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БІОТЕХНОЛОГІЯ ТА ЕЛЕКТРОТЕХНІКА В АГРОПРОМИСЛОВОМУ КОМПЛЕКСІ: КЛАСТЕРНІ ПІДХОДИ, ІННОВАЦІЇ ТА СТАЛИЙ РОЗВИТОК

Монографія

BIOTECHNOLOGY AND ELECTRICAL ENGINEERING IN THE AGRO-INDUSTRIAL COMPLEX: CLUSTER APPROACHES, INNOVATION, AND SUSTAINABLE DEVELOPMENT

Monograph

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Монографія присвячена дослідженню промислових, сільськогосподарських та біотехнологічних кластерів як форм взаємодії організацій у рамках єдиного ланцюга створення вартості, взаємозамінних елементів самодостатньої сфери виробництва або послуг. У монографії аналізуються передумови, мотивація та критерії створення кластерних структур у різних країнах. Розглядаються алгоритми взаємодії окремих елементів таких структур між собою, можливості їх взаємодії в рамках мегакластерів, а також наявність державної підтримки кластерних ініціатив.

The monograph is devoted to the study of industrial, agricultural and biotechnological clusters as forms of interaction of organizations in a common value chain, interchangeable elements of a self-sufficient sphere of production or services. The monograph analyzes the prerequisites, motivation and criteria for the creation of cluster structures in different countries. The algorithms of interaction of individual elements of such structures with each other, the possibilities of their interaction within megaclusters, as well as the presence of state support for cluster initiatives are considered.

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INTRODUCTION

One of the main tasks of reforming the economy of Ukraine within the framework of the government program "Main Directions of the Socio-Economic Policy of the Government of Ukraine for the Long-Term Perspective" is to ensure high competitiveness of products and services produced by enterprises and organizations as the basis for their sustainable economic development.

The formation of an optimal price-quality ratio is the basis for ensuring the competitiveness of products and services, which cannot be achieved without the use of organizational structures. These structures are a set of interconnected spheres of production and non-production activities and services concentrated around a specific key manufacturer and known as "industrial clusters".

Cluster structures can be represented by groups of industrial enterprises and non-industrial organizations, or groups of interconnected production and auxiliary enterprises and institutions, or communities of geographically interconnected companies-suppliers, etc.

Cluster structure membership is an important element of the individual competitiveness of each group member. A cluster is united on the basis of relationships of the "Buyer-Supplier" type, or through common technologies, common buyers, distribution channels or unskilled labor pools.

Cluster elements can be located in a common regional territory, where the region is defined as a municipal district, labor market or other functional economic unit.

A group of interconnected production and auxiliary enterprises and institutions, receiving additional basic elements, intercompany relationships or interconnected sectors within the framework of a cluster association, acquires a certain additional critical mass for economic sustainability in the market sectors already occupied by it and its participants, as well as the potential for further expansion of the scope of activity.

An industrial cluster, identified by the extended "input-output" method or by the "Buyer-Supplier" chain, can consist of numerous sectors or industries, including both final market producers and suppliers of the first, second and third levels, which are directly or indirectly engaged in trade.

A cluster can also be represented by a geographically concentrated group of companies that work directly or indirectly for a single end market, share the same values and knowledge, thereby creating a new cultural environment. At the same time, the companies themselves are interconnected by a complex mixture of competition and cooperation. Thus, cluster structures can represent a combination of leading companies that produce certain products and services, and suppliers that exist in the area of action of this industrial cluster, and interact with state economic and financial institutions, taking into account the real economic situation and current legislation.

Another typology of clusters can be represented by a group or community of geographically interconnected companies, suppliers of equipment, components, specialized services, infrastructure, research institutes, universities and other organizations that complement each other and strengthen the competitive advantages of an individual company and the cluster as a whole.

Clustering in the field of services is primarily attractive for such activities as real estate, communications, tourism, art and culture, which helps to reduce the cultural and economic gap between the country center and the provinces.

