based research should be understood in terms of contextualised explanation (Welch et al., 2022); as an exploration of the cluster profile (specialisation–diversification balance) during digital transformation, drawing on the concepts of RV and blending, which are illuminating the need to synchronise specialisation with diversification. This paper argues that the specialisation and diversification dichotomy could be outdated in complex economic and technological relations in the I4.0 era. The case study of the HAv cluster stresses the peculiarities of a cluster profile in digital times. It argues that related variety can be developed by blending processes which may provide complementarity safeguarding sustainable competitive advantages. The results obtained may advance still a relatively less known area of the cluster–Industry 4.0 nexus.

An adopted relational research approach (Feldman & Storper, 2018), which integrates the context, path dependency, and contingency factors, yields more authentic and empirically-grounded findings (Magnani & Gioia, 2023), which may serve as a departure point for prospective research. The practical implications offered by this study arise from the fact that the adopted case study approach enables comprehensive sense-making of the changing cluster profile in the digital age. It allows light to be shed on the mechanisms behind the complexities of the development of related variety and blending (Welch et al., 2011). The identified specificities and patterns seem aligned with the benefits of cluster diversification, diagnosed in the recent literature (Turkina & Oreshkin, 2022; Bellandi et al., 2019) as a factor contributing to cluster renewal. The insight provided in the natural setting from actors directly involved in the ongoing process should be harnessed for evidence-based policymaking aiming at strengthening regional innovativeness and competitiveness formidably impacted by digital transformation.

Reference List

Aarstad, J., Kvitastein, O. A., & Jakobsen, S. E. (2016). Related and unrelated variety as regional drivers of enterprise productivity and innovation: A multilevel study. *Research Policy*, *45*(4), 844–856.

Bathelt, H., & Glückler, J. (2018). Relational Research Design in Economic Geography. In G. L. Clark, M. P. Feldman, M. S. Gertler, D. Wójcik (Eds.), *The New Oxford Handbook of Economic Geography*. Oxford University Press.

Bailey, D., & De Propris, L. (2020). Industry 4.0 and transformative regional industrial policy. In L. De Propris, D. Bailey (Eds.), *Industry 4.0 and Regional Transformations* (pp. 230–252). Routledge.

Bellandi, M., Santini, E., Vecciolini, C., & De Propris, L. (2020). Industry 4.0: Transforming local productive systems in the Tuscany region. In L. De Propris, D. Bailey (Eds.), *Industry 4.0 and Regional Transformations* (pp. 84–96). Routledge.

Bellandi, M., De Propris, L., & Santini, E. (2019). Industry 4.0+ challenges to local productive systems and place based integrated industrial policies. In P. Bianchi, C. R. Durán, S. Labory (Eds.), *Transforming Industrial Policy for the Digital Age* (pp. 201–218). Edward Elgar Publishing.

Benitez, G. B., Ayala, N. F., & Frank, A. G. (2020). Industry 4.0 innovation ecosystems: An evolutionary perspective on value cocreation. *International Journal of Production Economics*, *228*, 107735.

Bianchi, P., Durán, C. R., & Labory, S. (Eds.). (2019). *Transforming Industrial Policy for the Digital Age*. Edward Elgar Publishing.

Billing, C. A., & Bryson, J. R. (2019). Heritage and satellite manufacturing: Firm-level competitiveness and the management of risk in global production networks. *Economic Geography*, *95*(5), 423–441.

Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies*, *39*(1), 61–74.

Boschma, R., & Frenken, K. (2011). The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, *11*(2), 295–307.

Bräuninger, M., Döll, S., Nolte, A., & Wohlers, E. (2010). *Zukunftsperspektiven der Luftfahrtindustrie – Chancen und Risiken für das Luftfahrtcluster in der Metropolregion Hamburg*. Hamburgisches WeltWirtschaftsInstitut.

Breznitz, D., (2021). *Four Are Better Than One—But First, Let Us Plan It Strategically, Innovation in Real Places: Strategies for Prosperity in an Unforgiving World* (online edn, Oxford Academic, March 18). https://doi.org/10.1093/oso/9780197508114.003.0006 (accessed: 30.10.2022).

Bustinza O. F., Vendrell-Herrero F., Santini E., Bellandi M., & De Propris L. (2017). MAKERS – Paper on servitization on manufacturing. http://www.makers-rise.org/wp-content/uploads/2016/04/Deliverable-1.2-protected.pdf (accessed: 30.10.2022).

Buxbaum-Conradi S., (2018). *Global and local knowledge dynamics in an industry during modular transition: A case study of the Airbus production network and the Aerospace Cluster in Hamburg, Northern Germany*. PhD Dissertation, Hamburg.

