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АГЛОМЕРАЦІЯ, МЕРЕЖІ ТА ІНСТИТУЦІЙНА ПІДТРИМКА В ІННОВАЦІЙНІЙ АЕРОКОСМІЧНІЙ ГАЛУЗІ ЄВРОПИ

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AGGLOMERATION, NETWORKS & INSTITUTIONAL SUPPORT IN THE INNOVATIVE EUROPEAN AEROSPACE INDUSTRY

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Аннотація. *У цій статті розглядається взаємопов'язана роль агломерації, мереж та інституційних переваг у формуванні конкурентної динаміки європейської аерокосмічної промисловості. Взаємодія агломерацій, формальних та неформальних мереж, а також державних та приватних інституцій створює фундамент для інноваційного розвитку, високої ефективності та конкурентоспроможності європейської аерокосмічної галузі. Метою статті є аналіз такої взаємодії та виявлення шляхів забезпечення стійких конкурентних переваг підприємств і галузі в цілому в процесі своєчасного реагування на виклики з боку зовнішнього середовища.*

Аерокосмічна галузь характеризується технологічною інтенсивністю, складними ланцюгами створення доданої вартості та міцною співпрацею між державним та приватним секторами, що забезпечує унікальний контекст для аналізу того, як просторова концентрація, формальні та неформальні мережі, зв'язки співпраці та інституційні рамки спільно сприяють інноваціям та конкурентоспроможності. Ці принципи цілком відповідають ESG-концепції, яка захищає європейські цінності. Агломерація відображається в аерокосмічних кластерах, таких як Тулуза, Гамбург та Турин, де обмін знаннями, дослідження та розробки, пули кваліфікованої робочої сили, інтеграційні зв'язки та близькість постачальників підвищують ефективність діяльності компаній та інноваційний рівень галузі. Мережі, як формальні, так і неформальні, дозволяють компаніям керувати ланцюгами поставок, отримувати доступ до додаткових можливостей та інтегруватися в глобальні системи, тоді як інституційні переваги, що виникають в результаті політики ЄС, національних стратегій та спеціалізованих державних та приватних установ, забезпечують регуляторну стабільність та фінансування. Разом з тим, компанії аерокосмічної галузі постійно стикаються з серйозними викликами, що можуть вплинути на їх стійкий розвиток. Серед найбільших викликів у статті відзначено інтенсивну глобальну конкуренцію, необхідність пошуку альтернативних джерел енергії, геополітичні ризики, нестача кваліфікованої робочої сили і масштабного інвестування, кібернетичні безпекові ризики.

Застосовуючи конфігураційний аналіз, автори висвітлюють, як ці три виміри- агломерація, мережі та інституційна підтримка - взаємодіють, реагуючи на виклики та створюючи кумулятивні переваги, що лежать в основі лідерства Європи в аерокосмічній галузі.

Ключові слова*: ESG концепція, агломерація, мережа, інституціональна підтримка, екосистема, європейська аерокосмічна галузь, стійкий розвиток, ефективність, інновації, конкурентоспроможність.*

Формул:0, рис.: 1, табл.:2, бібл.: 10

Abstract. *This article examines the interrelated role of agglomeration, networks and institutional advantages in shaping the competitive dynamics of the European aerospace industry. The interaction of agglomerations, formal and informal networks, and public and private institutions creates the foundation for innovative development, high efficiency and competitiveness of the European aerospace industry. The aim of the article is to analyze such interactions and identify ways to ensure sustainable competitive advantages of enterprises and the industry as a whole in the process of timely response to challenges from the external environment. The aerospace industry is characterized by technological intensity,*

complex value chains and strong cooperation between the public and private sectors, which provides a unique context for analyzing how spatial concentration, formal and informal networks, collaborative ties and institutional frameworks jointly promote innovation and competitiveness. These principles completely correspond with ESG conception which provides European values. Agglomeration is reflected in aerospace clusters such as Toulouse, Hamburg and Turin, where knowledge sharing, research and development, pools of skilled labour, integration links and proximity to suppliers increase the efficiency of companies and the innovation level of the industry. Networks, both formal and informal, allow companies to manage supply chains, access additional opportunities and integrate into global systems, while institutional advantages resulting from EU policies, national strategies and specialized public and private institutions provide regulatory stability and financing. At the same time, aerospace companies constantly face serious challenges that may affect their sustainable development. The article notes intense global competition, the need to find alternative energy sources, geopolitical risks, the shortage of skilled labour and large-scale investment, and cyber security risks.

