

The Concept of Clustering and Its Role in the Economic Development of the State

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ABSTRACT: The article examines the essence of clustering as a strategic mechanism for the development of the modern economy and for strengthening national competitiveness. The definition of the term “cluster” is clarified, and the theoretical foundations of its formation are presented, including the contributions of A. Marshall and M. Porter to the evolution of the conceptual framework. A historical review of cluster development is conducted, ranging from industrial agglomerations of the nineteenth century to the emergence of high-technology clusters in the United States, the European Union, Japan, South Korea, Taiwan, Singapore, and China. Special attention is given to the role of clusters in the structural transformation of national economies, the development of export potential, the enhancement of innovation activity, the digitalization of production processes, and the consolidation of technological sovereignty. The study demonstrates that clustering increases productivity, supports the formation of a highly skilled labor force, and facilitates the integration of countries into global value chains. It concludes that the cluster approach represents a sustainable and reproducible instrument of long-term economic development that remains highly relevant amid global competition and ongoing digital transformation.

KEYWORDS: clustering; economic development; competitiveness; industrial policy; innovation; regional economy; value added; industrial cooperation; digital transformation; historical evolution of clusters; technology clusters; export potential.

INTRODUCTION

The modern global economy is undergoing a profound structural transformation driven by the increasing complexity of production networks, the rising importance of technology, and intensified global competition. Under these conditions, traditional instruments for stimulating industrial development—targeted subsidies, the creation of isolated industrial zones, or the selective support of individual enterprises—no longer provide the necessary growth dynamics. What is required is a model capable of forming a stable ecosystem of mutually complementary industries, scientific institutions, infrastructure, and human capital. This function is fulfilled by clustering, which has gradually evolved from a theoretical concept into a practical tool of national economic strategy.

Today, a cluster is understood not merely as a group of factories or firms located in one area, but as a dynamic and dense network of economic agents interconnected through production, technological, and logistical chains. Within such systems, innovations spread more rapidly, joint investment projects emerge more easily, and favorable conditions are created for the development of new competencies and professional skills. Competition among cluster participants does not disappear; instead, it takes on a more productive form, encouraging companies to seek new solutions, improve product quality, and reduce production costs.

Thus, clustering functions not as a supplementary policy tool, but as a logical response to the challenges of a globalized economy. The formation of new-generation production and technological centers enables the synergy of business, science, and the state, creating long-term competitive advantages and strengthening economic resilience. The present study aims to define the concept of clustering, examine the prerequisites for the emergence of early clusters, and substantiate the key role this approach plays in the development of contemporary national economies.

LITERATURE REVIEW

The study of the cluster approach is grounded in a longstanding academic tradition. Its theoretical foundations were laid by A. Marshall, who in his 1890 work *Principles of Economics* justified the advantages of territorial concentration of enterprises through “localized externalities,” including a shared labor market, the presence of specialized suppliers, and accelerated knowledge diffusion. These ideas became the cornerstone for subsequent research on the spatial organization of economic activity.

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The second major stage is associated with the works of M. Porter. In *The Competitive Advantage of Nations* (1990), he defined clusters as a key element of national competitiveness, emphasizing the importance of sectoral, institutional, and innovation-driven interconnections. His “diamond model” became the methodological basis for cluster policies in the United States, Europe, and several East Asian countries.

European scholars also made a significant contribution to the development of cluster theory. The works of G. Becattini revealed the distinctive features of Italy’s “industrial districts,” where small and medium-sized enterprises play a central role within dense cooperative networks and strong local institutions. The German school, including research conducted by Fraunhofer institutes and the conceptual framework of the *Mittelstand*, highlighted the synergy between industry, engineering education, and applied science.

Contemporary literature underscores the role of clusters within global value chains and technological competition. Reports by the OECD, the European Commission, and the World Bank consistently demonstrate their importance in fostering innovation, increasing exports, and strengthening technological sovereignty. The U.S. Cluster Mapping Initiative and the research of C. Ketels, A. Saxenian, and M. Enright emphasize the resilience of cluster systems and their influence on regional economic development.

A separate body of work focuses on cluster development in East Asia. The experiences of Japan, Singapore, Taiwan, and China show that clusters can be effectively formed under conditions of strong government support, substantial infrastructure investment, and the active development of scientific and educational capacity. Programs such as Torch (China), Hsinchu Science Park (Taiwan), and the Industry 4.0 framework (Germany) demonstrate successful models of accelerated industrialization and technological modernization driven by clustering.