Cao, L., Navare, J., & Jin, Z. (2018). Business model innovation: How the international retailers rebuild their core business logic in a new host country. *International Business Review*, *27*(3), 543–562.

Cainelli, G., & Ganau, R. (2019). Related variety and firm heterogeneity. What really matters for short-run firm growth?. *Entrepreneurship & Regional Development*, *31*(9–10), 768–784.

CFK-Valley e.V. https://cfk-valley.com/en/association/club/.

Charmaz, K. (2009). Shifting the grounds: Constructivist grounded theory methods. In J. M. Morse et al. (Eds.), *Developing Grounded Theory: The Second Generation* (pp. 127–154). Routledge.

Co-Learning Space. https://www.co-learningspace.de

Content, J., & Frenken, C. (2016). Related variety and economic development: A literature review. *European Planning Studies*, *24*(12), 2097–2112.

Cooke, P. (2012). *Complex Adaptive Innovation Systems. Relatedness and Transversality in the Evolving Region. Regions and Cities.* Routledge.

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*, *26*(4–5), 475–491.

CPACS. https://www.dlr.de/lk/desktopdefault.aspx/tabid-4469/7258_read-39713/

Culot, G., Nassimbeni, G., Orzes, G., & Sartor, M. (2020). Behind the definition of industry 4.0: Analysis and open questions. *International Journal of Production Economics*, *226*, 107617.

Dalmarco, G., Ramalho, F. R., Barros, A. C., & Soares, A. L. (2019). Providing Industry 4.0 technologies: the case of a production technology cluster. *The Journal of High Technology Management Research*, *30*(2), 100355.

Delgado, M., Porter, M. E., & Stern, S. (2016). Defining clusters of related industries. *Journal of Economic Geography*, *16*(1), 1–38.

Denney, S, Southin, T., & Wolfe, D. A. (2021). Entrepreneurs and cluster evolution: The transformation of Toronto's ICT cluster. *Regional Studies 55*(2), 196–207.

Edmondson, A. C., & McManus, S. E. (2007). Methodological fit in management field research. *Academy of Management Review*, *32*(4), 1246–1264.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550.

Elekes, Z. (2014). Related Variety Research in Regional Economic Development. In É. Voszka, G. D. Kiss (Eds.), *Crisis Management and the Changing Role of the State* (pp. 169–178). University of Szeged Doctoral School in Economics.

Engel, J. S. (2014). Clusters of Innovation: Final thoughts. In J. S. Engel (Ed.), *Global Clusters of Innovation: Entrepreneurial Engines of Economic Growth around the World* (pp. 378–390*)*. Edward Elgar Publishing.

Enkel, E., & Gassmann, O. (2010). Creative imitation: Exploring the case of cross-industry innovation. *R&D Management*, *40*(3), 256–270.

Feldman, M., & Storper, M. (2018). Economic growth and economic development: Geographical dimensions, definition, and disparities. In G. L. Clark, M. P. Feldman, M. S. Gertler, D. Wójcik (Eds.), *The New Oxford Handbook of Economic Geography*. Oxford University Press.

Fitjar, R. D., & Timmermans, B. (2019). Relatedness and the Resource Curse: Is There a Liability of Relatedness? *Economic Geography*, *95*(3), 231–255.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219–245.

Fornahl, D., & Hassink, R. (Eds.). (2017). *The Life Cycle of Clusters: A Policy Perspective*. Edward Elgar Publishing.

Fornahl, D., Broekel, T., & Boschma, R. (2011). What drives patent performance of German biotech firms? The impact of R&D subsidies, knowledge networks and their location. *Papers in Regional Science*, *90*(2), 395–418.

Fornahl, D., Hassink, R., & Menzel, M. P. (2018). New Approaches on Cyclical Developments. In *Broadening Our Knowledge on Cluster Evolution* (pp. 12–14). London: Routledge.

Fratesi, U., & Rodríguez-Pose, A. (2016). The crisis and regional employment in Europe: what role for sheltered economies? *Cambridge Journal of Regions, Economy and Society*, *9*(1), 33–57.

Frenken, K., Van Oort, F., & Verburg, T. (2007). Related Variety, Unrelated Variety and Regional Economic Growth. *Regional Studies*, *41*(5), 685–697.

Fromhold-Eisebith, M. (2017). Intra-regional collaborative learning between cluster initiatives – a factor of cluster (policy) dynamics? In D. Fornahl, R. Hassink (Eds.), *The Life Cycle of Clusters: A Policy Perspective* (pp. 95–114). Edward Elgar Publishing.