Using configurational analysis, the authors highlight how these three dimensions – agglomeration, networks and institutional support – interact to respond to challenges and create the cumulative advantages that underpin Europe's leadership in aerospace.

Keywords: *ESG conception, Agglomeration, Network, Institutional support, Ecosystem, European Aerospace, Sustainable development, Effectiveness, Innovation, Competitiveness.*

Formula:0, fig.: 1, tab.: 2, bibl.: 10

Statement of the problem: The European aerospace industry is a global powerhouse, defined by its technological sophistication, high-value manufacturing, and economic significance. Its competitiveness is not merely the product of individual firm capabilities but is embedded in the strategic organization of its ecosystem. Companies of aerospace industry operate and develop in compliance with ESG conception, which mean that the interaction between Environmental, Social and Governance. In the Environmental aspect aerospace companies seek alternative sources of energy, in Social aspect they build steady and effective relations with all stakeholders, and in Governance they demonstrate qualitative and transparent managerial models. This article argues that three interdependent elements—agglomeration, networks, and institutional advantages—are essential to understanding the sector's innovative potential and enduring strength. The central research question is: How do agglomeration effects, network structures, and institutional advantages interact to produce regional performance in European aerospace. Rather than treating these drivers as independent, this study adopts a configurationally perspective to explore how specific combinations of conditions create distinct pathways to competitiveness.

Analysis of recent publications: Agglomeration, the geographical clustering of interconnected companies, specialized suppliers, service providers, and associated institutions in a particular field, generates external economies of scale and scope. Within the aerospace sector, this translates into shared labor pools, specialized knowledge spillovers, and efficient supply chain logistics (Aviation, 2025). Complementing this spatial proximity are robust network structures, encompassing formal and informal collaborations between firms, research institutions, and governmental bodies. These networks facilitate knowledge exchange, joint R&D, and risk sharing, crucial for an industry with high development costs and long project cycles. Finally, the institutional landscape, including regulatory frameworks, intellectual property rights, educational systems, and regional development policies, provides the essential scaffolding upon which agglomeration and networks can thrive.

The purpose of the article: This article will delve into each of these dimensions, examining their individual contributions and, more importantly, their synergistic relationships in fostering competitive advantage within the European aerospace industry. Through this analysis, we aim to offer insights into policy implications for sustaining and enhancing Europe's leadership in this critical sector.

Research methodology. This study employs a configurationally approach to examine the interaction of agglomeration, inter-firm networks, and institutional advantages in shaping competitiveness in the European aerospace industry. Using industry

statistics, case studies of clusters (Toulouse, Hamburg, Turin, and Aerospace Valley), and insights from Qualitative Comparative Analysis (QCA), the paper demonstrates that no single factor explains regional performance. Instead, high-performing hubs emerge from specific combinations of localized knowledge spillovers, robust supply-chain networks, and targeted institutional support from EU programs, national policies, and cluster organizations (Aviation, 2025). The European aerospace industry is a knowledge- and capital-intensive sector characterized by long product cycles, tightly integrated supply chains, and substantial public–private interaction (Facts & Figures 2024). Recent figures indicate the combined aerospace and defense sector accounts for nearly €290.4 billion in turnover and employs over 1 million people across Europe (ASD Facts & Figures, 2024). Within this macro-picture, the industry is geographically concentrated in several high-performing hubs — notably Toulouse (France), Hamburg (Germany), Turin (Italy) and the French Aerospace Valley cluster — where high-skill labor, specialized suppliers, and research institutions concentrate. Agglomeration theory traces back to Marshall (1890) and later cluster and industrial district literatures (e.g., Porter, 1995). In aerospace, spatial concentration produces benefits from knowledge spillovers, labour market pooling, and supplier proximity — critical when complex systems integration, certification and iterative R&D matter (Aviation, 2025). Toulouse and Hamburg exemplify these dynamics, with large anchor firms (Airbus, satellite and systems firms) and dense supplier networks (European Commission. (2021)).

