

Comparative Analysis of Traditional and Contemporary Advantages of Industrial Clusters

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ABSTRACT: Industrial clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, and associated scientific and educational institutions within a specific area, recognized as drivers of regional development since the late nineteenth century. This paper reviews classical and contemporary literature on industrial clusters, ranging from Marshall's original account of localization economies and Porter's diamond model to New Economic Geography and evolutionary economic geography, and develops a structured overview of the benefits clusters generate for their regions under modern economic conditions. Beyond traditional benefits long associated with clusters, such as labor market pooling, specialized access to inputs and suppliers, and knowledge spillovers, the paper places particular emphasis on benefits that have gained prominence in the modern economy: digital and platform-enabled cluster dynamics; integration into global value chains alongside local knowledge exchange; supply chain resilience; green and energy-transition industries; university-industry-government linkages; talent attraction in a mobile workforce; and clusters as instruments of place-based regional policy. A conceptual framework organizes these mechanisms into four categories of regional benefit: productivity and economic performance, innovation capacity, human and social capital, and resilience and sustainability. The paper concludes with implications for regional economic policy and directions for future research.

KEYWORDS: agglomeration economies, cluster policy, industrial clusters, innovation ecosystems

I. INTRODUCTION

Why do certain industries repeatedly concentrate in specific locations, such as semiconductors in Silicon Valley, financial services in London, the automotive industry in southern Germany, film production in Los Angeles, furniture manufacturing in northern Italy, and wine production in specific valleys of France, Italy, and California? This empirical regularity, observed across various countries, sectors, and historical periods, serves as the starting point for the economic literature on industrial clusters. An industrial cluster can be defined as a group of interconnected companies, specialized suppliers, service providers, and associated institutions such as universities, standardization agencies, and trade associations, located in a specific geographic area and linked by common characteristics and complementarities [1]. Clusters differ from simple industrial concentrations in that they are characterized by intense local interaction: companies within a cluster both compete and cooperate, share a specialized local pool of labor and suppliers, and benefit from the transfer of knowledge, both formal and informal, among actors located in the same area.

The thesis that geographic concentration yields economic benefits for both firms and regions has a long intellectual history, beginning with the description of external economies (agglomeration economies) defined by Alfred Marshall [2], available to firms located within an “industrial district.” These benefits stem from a shared pool of skilled labor, the local availability of specialized inputs, and the rapid diffusion of technical knowledge among firms in close proximity. This idea was significantly developed in the late twentieth century through the

work of Michael Porter [1, 3] on the competitive advantage of nations and regions, the New Economic Geography associated with Paul Krugman [4], and detailed empirical studies of specific regional economies, most notably Annalee Saxenian's [5] comparative study of Silicon Valley and the Route 128 area.

This paper has two goals. First, it synthesizes the classic and contemporary literature on industrial clusters to provide an integrated view of the mechanisms through which cluster membership benefits firms, and, at the aggregate level, the region and local citizens. Second, it examines how cluster benefits have developed in some respects and intensified under contemporary economic conditions, including digitalization, the reorganization of global value chains, growing attention to supply chain resilience, the acceleration of the energy transition, and the rise of place-based innovation policy, which were not fully anticipated in earlier cluster literature. The paper develops a conceptual framework that organizes cluster benefits into four categories relevant to regional economic development: productivity and economic performance, innovation capacity, human and social capital, and resilience and sustainability. It also discusses the conditions under which these benefits are, and are not, realized, since the literature increasingly recognizes that clusters can generate negative outcomes, including the risk of cognitive lock-in and excessive homogeneity, if not actively renewed.

II. TRADITIONAL ADVANTAGES OF CLUSTERS

2.1. Marshall's agglomeration economies

Marshall [2] identified three main sources of advantage for firms located within an industrial district: (1) the emergence of a specialized local labor market, which grants firms access to a large pool of workers with industry-specific skills while protecting workers against firm-specific employment risks due to the presence of multiple potential local employers; (2) the local availability of specialized intermediate goods and services, supported by a critical mass of demand sufficient to sustain specialized suppliers that would not be viable if serving only a single firm; and (3) knowledge spillovers, whereby technical and commercial knowledge spreads among spatially proximate firms through both formal channels (supplier relationships, joint ventures) and informal channels (labor mobility between local firms, informal social interaction among industry participants). These three mechanisms, labor pooling, input sharing, and knowledge spillovers, remain fundamental elements of virtually all subsequent cluster theory [6].