Gancarczyk, M. (2019). The Performance of High-Growers and Regional Entrepreneurial Ecosystems: A Research Framework. *Entrepreneurial Business and Economics Review*, *7*(3), 99–123.

Gaschet, F., Becue, M., Bouaroudj, V., Flamand, M., Meunie, A., Pouyanne, G., & Talbot, D. (2017). Related variety and the dynamics of European photonic clusters. *European Planning Studies*, *25*(8), 1292–1315.

Giannini, V., Iacobucci D., & Perugini, F. (2019). Local variety and innovation performance in the EU textile and clothing industry. *Economics of Innovation and New Technology*, *28*(8), 841–857.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15–31.

Glaser, B., & Strauss, A. (1967). Grounded theory: The discovery of grounded theory. *Sociology*, *12*(1), 27–49.

Graebner, M. E., & Eisenhardt, K. M. (2004). The seller's side of the story: Acquisition as courtship and governance as syndicate in entrepreneurial firms. *Administrative Science Quarterly*, *49*(3), 366–403.

Grashof, N., Kopka, A., Wessendorf, C., & Fornahl, D. (2020). Industry 4.0 and clusters: Complementaries or substitutes in firm's knowledge creation? *Competitiveness Review*, *31*(1), 83–105.

Greening, D. W., Barringer, B. R., & Macy, G. (1996). A qualitative study of managerial challenges facing small business geographic expansion. *Journal of Business Venturing*, *11*(4), 233–256.

Grillitsch, M., Asheim, B., & Trippl, M. (2018). Unrelated knowledge combinations: The unexplored potential for regional industrial path development. *Cambridge Journal of Regions, Economy and Society*, *11*(2), 257–274.

Hassink, R., & Gong, H. (2019). Six critical questions about smart specialization. *European Planning Studies*, *27*(10), 2049–2065.

Ingstrup, M. B., & Menzel, M. P. (2019). The emergence of relatedness between industries: The example of offshore oil and gas and offshore wind energy in Esbjerg, Denmark. Papers in Evolutionary Economic Geography, 19.29. Utrecht University, Department of Human Geography and Spatial Planning, Group Economic Geography, the Netherlands.

Isaksen, A., Trippl, M., Kyllingstad, N., & Rypestøl, J. O. (2020). Digital transformation of regional industries through asset modification. *Competitiveness Review: An International Business Journal*, *31(1)*, 130–144.

Jacobs, J. (1969). *The Economy of Cities*. Vintage Books.

James, L., & Halkier, H. (2016). Regional development platforms and related variety: Exploring the changing practices of food tourism in North Jutland, Denmark. *European Urban and Regional Studies*, *23*(4), 831–847.

Johansen, F. H, Kerndrup, S., Andersson, G., & Rubach, S. (2020). A view of clustering as emergent and innovative processes. *Industry and Innovation*, *27*(4), 390–419. DOI: 10.1080/13662716.2020.1718618

Karafyllia, M., & Zucchella, A. (2017). Synergies and tensions between and within domestic and international market activities of firms. *International Business Review*, *26*(5), 942–958.

Kasabov, E. (2015). Start-Up Difficulties in Early-Stage Peripheral Clusters: The Case of IT in an Emerging Economy. *Entrepreneurship Theory and Practice*, *39*(4), 727–761.

Ketels, C., & Protsiv, S. (2021). Cluster presence and economic performance: a new look based on European data. *Regional Studies*, *55*(2), 208–220.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, *99*(3), 483–499.

Kuusk, K., & Martynovich, M. (2018). What kind of related variety for long-term regional growth? Papers in Evolutionary Economic Geography (PEEG), 1834. Utrecht University, Department of Human Geography and Spatial Planning, Group Economic Geography, the Netherlands.

Lanteri, A. (2021). Strategic drivers for the fourth industrial revolution. *Thunderbird International Business Review*, *63*(3), 273–283.

Lazzeretti, L., Capone, F., Caloffi, A., & Sedita, S. R. (2019). Rethinking clusters. Towards a new research agenda for cluster research. *European Planning Studies*, *27*(10), 1879–1903.

Magnani, G., & Gioia, D. (2023). Using the Gioia Methodology in international business and entrepreneurship research. *International Business Review*, *32*(2), 102097. https://doi.org/10.1016/j.ibusrev.2022.102097

MAKERS 7.12.2018, CEPS Brussels, https://www.makers-rise.org/makers-final-workshop-friday-7th-december-2018-brussels/

Martin, R., & Sunley, P. (2015). On the notion of regional economic resilience: Conceptualization and explanation. *Journal of Economic Geography*, *15*(1), 1–42

McCann, P., & Ortega-Argilés, O. (2014). The role of the smart specialisation agenda in a reformed EU cohesion policy. *Scienze Regionali*, *13*(1), 15–32.