In different countries, there are groups of competitive enterprises within certain industries, which, despite their small territorial size, occupy leading positions in the world market. Moreover, these are not individual enterprises, but groups of enterprises operating in different countries, regardless of whether it is a developing country trying to liberalize its economy (for example, Chile), an Asian country such as Japan, with its traditions and specifics, or a European country, stable, with a good balance of payments, such as Germany.

Such groups of enterprises operate and remain competitive over a fairly large area under different economic and social conditions.

In countries with economies in transition, the concept of forming industrial clusters is interesting primarily for small and especially medium-sized companies, for which the access to foreign and export markets is difficult. In this regard, the experience of Italy is typical, where furniture companies alone cannot enter foreign markets, but their associations, regional, branch or all-Italian cooperatives have the opportunities to enter foreign markets using the cluster approach.

Groups of companies in the field of information technology in Silicon Valley, telecommunications in Helsinki, film production in Hollywood are classic examples of successful clusters.

Cluster theory is successfully used to analyze economic development not only abroad, but also in Ukraine. The experience of building a flax cluster, a forest cluster and the development of the service sector in Kyiv are successful examples.

The development of conceptual approaches to the formation of industrial clusters allows creating a more pragmatic approach to the formation of joint educational and research programs.

At the moment, the use of a cluster approach is considered one of the most effective ways of developing territories.

For the administration, a cluster is, firstly, the most modern and convenient tool in industrial policy. Secondly, it is an effective platform for interaction with business. Thirdly, regional and municipal administrations are entrusted with a significant amount of tasks, for the solution of which there is often not enough resources, money, or time. The cluster approach provides an effective tool for achieving the main goals: the profitability of the region and employment of the population.

It is known that the price of a product and its competitiveness are largely, not less than half, determined by the competitiveness of suppliers and the quality of their products. Accordingly, the development of clusters allows enterprises, first of all, to increase their flexibility, gain access to innovations and certain resources.

An important role in the creation of clusters is played by European scientific and technical cooperation programs, in particular "Eureka" and the Sixth Framework Programme of the EU 2002-2006 (6FP) [the Sixth Framework

Programme of the European Community for research technological development and demonstration activities, contributing to the European Research Area and to innovation (2002-2006)]. These programmes bring together potential partners who have not been able to establish contacts at the national level on their own. In addition to the above programmes, modern European programmes supporting scientific and technical cooperation and clustering include: Digital Europe Programme: This programme aims to support the digital transformation in Europe, including the development of digital infrastructure, cybersecurity, artificial intelligence and advanced digital skills.

European Innovation Council (EIC): The EIC supports high-risk, high-impact innovations with the potential to create new markets or significant growth. It particularly promotes the development of start-ups, SMEs and clusters engaged in innovative technologies.

InvestEU Programme: This programme aims to support investments in key areas of the EU economy, including infrastructure, research, innovation and SME development. It also supports clusters focused on sustainable development and innovation.

EUREKA Clusters Programme: This is a modern initiative that focuses on supporting international research and innovation projects in various technology sectors such as ICT, energy, smart manufacturing systems, etc.

The LIFE Programme: The programme that supports projects aimed at environmental protection, climate action and the transition to clean energy. It can contribute to the creation of clusters that are focused on green technologies and sustainable development.

Supranational bodies, in particular the European Commission, have introduced institutional support for cluster development within the framework of cluster policy, with an emphasis on small and medium-sized businesses as one of the priority areas for strengthening the EU economy. A number of framework programmes have been created in which various initiatives and projects have been promoted. Firstly, these include the creation of the European Cluster Collaboration Platform1, which allows for the development of transnational and international cooperation; the EU cluster portal (Industrial Cluster Policy) created by DG-GROW, in which cluster policy is presented as a component of EU industrial policy; the European Cluster observatory (statistical information, analysis and mapping of clusters and cluster policy in Europe); Emerging industries clustering (policies, programs and measures for new or existing industrial sectors and value chains penetrating new industries) such as Creative Industries, or the Mobile and Mobility Industries Alliance and others. However, more significant support is provided to clusters within the framework of state economic policy. The experience of cluster development in EU countries shows that most countries implement separate cluster policies at the national and regional levels, or have cluster development tasks and objectives in related policies [1].