RESEARCH METHODOLOGY

The methodological foundation of the study is based on a comprehensive interdisciplinary approach that combines both theoretical and empirical methods of analysis. The theoretical and conceptual framework is formed on the basis of fundamental works by leading scholars in the field of territorial economic development, including studies by A. Marshall, M. Porter, and G. Becattini, as well as contemporary analytical materials produced by international organizations such as the OECD, the European Commission, and the World Bank, along with specialized research institutions in the United States, Germany, Japan, and China. This combination makes it possible to examine clustering as a structural component of economic growth and as an instrument for enhancing national competitiveness.

The research employs several key methodological tools. The historical-chronological method is used to identify the stages in the evolution of the cluster approach. The comparative-analytical method allows for the examination and comparison of clustering models across countries with different economic development trajectories. The systems approach ensures a holistic analysis of clusters as institutionally organized ecosystems that integrate industry, the scientific and educational sector, and governmental institutions. Special emphasis is placed on the principles of structural analysis, which make it possible to identify the interconnections between cluster mechanisms and macroeconomic indicators, including productivity, technological dynamics, export potential, and participation in global value chains.

The empirical component of the study is based on the analysis of official statistical data from international economic organizations, national industrial development programs, sectoral reports, and analytical reviews. The use of document analysis made it possible to systematize regulatory and strategic documents that reflect the practical implementation of cluster policies in various countries. To enhance the objectivity of the findings, a method of critical interpretation of sources was applied, aimed at comparing the positive effects of clustering with potential institutional and organizational risks.

Definition of Clustering

The formation of territorially concentrated production systems based on the close interconnection of enterprises, research institutions, and infrastructure organizations became one of the key directions of economic modernization in the late twentieth and early twenty-first centuries. In contemporary economic literature, clustering is understood as the process of creating and developing a group of interrelated companies and institutions that are geographically proximate and united by a common technological logic, shared infrastructure, and continuous knowledge exchange. This model combines elements of both competition and cooperation: firms compete in the marketplace while simultaneously collaborating in innovation, workforce development, and logistics, which generates sustainable economic benefits.

Historically, the idea of territorial concentration of production is not new. As early as the nineteenth century, industrial regions of England—Manchester, Birmingham, Lancashire—displayed characteristics of early cluster structures: factory concentration, shared labor markets, and interconnected infrastructure. The theoretical interpretation of these phenomena began

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with the works of A. Marshall, who in *Principles of Economics* (1890) introduced the concept of “localized externalities.” He identified three key advantages of industrial concentration: the formation of a skilled labor pool, the presence of specialized suppliers, and rapid knowledge diffusion.

However, the modern understanding of clusters emerged much later. A pivotal point was M. Porter’s *The Competitive Advantage of Nations* (1990), in which the author demonstrated that a country’s competitiveness is determined not by individual firms, but by “nodes of economic activity” endowed with synergistic advantages. Following the publication of this work, the cluster approach began to evolve rapidly within the industrial policies of developed economies.

Since the late 1990s, clustering models have been institutionalized at the policy level. In 1998, the United States launched the Cluster Mapping Initiative, which made it possible to systematically analyze the structure and dynamics of clusters. By 2023, more than 700 cluster formations had been identified in the U.S. economy, providing employment for approximately 63 million people, or about 45 percent of the country’s private-sector workforce. The European Union began actively promoting cluster policy after the adoption of the European Cluster Memorandum in 2007. According to the European Commission (2023), around 2.95 thousand clusters operate within the EU, generating over €5.3 trillion in added value and supporting 117 million jobs. In China, state support for clusters strengthened after the launch of the Torch program in 1988, and by 2022 the country had more than 1.3 thousand industrial clusters, including about 150 at the national level, collectively accounting for up to 35 percent of total industrial output.

So, clustering is not merely a spatial concentration of production facilities but a systemic mechanism of economic development that includes:

- territorial localization of enterprises and institutions;
- functional interconnections among participants across the entire value chain;
- shared use of infrastructure (laboratories, logistics, engineering services, training centers);
- institutional coordination (cluster associations, project offices, sectoral competence centers);
- an innovation framework, including joint research activities, digital data-exchange platforms, and collective technology adoption.

The key distinction between a cluster and an industrial park or a free economic zone lies in their value-creation mechanisms. While the latter rely primarily on physical infrastructure and tax incentives, a cluster develops intellectual, technological, and cooperative advantages that ensure sustained productivity growth and continuous technological renewal. According to estimates by the European Commission, labor productivity in mature clusters is 25–30% higher than the national average, whereas innovation adoption rates are up to 50% faster.