2.2. Porter's cluster framework and the diamond model

Porter [1, 3] extended Marshall's insights into an explicit theory of competitive advantage, arguing that a nation's or region's competitiveness in a given industry depends on four interrelated conditions captured in his “diamond” framework: factor conditions (specialized inputs, including skilled labor and infrastructure), demand conditions (the sophistication and scale of local demand), related and supporting industries (the presence of competitive local suppliers and complementary industries), and firm strategy, structure, and rivalry (the intensity of local competition, which Porter argued spurs innovation more effectively than distant competition). Porter argued that these conditions interact most powerfully when firms are geographically concentrated, because proximity intensifies both local rivalry and the rate of information exchange, and because a critical mass of related firms and institutions is required to sustain a genuinely competitive local supplier base. Porter's framework was particularly influential in shifting the policy conversation from a focus on individual firm competitiveness to a focus on the competitiveness of clusters and regional business environments as a whole.

2.3. New economic geography and modeling of agglomeration

Krugman's [4] new economic geography formalized the dynamics of agglomeration using general equilibrium trade models, showing how the interaction of increasing returns to scale, transportation costs, and labor mobility can create a self-reinforcing spatial concentration of economic activity, even among initially identical locations. In this tradition, a distinction is usually made between localization economies, external economies specific to a certain industry, consistent with Marshall's interpretation, and urbanization economies,

which arise from the scale and diversity of economic activity in a city or region as a whole, independent of industry [7]. Jane Jacobs [8] offered an influential alternative interpretation emphasizing the potential of industrial diversity within cities to generate innovation; she argued that the cross-fertilization of ideas from different industries, rather than specialization within a single industry, is often a stronger driver of urban innovation. This distinction between “Marshall-Arrow-Romer” externalities (specialization) and “Jacobs” externalities (diversity) remains the subject of active empirical research [6].

2.4. Evolutionary economic geography and relational approaches

Recent research emphasizes that clusters are not static but evolve through distinct life-cycle stages, emergence, growth, maturity, and either renewal or decline, and that their competitive advantage depends on continuous knowledge creation and adaptability rather than merely on the static presence of agglomeration effects [9]. Bathelt, Malmberg, and Maskell [10] introduced an influential distinction between “local buzz,” an intense, informal exchange of information and knowledge stemming from spatial proximity and frequent face-to-face interaction, and “global pipelines,” purposefully established channels through which clusters access knowledge, capital, and markets outside the region. Their core thesis, directly relevant to contemporary cluster literature, is that the most dynamic and competitive clusters combine strong local buzz with well-developed global pipelines rather than relying solely on local interaction; clusters that are intensely connected locally but isolated globally are at risk of technological obsolescence and cognitive lock-in.

2.5. Measuring clusters and their regional impact

Empirical cluster research depends on the ability to identify and measure cluster strength within a specific region, a task complicated by the lack of a unified official statistical definition of a cluster. The most commonly used approach relies on location quotients, which compare the share of regional employment in a specific industry to that industry's share of national employment; values significantly above one indicate regional specialization consistent with the presence of a cluster [11]. Delgado, Porter, and Stern [12] advanced this approach by developing standardized, statistically derived definitions of clusters, groupings of related industries found together more frequently than chance would predict, which are now widely used for cluster mapping in North America and Europe, including by the European Cluster Observatory. Beyond employment-based metrics, researchers have employed patent citation analysis to track the geographic localization of knowledge spillovers [13], input-output analysis to identify related and supporting industry linkages, and survey-based measures of perceived local collaboration and knowledge exchange among firms to capture the relational dimension of cluster membership, aspects that purely quantitative measures of industrial concentration cannot directly observe.

III. CONTEMPORARY ADVANTAGES OF INDUSTRIAL CLUSTERS

Although the mechanisms outlined in the previous chapter remain fully relevant, several advantages of industrial clusters have taken on new forms in contemporary economic conditions. This chapter examines eight such advantages.