A key factor in the competitiveness of many Western companies is innovation, that is, the ability of a company to quickly launch a new product on the market. Recent studies concompany that the highest probability of innovation occurs precisely in industrial clusters.

The creation of industrial clusters allows solving important national economic problems timely; quickly regulating production relations both within the clusters and between them.

The degree of justification for including certain components in industrial clusters is usually defined using various statistical methods, which, in turn, allows optimizing the number of cluster components according to its type and purpose.

The creation of industrial clusters improves the overall indicators of the country's economic activity, reduces the level of conflict between sectors of the economy, improves their interaction and stimulates activities to increase the weight of discrete production.

The paper analyzes the prerequisites, motivation and criteria for the creation of cluster structures in different countries. The algorithms of interaction of individual elements of such structures with each other, the possibilities of their interaction within megaclusters, as well as the availability of state support for cluster initiatives are considered [2].

1. CHAPTER I THEORY OF INDUSTRIAL CLUSTERS

1.1.General Provisions

Industrial policy in different countries of the world is characterized by a great variety of methods and approaches. In the recent decade, the cluster approach has become one of the most famous and widely developed ones.

The rapidly developing Ukrainian market is increasingly susceptible to the influence of international trends in the creation and development of cluster systems as one of the mechanisms for increasing the competitiveness of enterprises.

When developing new cluster schemes, the question arises of the quantity and quality of information for conducting a systemic analysis. An important factor is that national users of information on cluster schemes want to:

- receive qualitative and quantitative information on the effectiveness of the activities of various cluster structures in other countries;
- compare existing national economic conditions with those ones of other countries.

At the same time, users from other countries, including international organizations, also want to compare and exchange information on the development of clusters on an international scale.

The use of uniform principles when analyzing the causes of the emergence and development of clusters of different levels in different economic conditions could help to avoid the need to establish a multitude of pairwise relationships.

The implementation of cluster analysis methods in practice, as a means of ensuring the process of sustainable development of both the country and the regions, will definitely help to outline the framework and boundaries of the integration of all the main instruments of economic development policy available to the government.

For developing various cluster policy instruments, it is necessary to use an integrated approach, including elements of the policy of attracting foreign investment, developing skills and expertise, creating venture structures, financial and export strategies in the guiding principles of clustering.

The use of any of the above strategies or their combinations depends entirely on the nature of the cluster.

The most important thing is that cluster analysis makes it possible to analyze the specific needs of territories or regions and, on this basis, determine the strategy and ways of their further development.

Thus, when making a decision on the strategy for the development of cluster schemes in Ukraine, it is necessary to have comparable results of the analysis of:

- international experience in the field of creating effective cluster systems;
- experience of national cluster schemes used abroad (primarily in OECD countries), including the strategy of linking the interests of cluster participants with the economic policy of the state, the difficulties encountered in creating clusters in other countries and ways to overcome them; experience in the development of clusters already existing in Ukraine.

1.1.1. History of the development of cluster systems

Clusters are not an entirely new phenomenon. The well-known theorist and practitioner of the cluster approach to economic development Roelandt notes that "industrial agglomerations and clusters have existed for as long as the industrial economy has existed" [3].

In England, at the end of the 19th century, the famous economist Alfred Marshall identified and assessed the importance of the textile cluster in the Manchester area and the metalworking cluster in Sheffield. In 1920, his first developments of the cluster approach were published [4].

In the middle of the 20th century, a great contribution to the further development of network systems in the form of “industrial districts” – clusters was made by Italian researchers and practitioners.

In 1979, the concept of an “industrial cluster” appeared in the works of Czamanski and de Ablas as “a subset of industries of the economy, connected by flows of goods and services, more strongly than with other sectors of the national economy” [5].