Consequently, clustering represents a fundamental element of modern economic strategy aimed at enhancing national competitiveness, accelerating structural transformation, and strengthening technological capacity. The formation of clusters creates conditions for deep reallocation of economic functions, modernization of production chains, and the development of export-oriented industries, making this mechanism one of the most effective instruments for long-term economic development.

The History of the Formation of Early Clusters

The emergence of cluster structures has deep historical roots dating back to the era of the First Industrial Revolution. As early as the mid-nineteenth century, stable territorial industrial concentrations displaying the characteristics of future clusters appeared in the United Kingdom and Germany. Between the 1830s and 1870s, Manchester and Lancashire became major centers of textile production, where factories, cotton exchanges, warehouses, and canal transport routes for raw materials were concentrated within a single agglomeration. A similar pattern developed in Germany’s Ruhr industrial region in the 1880s, where the integration of coal mining, metallurgy, and railway transport stimulated industrial expansion, technological specialization, and large-scale employment. Although these regions lacked a formal theoretical definition, they exhibited the core attributes of clusters: geographically concentrated and interlinked industries, shared infrastructure, and intensive knowledge exchange.

The theoretical interpretation of these processes became possible through the works of Alfred Marshall, who in *Principles of Economics* (1890) described the phenomenon of “industrial districts.” Marshall identified three mechanisms that generated the enduring advantages of such territories: a shared labor pool, specialized suppliers, and accelerated diffusion of production-related knowledge. These effects—difficult to quantify yet clearly observable in practice—formed the foundation for the later development of cluster theory, although throughout the first half of the twentieth century it remained largely descriptive.

The actual institutionalization of cluster principles began in the United States in the mid-twentieth century, driven by technological leaps and the rapid growth of the defense industry. The year 1951 is widely regarded as the starting point of Silicon Valley, marked by the establishment of Stanford Research Park, which concentrated research laboratories, start-ups, and university departments within one territory. What followed was a continuous cycle of technological entrepreneurial “branching”: the

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founding of Shockley Semiconductor in 1956, the creation of Fairchild Semiconductor in 1957, and the establishment of Intel in 1968 laid the foundations for a stable innovation ecosystem characterized by rapid knowledge transfer, venture financing, high engineer mobility, and a unified labor market. In parallel, during the 1950s and 1960s, the Route 128 corridor near Boston formed around MIT and Harvard, fostering the growth of firms specializing in electronic measurement and computing equipment. These developments were supported by active government funding of scientific programs and defense contracts, which further strengthened the concentration of high-technology capabilities.

In Europe, the formation of cluster structures followed a different trajectory. In the 1970s and 1980s, Italy saw the emergence of the industrial districts of Emilia-Romagna and Veneto. Thousands of small manufacturing firms—primarily in furniture, textiles, ceramics, and fashion—created flexible production networks built on trust, local banking systems, and horizontal division of labor. At the same time, in Germany, particularly in Baden-Württemberg and Bavaria, machinery and automotive hubs were developing, where Fraunhofer research institutes, technical universities, and medium-sized enterprises ensured the continuous reproduction of engineering competencies and the introduction of applied research. These examples demonstrated that clusters can be built not only around large technological corporations, but also through dense cooperation among small and medium-sized enterprises supported by a strong educational and scientific infrastructure.

In East Asia, clusters developed under conditions of strong government involvement. In Japan, after the launch of the Tsukuba Science City project in 1963, large-scale programs for creating science cities and industrial belts—Keihin and Hanshin—were initiated. Singapore, after establishing the Economic Development Board in 1961, systematically developed export-oriented industrial zones linked to port logistics and engineering education. Taiwan, following the opening of Hsinchu Science Park in 1980, became one of the world's leading centers for microelectronics. In China, the introduction of Special Economic Zones beginning in 1980, followed by the state-led Torch Program in 1988, became key milestones that supported the formation of high-technology clusters in Shenzhen, Pudong, Dalian, and Zhongguancun. Here, the cluster model evolved through a combination of industrial policy, infrastructure investment, and the integration of education, science, and production.