Agglomeration refers to the benefits derived from the geographical concentration of economic activity. For the aerospace industry, these benefits are particularly pronounced due to the complex nature of its products, the need for highly specialized skills, knowledge, innovations and extensive supply chains.

We distinguish such types of agglomeration advantages:

1/ High quality workforce pooling: a concentrated industry creates a deep pool of specialized workforce, reducing search costs for firms and offering diverse employment opportunities for skilled workers (Marshall, 1920).

2/ Specialized Inputs & Services: The presence of numerous aerospace firms attracts specialized suppliers and service providers (e.g., precision machining, advanced materials, engineering consulting), creating a local ecosystem of expertise (Porter, 1995).

3/ Knowledge Spillovers: Proximity facilitates informal interaction, knowledge sharing, and learning among firms and individuals, accelerating innovation. This is often termed "untraded interdependencies" (Storper, 1995).

Europe hosts several prominent aerospace clusters, each with distinct specializations and historical trajectories (Fig.1). The article highlights some of them:

-Toulouse, France: The famous center of Airbus's commercial aircraft operations, which includes engineering, vast network of suppliers, R&D facilities and a final assembly lines.

-Hamburg, Germany: One of the major Airbus site, specialized on overhaul (MRO) activities and fuselage sections, including cabin outfitting, and maintenance, repair, and (European Commission. (2021)).

-Bristol, UK: An important hub for aerospace design and manufacturing. It characterized with a systems integration, strong presence in aerostructures, engines. Besides, it includes Rolls-Royce and Airbus engineering centers.

-Bavaria, Germany: It occupies such successful companies as MTU Aero Engines, EADS/Airbus Defense and Space, and numbers of SMEs specializing in military aviation, space technology, and propulsion systems (European Commission. (2021)).

-Northern Italy (Piedmont, Lombardy): This cluster is concentrated on aerostructures, like regional aircraft (Leonardo), and helicopter manufacturing, having strong advantages in perspective composites and avionics.

Table 1

Map of Key European Aerospace Agglomeration Zones

Cluster Location	Primary National Contributor	Key Activities / Specializations	Prominent Companies (Examples)
Toulouse, France	France	Commercial aircraft final assembly, engineering, R&D	Airbus, ATR, Thales Alenia Space
Hamburg, Germany	Germany	Fuselage sections, cabin outfitting, MRO, space components	Airbus, Premium AEROTEC, Lufthansa Technik
Bristol, UK	United Kingdom	Aerostructures, engine design, systems integration	Airbus (engineering), Rolls-Royce, GKN Aerospace
Bavaria, Germany	Germany	Military aviation, space, propulsion, defense electronics	Airbus Defense and Space, MTU Aero Engines, Hensoldt
Northern Italy	Italy	Regional aircraft, helicopters, aerostructures, advanced composites	Leonardo, GE Avio Aero, DEMA
Andalusia, Spain	Spain	Military transport aircraft, aerostructures, maintenance	Airbus Defense and Space (Seville), Aernnova
Linköping, Sweden	Sweden	Fighter aircraft (Saab Gripen), defense systems, UAVs	Saab Aeronautics

Source (European Commission. (2021))

Figure 1: Map of Key European Aerospace Agglomeration Zones

Source (Work programme and budget 2024–2025)

Agglomeration theory traces back to Marshall (1890) and later cluster and industrial district literatures (e.g., Porter, 1990). In aerospace, spatial concentration produces benefits from knowledge spillovers, labour market pooling, and supplier proximity — critical when complex systems integration, certification and iterative R&D matter (Aviation, 2025). Toulouse and Hamburg exemplify these dynamics, with large anchor firms (Airbus, satellite and systems firms) and dense supplier networks.