Michailova, S., & Mustaffa, Z. (2012). Subsidiary knowledge flows in multinational corporations: Research accomplishments, gaps and opportunities. *Journal of World Business*, *47*, 383–396.

NACE Classification – https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Njøs, R., & Jakobsen, S. E. (2016). Cluster policy and regional development: Scale, scope and renewal. *Regional Studies, Regional Science*, *3*(1), 146–169. DOI: 10.1080/21681376.2015.1138094

Njøs, R. (2018). *The role of multilevel dynamics and agency in regional industry renewal*. Doctoral dissertation. University of Bergen, Norway. Available at: https://www.researchgate.net/publication/325285241_The_role_of_multilevel_dynamics_and_agency_in_regional_industry_renewal (accessed: 17.06.2018).

Njøs, R., Jakobsen, S. E., Wiig Aslesen, H., & Fløysand, A. (2017). Encounters between cluster theory, policy and practice in Norway: Hubbing, blending and conceptual stretching. *European Urban and Regional Studies*, *24*(3), 274–289.

Owens, M., Ramsey, E., & Loane, S. (2018). Resolving post-formation challenges in shared IJVs: The impact of shared IJV structure on inter-partner relationships. *International Business Review*, *27*(3), 584–593.

Pagano, A., Carloni, E., Galvani, S., & Bocconcelli, R. (2021). The dissemination mechanisms of Industry 4.0 knowledge in traditional industrial districts: evidence from Italy. *Competitiveness Review*, *31*(1), 27–53.

Puig, F. (2019). New insights regarding clusters and industrial districts. *Competitiveness Review*, *29*(3), 206–210, https://doi.org/10.1108/CR-03-2019-0033

Ryan, P, Buciuni, G, Giblin, M, & Andersson, U. (2020). Subsidiary upgrading and global value chain governance in the multinational enterprise. *Global Strategy Journal*, *10*, 496–519.

Szalavetz, A. (2022). The digitalisation of manufacturing and blurring industry boundaries. *CIRP Journal of Manufacturing Science and Technology*, *37*, 332–343.

Sedita, S. R., de Noni, I., & Pilotti, L. (2015). How Do Related Variety and Differentiated Knowledge Bases Influence the Resilience of Local Production System? *Paper in Innovation Studies*, *20*, CIRCLE, Lund University, Sweden.

Smith, M., Wilson, J. R., & Wise, E. (2020). Evaluating clusters: Where theory collides with practice. *Regional Science Policy & Practice*, *12*(3), 413–430.

Strauss, A., & Corbin, J. (1990). *Basics of Qualitative Research*. Sage Publications.

Tsang, E.W.K. (2022). Alternative typologies of case study theorizing: Causal explanation versus theory development as a classification dimension. *Journal of International Business Studies*, *53*, 53–63.

Turkina, E., & Oreshkin, B. (2022). Evolving industrial districts and changing innovation patterns: The case of Montreal. *Competitiveness Review*, *32*(5), 667–685.

Urquhart, C., Lehmann, H., & Myers, M. D. (2010). Putting the 'theory' back into grounded theory: Guidelines for grounded theory studies in information systems. *Information Systems Journal*, *20*(4), 357–381.

Uyarra, E. (2010). What is evolutionary about "regional systems of innovation"? Implications for regional policy. *Journal of Evolutionary Economics*, *20*(1), 115–137.

Vanninen, H., Kuivalainen, O., & Ciravegna, L. (2017). Rapid multinationalization: Propositions for studying born micromultinationals. *International Business Review*, *26*(2), 365–379.

Welch, C., Piekkari, R., Plakoyiannaki, E., & Paavilainen-Mäntymäki, E. (2011). Theorising from case studies: Towards a pluralist future for international business research. *Journal of International Business Studies*, *42*, 740–762.

Welch, C., Paavilainen-Mäntymäki, E., Piekkari, R., & Plakoyiannaki, E. (2022). Reconciling theory and context: How the case study can set a new agenda for international business research. *Journal of International Business Studies*, *53*, 4–26.

Whittle, A., & Kogler, D. F. (2020). Related to what? Reviewing the literature on technological relatedness: Where we are now and where can we go? *Papers in Regional Science*, *99*(1), 97–113.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Los Angeles, CA: Sage