A conceptual and policy shift occurred at the end of the twentieth century. The theory of clusters was fully formalized in Michael Porter's *The Competitive Advantage of Nations* (1990). This publication established clusters as an instrument of national competitive strategy. Within a few years, institutional steps were taken: the launch of the U.S. Cluster Mapping Initiative in 1998, the establishment of the European Cluster Observatory in 2006, and the adoption of the European Cluster Memorandum in 2007. These initiatives led to the systematization of clusters, the creation of national registries, the development of innovation consortia, and the introduction of training programs tailored to the needs of a cluster-based economy.

The modern stage of cluster development is driven by digitalization and the rise of platform-based ecosystems. Since the 2010s, classical clustering mechanisms have been supplemented with digital cooperation platforms, joint testing laboratories, industrial analytics systems, and accelerated certification tools. The cluster is no longer solely a geographical formation; it is becoming a multi-level network of competencies, data, infrastructure, and standards capable of integrating multiple regions and international partners.

Table 1.¹: Chronology of Key Milestones (dated table)

No	Period	Country	Key Event/Mechanism
1.	1830-1870 yy.	United Kingdom	Manchester–Lancashire: textile “pre-cluster,” canals, exchanges
2.	1880 y.	Germany	Ruhr: metallurgy + coal + railways/ivers, synchronized logistics
3.	1890 y.	United Kingdom	A. Marshall: theory of localized externalities
4.	1903-1913 yy.	United States	Ford: assembly line, integration of component supply
5.	1917-1928 yy.	United States	River Rouge: full technological cycle of automobile manufacturing
6.	1951 y.	United States	Stanford Research Park: university as a cluster “anchor”
7.	1956-1968 yy.	United States	Shockley → Fairchild → Intel: spin-offs, venture loop
8.	1961-1968 yy.	Singapore	EDB, JTC: industrial parks + port logistics

¹ Compiled by the author based on the sources used

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9.	1963-1980 yy.	Japan	Tsukuba Science City: coordination by MITI/METI
10.	1970 y.	Italy	Industrial districts: SME networks, exports, shared services
11.	1973-1979 yy.	European Union (EU)	Oil shocks → modernization through cooperation and standards
12.	1979 y.	Denmark	Shift to wind energy; assembly/testing linkages
13.	1980 y.	China	Shenzhen SEZ: launch of the “cluster + SEZ” growth model
14.	1988 y.	China	Torch Program: framework for technoparks and high-tech zones
15.	1990 y.	–	M. Porter: theoretical canonization of clusters
16.	1998 y.	United States	Cluster Mapping Initiative: statistics and policy development
17.	2006-2007 yy.	European Union (EU)	ECO, ECM: institutionalization of cluster policy
18.	2010 y.	–	Platform ecosystems, interregional formats

Translation (high-quality, precise, academic English)

So, the history of cluster development reflects the evolution from local industrial districts of the nineteenth century to complex scientific and production ecosystems of the twenty-first century. At every stage—from the earliest factory-based agglomerations to modern digital clusters—the key success factors have consistently included the concentration of knowledge, high-quality infrastructure, institutional support, and a readiness for continuous technological reinvention. The historical trajectory demonstrates that clustering is not an accidental phenomenon but a stable mechanism of economic development that has progressively strengthened its role within the global economy.