3.1. Integration into global value chains with local knowledge exchange

Contemporary clusters rarely operate as self-contained local economies; on the contrary, the most competitive modern clusters combine intense local interaction with deliberate integration into global value chains and international knowledge networks [10]. For a region, this means that a well-developed cluster functions as an effective hub connecting local firms, including small and medium-sized enterprises that could not independently access international markets, with global demand, capital, and technology, while simultaneously retaining the productivity and innovation advantages of local density. Regions that succeed in combining strong local knowledge exchange with well-developed global pipelines typically demonstrate greater resilience to demand shocks in any single external market, as well as a greater capacity to absorb and adapt technology developed elsewhere.

3.2. Supply chain resilience and diversification

Recent global disruptions, including the COVID-19 pandemic, geopolitical trade tensions, and major shipping disruptions, have increased the importance of supply chain resilience as an explicit economic policy objective, and industrial clusters have regained attention as a mechanism for achieving it. A regional cluster with a dense network of local suppliers reduces the region's dependence on single, distant suppliers of key inputs and facilitates faster reconfiguration of local production in response to disruptions, as substitute suppliers, adaptable production capacity, and relevant technical expertise are more likely to be available locally [14]. This resilience benefit has become a central justification for contemporary reshoring and friend-shoring industrial policy in North America and Europe, which often takes the explicit form of cluster-based investment in strategic sectors such as semiconductors, batteries, and pharmaceuticals.

3.3. Clusters in the green and energy transition

The transition to renewable energy and low-carbon industrial processes has generated a new generation of clusters organized around wind, solar, battery, hydrogen, and circular-economy technologies, in which the classical cluster mechanisms, specialized labor, supplier networks, and knowledge spillovers, apply directly to emerging green industries [15]. For the host region, green industrial clusters offer the traditional benefits of agglomeration together with the strategic benefit of positioning the regional economy within a growing global market, and, where the cluster displaces or repurposes legacy carbon-intensive industry, a pathway for “just transition” that preserves regional industrial employment and specialized technical capacity rather than allowing it to be lost during decarbonization.

3.4. University-industry-government linkages and regional innovation systems

Contemporary cluster policy increasingly emphasizes the systematic linkage of clusters to universities and public research organizations, reflecting the broader concept of regional innovation systems, in which sustained regional innovation capacity depends on institutionalized channels connecting firms, universities, and government agencies, rather than on firm-level R&D investment alone [16]. For the local region, strong university-industry linkages within a cluster provide a continuous supply of trained graduates suited to the cluster's specific technical needs, a channel for commercializing university research through spin-offs and licensing, and access to shared research infrastructure, laboratories, testbeds, and incubators, that individual firms, particularly SMEs, could not sustain independently.

3.5. Attracting and retaining talent in the mobile knowledge economy

In a labor market characterized by high mobility of skilled and knowledge-intensive workers, the existence of a recognizable industrial cluster acts as a regional brand that helps attract and retain the most promising talent, because potential employees value the reduced career risk associated with locating in a region that offers multiple potential employers in their field, as well as the professional networks, informal learning opportunities, and lifestyle amenities that typically develop around successful clusters [17]. This talent-attraction role has become increasingly important as remote and hybrid work arrangements have made highly skilled workers more geographically mobile, intensifying interregional competition for the same talent pool; a strong cluster identity provides the regional economy with a competitive advantage in this contest that dispersed individual employers, acting alone, cannot easily replicate.

3.6. Cluster-based regional policy and smart specialization

Since the early 2010s, cluster-based thinking has become a central organizing principle of regional innovation policy, most explicitly within the European Union's smart specialization strategy (S3) framework, which requires regions to identify and concentrate innovation investment in a limited number of fields in which they possess or can plausibly develop a distinctive competitive advantage, rather than spreading limited public investment across all sectors [18]. For the local region, this represents a modern benefit distinct from the market-

driven mechanisms discussed above: a clear cluster identity provides a coherent basis for attracting public infrastructure investment, targeted innovation funding, and coordinated multi-level governance support that diffuse, non-clustered economic activity finds more difficult to secure. The cluster—as a concept, a phenomenon, and a modern business organization model—contributes positively to the development of member companies and the regions in which they operate [19].