Networks in aerospace are both vertical (multi-tier suppliers) and horizontal (consortia, research partnerships). Strong network ties reduce transaction costs, enable modular production, and facilitate rapid knowledge recombination. The literature on cluster intermediation highlights the role of boundary-spanning organizations in linking SMEs to prime contractors and research labs. Institutional advantages refer to policy, regulatory stability, public procurement, R&D funding, and supporting organizations (clusters, technology centres) (Speldekamp, D. (2020/2023)). EU programmes (Horizon Europe, Clean Aviation) and national industrial strategies shape investment incentives and technical roadmaps. Institutional structures also influence the formation of consortia (e.g., Clean Aviation Joint Undertaking projects) and technological priorities (decarbonisation, digitalisation) (Opportunities and challenges arising from European sustainable aviation fuel regulations). Configurational methods, such as Qualitative Comparative Analysis (QCA), allow researchers to identify combinations of conditions associated with outcomes (Speldekamp, D. (2020/2023)). Prior work has applied configurational analysis to European aerospace clusters, showing multiple pathways to innovation performance depending on cluster composition, intermediation, and institutional embedding (Facts & Figures 2024).

We would like to analyze some Case studies of aerospace clusters which reveals specificity of clusters and their environmental effects. It helps to better understand how aerospace clusters function in practice. These clusters differ not only in their industrial structure and institutional background, but also in how they respond to growing environmental pressure on the aerospace sector. In particular, recent developments show that clusters increasingly influence technological change related to hydrogen use, emission reduction, and carbon-intensive production. So, those are the most significant European aerospace clusters:

-Toulouse (France). The Toulouse region is often described as the main center of the European aerospace industry. The presence of Airbus headquarters and final assembly lines has led to the formation of a dense local network of suppliers, research institutes, and engineering schools. What makes this cluster distinctive is the close and long-term cooperation between industrial and scientific actors. In recent years, this cooperation has increasingly focused on environmental challenges. Toulouse plays an important role in the development of hydrogen-powered aircraft concepts, mainly through Airbus-led projects and joint research with ONERA and local universities. These activities aim to move away from conventional kerosene-based propulsion, which directly affects carbon emissions and the use of oxygen in combustion processes. Although large-scale application is still distant, the cluster already influences the direction of technological change in European aviation by prioritizing low-carbon solutions;

- Hamburg (Germany). Hamburg represents a different type of aerospace cluster, with a strong focus on manufacturing, aircraft systems, and maintenance activities. Its development is closely linked to Airbus production facilities and a well-established vocational training system. Compared to Toulouse, environmental innovation in Hamburg is less centered on radical propulsion change and more on gradual improvement. Cluster firms and research institutions work on weight reduction, fuel efficiency, and cleaner production processes. These efforts contribute to lowering carbon emissions across the aircraft life cycle rather than replacing combustion entirely. At the same time,

research on hydrogen-compatible systems and alternative fuels is gaining attention, supported by Germany's broader climate and industrial policies. In this sense, Hamburg's ecological impact is mainly incremental but still significant;

- Turin agglomeration (Italy). The aerospace cluster in the Turin area has developed through a long industrial tradition, particularly in defense and space-related activities. Large firms such as Leonardo, together with a network of specialized suppliers, shape the cluster's technological profile. Environmental issues have only recently become more visible within this agglomeration. Current initiatives focus on improving energy efficiency, reducing material use, and adapting existing technologies to meet stricter environmental standards. While hydrogen-based propulsion is not yet a central focus, research on hybrid systems and advanced materials indirectly supports future decarbonization efforts. As a result, the cluster's influence on hydrogen and carbon reduction remains limited but shows signs of gradual adjustment to European environmental goals;
- Aerospace Valley (South-West France). Aerospace Valley differs from the other cases, as it operates mainly as a formal cluster organization rather than a single concentrated location. Its main task is to connect companies, research institutions, and public authorities and to support joint innovation projects. Environmental sustainability has become one of its declared priorities. The cluster actively promotes research on hydrogen technologies, sustainable aviation fuels, and more environmentally friendly manufacturing processes. By coordinating projects and supporting smaller firms, Aerospace Valley helps spread low-carbon technologies across the regional aerospace industry. This contributes to reducing carbon emissions and encourages alternatives to traditional oxygen-dependent combustion systems.

Rethinking the advantages of clustering in aerospace, we would like to emphasize the next ones.