Role of Clustering in the Economic Development of the State

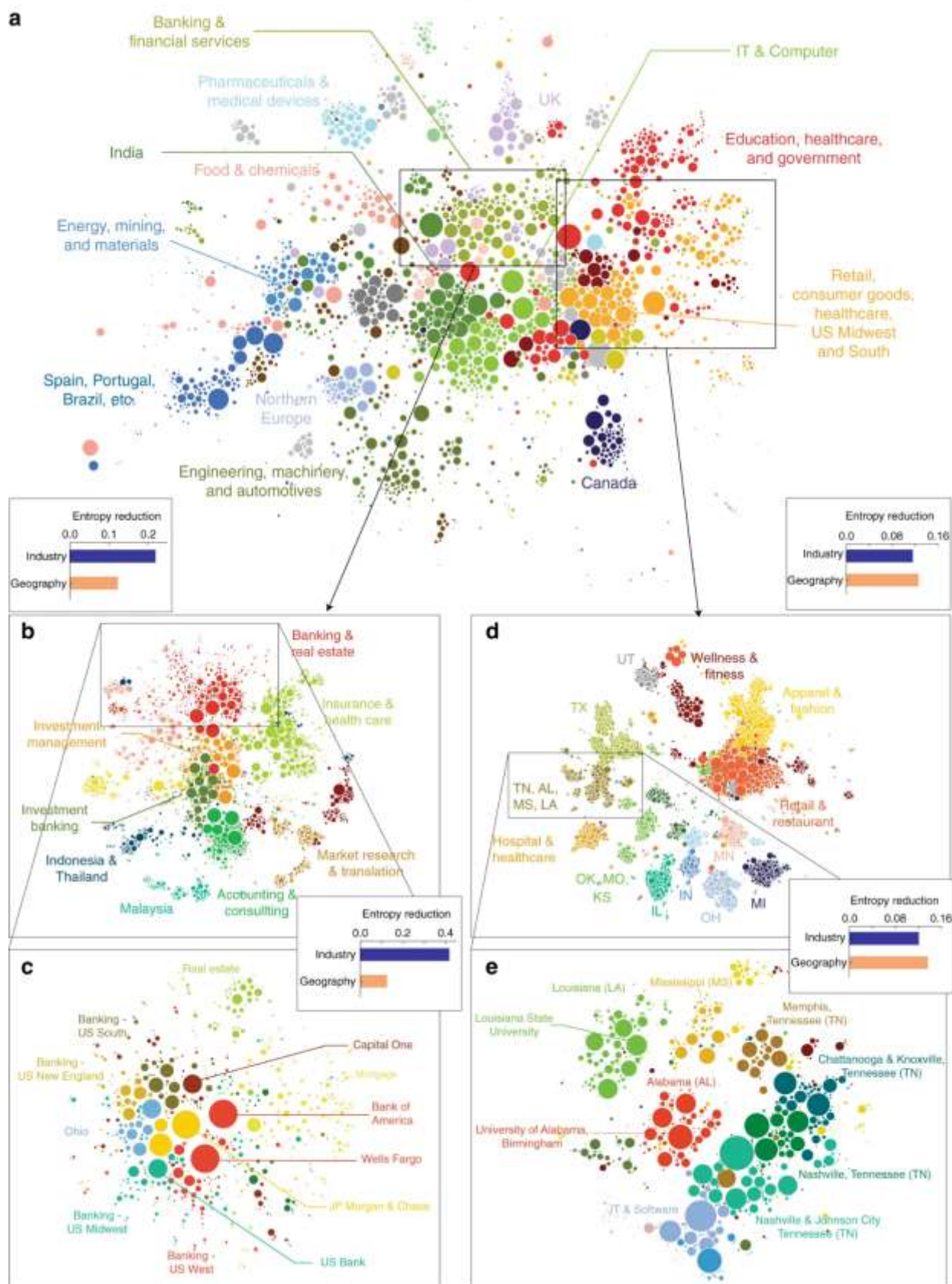
Clustering holds a central place in the contemporary economic development of states, serving as an instrument that enables the overcoming of structural constraints, the acceleration of technological renewal, and the formation of new competitive advantages. Unlike isolated industrial policy measures aimed at individual enterprises or sectors, the cluster approach creates an integrated production and innovation environment that brings together industry, education, science, finance, and infrastructure. This integration establishes the conditions for sustainable growth, structural modernization, and enhanced national economic resilience.

At the macroeconomic level, clusters contribute to higher economic growth rates due to their large-scale multiplier effect. International practice shows that developed cluster systems make a substantial contribution to GDP. According to the European Commission, clusters in the EU account for more than €5.3 trillion in added value and approximately 117 million jobs. In the United States, cluster structures employ about 63 million people, representing nearly 45 percent of the private sector, and productivity in these regions consistently exceeds the national average. In China, clusters generate up to 35 percent of the country's industrial output, supporting rapid sectoral modernization and the active development of export-oriented industries.

The economic impact of clusters is explained by several complementary mechanisms. First, the geographic and functional concentration of enterprises allows for cost optimization through reduced logistics expenditures, process standardization, and access to specialized services. Cooperation within clusters creates favorable conditions for joint investment projects, innovation diffusion, and accelerated technological cycles. As a result, labor productivity in clusters exceeds the national economic average by 25–30 percent, while the rate of innovation adoption is up to 50 percent higher, according to European analytical centers.

Clustering also strengthens the ability of states to participate in global value chains. Territories with well-developed cluster ecosystems attract multinational corporations, venture capital, and research institutions. In the United States, for example, the presence of robust technology clusters has underpinned the country's global leadership in digital technologies, bioengineering, and semiconductor manufacturing. In Asia, cluster-based policies have enabled Japan, South Korea, Taiwan, and Singapore to build export-oriented production chains and achieve technological autonomy in strategic industries.