3.7. Digital and platform-enabled cluster dynamics

Digital technologies have altered the spatial logic of clusters without eliminating the value of physical proximity. On the one hand, digital platforms and collaboration tools enable cluster-based firms to extend their local knowledge networks into distributed “virtual clusters” or communities of practice that include remote collaborators; they also grant small regional firms access to specialized digital infrastructure, such as cloud computing, data-sharing platforms, and digital design and simulation tools, that previously required a scale unattainable for individual small and medium-sized enterprises [14]. On the other hand, empirical evidence regarding the geography of digitally enabled innovation generally shows that physical proximity continues to disproportionately influence the exchange of tacit, non-codifiable knowledge, meaning that digital connectivity has tended to complement rather than replace local cluster interaction. For the host region, this suggests a modern benefit absent from earlier cluster theory: regions with strong clusters can now combine the traditional advantages of local agglomeration with digitally extended access to global markets, talent pools, and collaborative research networks, effectively lowering the threshold for a regional cluster to compete internationally.

3.8. Inclusive growth and reduction of regional disparities

Another contemporary dimension of cluster benefits relates to the potential contribution of cluster-based development to inclusive regional growth. Since clusters generate demand for a range of complementary skills and services, spanning not only core technical roles but also logistics, maintenance, hospitality, and support services, well-designed cluster initiatives can create employment pathways for a broader segment of the regional workforce than the anchor industry would employ directly on its own [15]. Consequently, cluster-based development is an increasingly common component of place-based policy specifically targeting lagging or post-industrial regions; the underlying premise is that well-supported clusters in emerging sectors, such as renewable energy, advanced green manufacturing, or the life sciences, can offer a sustainable growth path for regions that have experienced the decline of historically dominant industries. At the same time, the literature cautions that this growth potential is not automatic: it cannot be realized without targeted attention to workforce development and equitable access to cluster-related opportunities, since the employment and wage benefits of a cluster can otherwise accrue disproportionately to already-advantaged workers and firms.

IV. CONCEPTUAL FRAMEWORK OF CLUSTER BENEFITS FOR THE LOCAL REGION

Table 1 consolidates the mechanisms discussed in the previous sections into four categories of regional benefits: productivity and economic performance, innovation capacity, human and social capital, and resilience and sustainability.

Table 1. Mechanisms and categories of regional benefits from industrial clusters

Benefit Category	Classical Mechanisms	Modern / Contemporary Mechanisms
Productivity & economic performance	Labor pooling; specialized input sharing; localization economies	Global value chain integration; supply chain resilience and reduced input disruption cost

Benefit Category	Classical Mechanisms	Modern / Contemporary Mechanisms
Innovation capacity	Localized knowledge spillovers; specialization (MAR) and diversity (Jacobs) externalities	University-industry-government linkages; regional innovation systems; access to global knowledge pipelines
Human & social capital	Deep specialized local labor market; informal inter-firm knowledge exchange ('local buzz')	Talent attraction/retention branding in a mobile knowledge economy; entrepreneurial spin-off culture
Resilience & sustainability	Flexible local supplier substitution; diversified local demand base	Reshoring/friend-shoring policy targets; green and energy-transition cluster formation; smart-specialization policy support

Source: prepared by the author.

This framework illustrates the paper's broader thesis: modern mechanisms do not replace classical ones but rather build upon and elaborate on them within the contemporary context of globalization, digitalization, labor mobility, and a policy focus on resilience and sustainability. A region seeking to maximize the benefits of an industrial cluster must continue investing in classical economic foundations, such as broad labor markets, a dense supplier network, and local knowledge exchange, while simultaneously building global connectivity channels, linkages within the innovation system, and policy coherence; these factors determine whether those foundations translate into a modern competitive advantage.

Although this paper is conceptual in nature rather than based on individual case studies, it is useful to illustrate the framework presented in Table 1 with well-documented examples of regional clusters frequently discussed in the literature. Table 2 summarizes several frequently cited examples, selected to represent diverse industries, regions, and stages of cluster development, and to demonstrate how the contemporary mechanisms discussed in the previous chapter operate in practice.