The concentration of aerospace activities in specific regions creates advantages that go beyond cost savings or scale effects. One important aspect is the accumulation of experience and skills in a limited geographical area. It means Knowledge Spillovers and Diffusion of Innovations effect. Researches also noted spontaneous knowledge sharing, benchmarking, and the cross-pollination of ideas in a regional level (Audretsch & Feldman, 1996). Innovation Engineers, technicians, and researchers often move between firms within the same region, which helps maintain a shared knowledge base. This is particularly important when new environmental requirements demand new competencies, such as hydrogen safety or emissions monitoring.

Another advantage lies in the close coordination between firms and suppliers. When production and development take place nearby, changes in design or materials can be tested and adjusted more quickly. This flexibility becomes increasingly relevant as firms attempt to reduce carbon footprints and comply with stricter environmental regulations.

Finally, clusters provide spaces where ideas circulate more easily. Not all innovation comes from formal projects; many solutions emerge through repeated interaction and informal exchange. Universities and research centers located within clusters play a key role in translating environmental policies into practical technological solutions. In this way, aerospace clusters influence not only industrial performance but also the ecological direction of the sector.

On the other side, governmental support (the third forth of agglomeration, networks and government unity) is crucial for the innovative development of the industry, providing significant institutional advantages and the Guiding Frameworks. Actually, the success of European aerospace is deeply intertwined with the supportive and regulatory frameworks provided by national governments and supranational bodies. The high-value, high-skill nature of the aerospace industry within these agglomerations creates a profound

multiplier effect on the regional economy. For every direct aerospace job, approximately 2.6 indirect jobs are created in supporting sectors, underscoring the extensive ripple effects throughout the economic landscape. This broad base of indirect employment and economic activity extends to various supporting industries, including IT services, specialized engineering, and advanced logistics. Furthermore, the substantial sunk costs associated with developing aerospace infrastructure, specialized equipment, and a highly trained human capital base within these clusters generate a phenomenon known as "sticky capital." These are investments that are difficult and costly to relocate, thereby ensuring long-term economic stability and sustained growth for the regions hosting these agglomerations. This inherent stability and the significant broader economic benefits mean that governments and regional authorities should view aerospace agglomerations not just as industrial hubs, but as long-term strategic assets. Providing sustained support to these clusters is crucial for maximizing their extensive economic benefits and ensuring the retention of high-value capital and jobs within the region. Among the most significant governance institutions it is worth mentioning the following ones:

-The European Union (EU) and its Single Market, where the EU's role is foundational. It provides a vast, single market that allows for the free movement of goods, capital, and labor, reducing trade barriers and enabling economies of scale. Furthermore, the EU implements a specific industrial policy for aeronautics, promotes sustainable competitiveness, and engages in trade diplomacy to secure a level playing field globally;

-European Space Agency (ESA). It is not an EU agency, but an independent intergovernmental organization that coordinates the activities of its member states in the airspace sphere. Gathering financial and scientific resources, ESA enables projects like the Ariane launchers, the Galileo satellite navigation system, and the Copernicus Earth observation program. These projects would be impossible for any single European country to undertake, and they provide Europe with strategic autonomy and a leading position in the global space sector;

-National and Supranational Regulation. Regulatory bodies like the European Union Aviation Safety Agency (EASA) are critical. EASA's harmonized standards ensure the safety and airworthiness of European-manufactured products, building international trust and facilitating global exports. Similarly, the ongoing development of an EU Space Law aims to provide a clear and stable regulatory framework for the burgeoning "New Space" industry, encouraging investment and innovation (Speldekamp, D. (2020/2023)). These advantages discover the basic principles of Environmental, Social and Governance aspects, and their effective interaction.

We are deeply convinced that the role of such institutions in the innovative development of aerospace sphere is crucial, and without this valuable support, clusters cannot realize their basic advantages.

Despite of great opportunities, clusters face a lot of challenges.