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Pic. 1. Global Network of Geo-Industrial Clusters.²

² Global labor flow network reveals the hierarchical organization and dynamics of geo-industrial clusters | Nature Communications

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Clusters play a particularly important role in the structural transformation of the economy. They serve as platforms where industry shifts from resource-based and labor-intensive operations to high-tech and knowledge-intensive sectors. China's development trajectory is especially illustrative in this regard: technology centers created under the Torch Program and the Made in China 2025 initiative enabled annual growth of high-tech exports at 8–12 percent throughout the 2010s, strengthening the country's position in microelectronics, biotechnology, and energy engineering.

Human capital is another essential element of cluster development. Clusters stimulate the creation of specialized educational programs, innovation laboratories, and professional training centers. In Italy, the industrial districts fostered the establishment of craft and engineering schools that supplied local firms with skilled labor. In Germany, the integration of universities, Fraunhofer research institutes, and the private sector formed the foundation of the dual education model, which solidified the country's status as a global leader in mechanical engineering and industrial automation.

Clusters also play a critical role in ensuring the economic resilience of the state. They reduce dependence on imports of technologically complex goods, increase the level of production localization, and strengthen technological sovereignty. For countries undergoing industrialization or modernization, the cluster approach becomes a key instrument of accelerated development: it enables the formation of domestic science and technology capabilities, supports the expansion of processing industries, increases export potential, and reinforces food, energy, and industrial security.

In the modern era, clusters have also become the backbone of the digital economy. The development of AI platforms, smart manufacturing, industrial Internet-of-Things technologies, and advanced production modeling systems progresses significantly faster in regions with a critical concentration of engineering skills, research institutions, and industrial companies. For example, Germany's modernization of industrial hubs under the Industry 4.0 program relies on existing cluster structures that integrate universities, IT firms, machine-building companies, and startups.

Thus, clustering serves as a strategic instrument of long-term economic development. It enables states to create new sources of growth, modernize production chains, strengthen national competitiveness, and ensure sustainable development in a globally competitive environment. The experience of both developed and rapidly transforming economies demonstrates that the cluster approach is an effective mechanism for transitioning from a raw-material or fragmented economic model to an innovative, export-oriented, and technologically autonomous system.

CONCLUSION

Clustering represents one of the most effective forms of organizing the modern economy, enabling countries to systematically strengthen their competitiveness and ensure sustainable economic growth. The historical examples examined—from the textile centers of nineteenth-century Britain to the high-technology regions of the United States, the European Union, and East Asia in the late twentieth and early twenty-first centuries—clearly demonstrate that the concentration of interconnected enterprises, research institutions, human resources, and infrastructure consistently creates favorable conditions for accelerated development and technological renewal. The evolution of clusters follows an internal logic: a territorial agglomeration transforms into a production hub, then into an innovation center, and eventually into a digital multilayered ecosystem.

Global experience shows that successful clusters become the core of national economic transformation. Their contribution is reflected not only in higher GDP growth rates and increased export activity, but also in the emergence of new industries, the development of highly skilled human capital, and the formation of extensive value-added chains. High levels of cooperation, strong institutional support, and a concentration of scientific and educational resources enable cluster regions to maintain stable levels of productivity, innovation, and investment attractiveness. It is no coincidence that clusters account for more than €5 trillion in added value in the European Union and nearly half of private-sector employment in the United States. These results affirm the universality of this development mechanism and its adaptability across diverse economic models.

The current stage of cluster development is characterized by digitalization and the transition to platform-based systems of coordination. Clusters are no longer solely geographic constructs; they are becoming networked structures that integrate enterprises, research centers, technology laboratories, and service platforms. New digital instruments—cooperation platforms, unified competency databases, and artificial intelligence systems in manufacturing—create the conditions for rapid knowledge exchange and the seamless integration of innovations into production chains. This demonstrates that clustering remains relevant not only as a tool of industrial policy but also as a foundation for the digital transformation of the economy.

Thus, the cluster approach is not a temporary trend but a stable strategic model that has proven its effectiveness for more than a century and a half. It combines territorial, technological, and institutional advantages, provides a solid foundation for industry modernization, and strengthens the global competitive position of states. In an era of intensifying technological competition, the growing importance of data, and rapid renewal of production models, clusters are becoming the focal points of the future economy, ensuring sustainable development, innovation dynamics, and national economic security.

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