Table 2. Illustrative examples of regional industrial clusters

Cluster / Region	Core Industry	Illustrative Contemporary Benefit Mechanism
Silicon Valley, California, USA	Information technology and software	Global talent attraction; dense entrepreneurial spin-off culture; strong global pipelines alongside local buzz [5]
Boston / Cambridge, Massachusetts, USA	Biotechnology and life sciences	University-industry-government linkages anchored around leading research universities and teaching hospitals
Baden-Württemberg, Germany	Automotive and precision engineering	Deep specialized supplier networks; ongoing adaptation toward electric-vehicle and green manufacturing technologies

Cluster / Region	Core Industry	Illustrative Contemporary Benefit Mechanism
Jutland / Esbjerg, Denmark	Offshore wind energy	Green/energy-transition cluster formation supporting national and export-oriented decarbonization goals
Shenzhen, China	Electronics manufacturing and hardware	Rapid supplier-network flexibility and prototyping speed enabling integration into global electronics value chains

Source: prepared by the author based on sources cited in previous chapters.

These examples illustrate that the specific combination of mechanisms identified in Table 1 varies significantly across clusters, depending on the nature of the industry, the cluster's stage of development, and the surrounding institutional and policy environment. They also illustrate the point made above regarding the importance of combining local knowledge exchange with global connectivity: each of the clusters listed in Table 2 is deeply embedded in international markets, technology flows, or capital markets, even while retaining a distinctive, geographically concentrated local core that sustains the classical Marshallian mechanisms outlined in Section 2.

For regional and local economic development authorities, the literature and framework reviewed in this paper suggest several practical implications. First, cluster policy should be viewed as a complement to, rather than a substitute for, broad-based investment in education, infrastructure, and institutional quality, since clusters amplify, but do not create, a region's fundamental productive capacity. Second, given the risk of cognitive lock-in, cluster development policy should explicitly support mechanisms for new firm entry, linkages to adjacent and emerging technological fields, and international knowledge pipelines, rather than focusing exclusively on strengthening ties among existing, established cluster members. Third, because smaller local firms are less able than large anchor firms to independently establish global pipelines, forge university linkages, or influence policy processes, effective cluster governance organizations play a disproportionately important role in ensuring that cluster benefits are broadly distributed across the regional business population rather than captured mainly by dominant incumbents. Fourth, given the growing role of clusters in reshoring, green-transition, and resilience-oriented industrial policy, regions are increasingly able to align cluster development with national and supranational strategic priorities and associated funding instruments, such as the European Union's smart specialization framework, provided that the region can credibly demonstrate an existing or emerging comparative advantage in the targeted field.

V. CONCLUSION

This paper demonstrates that industrial clusters continue to serve as a vital framework for understanding regional competitiveness, innovation, and economic development. Their traditional advantages stem from Marshallian agglomeration economies, specifically, a shared labor market, the availability of specialized suppliers and inputs, and localized knowledge spillovers. Porter's approach further emphasizes that the spatial concentration of firms, institutions, and related activities can boost productivity, drive innovation, and strengthen a region's competitive position.

Today, the benefits of clusters extend beyond the traditional effects of specialization and spatial proximity. Successful clusters combine local knowledge exchange and collaboration with access to global markets, technologies, capital, and talent networks. Digitalization, integration into global value chains, the development of regional innovation systems, the strengthening of supply chain resilience, and the green and energy transitions are creating new opportunities for cluster development. In this context, clusters can act as platforms connecting businesses, universities, public institutions, and other development stakeholders.

However, the positive effects of clusters are not automatic. Realizing them depends on the quality of governance, openness to new knowledge and enterprises, the strength of ties with universities and international partners, and the ability to avoid excessive specialization and cognitive lock-in. Regional policies should therefore foster clusters as open and inclusive innovation ecosystems, while simultaneously investing in education, infrastructure, digital capabilities, and institutional quality. In conclusion, industrial clusters can serve as a significant instrument for regional development if they combine the traditional advantages of local agglomeration with modern demands for innovation, resilience, sustainability, and global connectivity. Future research should empirically examine how various forms of governance, digitalization, and international integration influence the economic, innovative, and social outcomes of clusters across different regional contexts.

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