While the European aerospace industry has a strong foundation, it meets significant headwinds:

Table 2

Challenges and Policy Responses in European Aerospace Agglomerations

Challenge	Description of Challenge	Key Impacts	Corresponding Policy Response/Initiative	Policy Objective
Supply Chain Resilience	Vulnerabilities due to geopolitical tensions, material shortages, and multi-tiered, complex networks.	Production bottlenecks, increased costs, fragility of just-in-time logistics, cascading disruptions.	Strategic measures (multi-sourcing, near shoring, stockpiling), adoption of AI/digital twins for visibility, EACP Supply Chain & Technology Working Group.	Enhance transparency, increase agility, mitigate disruptions, build robust supply chains.
Skills Gap & Workforce Shortages	Aging workforce, loss of institutional knowledge, demand for new skills (AI, advanced manufacturing) not met by current talent pool.	Innovation slowdown, production constraints, reduced competitiveness, difficulty attracting young talent.	Investment in apprenticeship programs, university partnerships, reskilling initiatives, EACP Skills Working Group, EU's "Year of Skills" initiative.	Develop future-proof skills, ensure knowledge transfer, attract new talent, maintain a skilled workforce.
Technological Disruption & Cybersecurity Threats	Rapid digital transformation introduces new vulnerabilities and increased cyber-attack surface.	Data breaches, intellectual property theft, operational disruptions, security risks to critical infrastructure.	Integration of AI/digital twins for efficiency, EU Vulnerability Database (EUVD), strong cybersecurity measures.	Safeguard IP, ensure operational continuity, protect critical infrastructure, and enhance digital resilience.
Intensifying Global Competition	Strong competition from US and China, lower investment levels in some sectors (e.g., space), reliance on external suppliers.	Reduced market share, risk of export controls/sanctions, pressure on innovation pace.	EU industrial strategy, EU Space Program , Aviation Research and Innovation Strategy (ARIS), emphasis on "technological sovereignty."	Maintain global leadership, reduce strategic dependencies, foster domestic capabilities, accelerate innovation.

Source (Speldekamp, D. (2020/2023))

Among the biggest challenges we can distinguish:

-Intensifying Global Competition: The industry is locked in a fierce rivalry with established players like the US (Boeing, Lockheed Martin) and increasingly with new, well-funded entrants from China. This pressure requires Europe to continuously innovate and enhance its efficiency.

-The Sustainability Imperative. From ecological perspective, the global push for decarbonization is a major challenge. The aerospace industry must accelerate the development of disruptive technologies like Sustainable Aviation Fuels (SAFs), hydrogen propulsion, and hybrid-electric aircraft. This will require massive investment and coordinated R&D efforts.

-Supply Chain Resilience. Recent global events have exposed vulnerabilities in the complex supply chain. The industry must build greater resilience to geopolitical risks, material shortages, and other disruptions.

-Digital Transformation and "New Space". The rise of digital manufacturing, AI, and the "New Space" economy (driven by private enterprise and smaller satellites) is forcing a strategic shift. The traditional model of large, government-led space projects is being challenged. European firms must adapt their business models and embrace new technologies to remain competitive.

-Skills Gap & Workforce Shortages. It is extremely needed to intensify the processes of learning, training and development to

prepare innovative people capable to make creative decisions.

To address these challenges, the European aerospace sector must continue to leverage its unique strengths. This includes reinforcing its existing clusters, building even stronger and more resilient networks, and ensuring that its institutional frameworks are agile and forward-looking, capable of supporting the next generation of aerospace technologies and business models.

Implementing the ESG principles requires the essential improving conditions for innovations, including environmental, social, and governance aspects, allowing aerospace industry to evaluate sustainable and ethical practices .

Conclusion. Agglomeration, networks, and institutional advantages jointly shape the performance of European aerospace clusters. Successful regional pathways combine anchor companies, supplier ecosystems, strong research institutions, and proactive institutional supports. They actively interact in compliance with the main components of ESG conception, providing environmental, social and governance policy. For policymakers, the key recommendation is to strengthen existing regional assets through complementary policies rather than attempting one-size-fits-all solutions. Future research should expand comparative studies between European clusters and those in the US and China, with special attention to sustainability, digital transformation, and strategic autonomy. As the industry faces challenges from decarbonization, resources shortage and other environmental problems, supply chain resilience, and global competition, leveraging these interdependencies will remain critical for maintaining Europe's leadership in aerospace. For companies we recommended to strengthen their leadership in innovation, invest to human capital, continual learning, training and development, to implement advantages of public-private partnership and to open new sources and possibilities for sustainability and growth.

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