In 1990, Michael Porter defined a cluster or industrial group as a group of geographically adjacent interconnected companies and related organizations operating in a certain field and characterized by commonality of activities and complementing each other. The geographical scale of a cluster can vary from one city or state to a country or even a number of neighboring countries [3, 6,7].

In the works of 1996, clusters are defined as: forms of economic activity concentrated on a regional basis, carried out within the framework of the relevant sectors, as a rule, associated with the knowledge infrastructure, research institutes, universities, etc [8].

The data bank on clusters in various industrial sectors as of the beginning of 2003, published by the Institute for Strategy and Competitiveness of the Harvard Business School in October 2003, includes 833 clusters operating in 49 countries, including 25 developed countries and 24 developing countries (see Appendix 1). At the same time, clusters of developing countries accounted for 20.3% of the total number of clusters [9]. From the former USSR countries, the register included a woodworking cluster operating in Estonia. However, the above Register is an open system for the introduction of new factual data.

The oldest leading world cluster, currently existing, is associated with the production of cutlery "Solingen" (Germany, Solingen). The first mention of this production dates back to 1348.

Among the youngest world-leading clusters is the multimedia cluster (USA, San Francisco), which was organized in 1990.

Thus, leading clusters can be equally likely to be both clusters with a century-old history and those created only one or two decades ago.

1.1.2. Basic concepts

The main approaches to building cluster systems can be clearly structured according to conceptual definitions related to functional types (kinds) of cluster structures, taking into account specialization factors [10].

By sequentially listing the conceptual points of the definitions, the following complementary conceptual series can be constructed:

- "industrial districts";
- "a subset of economic industries connected by flows of goods and services";
- "an industrial group of geographically neighboring interconnected companies and related organizations operating in a certain field and characterized by commonality of activity and complementing each other";
- "concentrated on a regional principle forms of economic activity carried out within the framework of the relevant sectors, as a rule, associated with knowledge infrastructure, research institutes, universities, etc.".

A potential industrial cluster is a group of interconnected production and auxiliary enterprises and institutions, which, having received additional basic elements, cross-company relations, or critically related sectors, should receive a certain predetermined critical mass.

In a general economic sense, ***a cluster*** can be defined as a group of geographically localized interconnected companies, suppliers of equipment, components, specialized production services, infrastructure, research centers, universities and other organizations that complement each other in achieving a specific economic effect and strengthen the competitive advantages of individual companies and, therefore, the cluster as a whole.

In modern industrial policy, ***an industrial cluster*** is a group of geographically neighboring and interacting unifying companies and related organizations that operate in a certain industrial (multi-industrial) sphere and complement each other.

An industrial cluster can be represented by both industrial and non-industrial organizations, for which membership within the cluster is an important element of their individual competitiveness.

An industrial cluster can be considered as a chain of added value. In this case, it is identified by the extended input-output method or the Buyer-Supplier chain and includes final market producers and suppliers of the first, second and third levels, who are directly and indirectly engaged in trade. It consists of numerous sectors or industries [11].

As can be seen from the above definitions, one of the distinctive features of an industrial cluster in the general model of production-cooperative and other interactions of business entities is the ***principle of territorial localization***.

The geographical scale of a cluster can vary from one city or state to a country or even a number of neighboring countries.

Territorial localization includes: cluster networks (USA, Australia), industrial cluster districts (Italy), regional industrial clusters (Germany, Ukraine), transnational megaclusters.

Cluster network is a group of companies with limited membership and specific, and often contractual, business objectives that may result in mutual financial gains. Network members choose each other for various reasons; they agree to cooperate openly in some way and to depend on each other to some extent. Networks are developed easily within clusters where numerous business transactions have created good awareness and built trust [12]. Ties between companies in networks are generally more formal than in clusters.

Regional industrial cluster is a cluster whose elements are located in a common regional area, where the region is defined as a municipal district, labor market, or another functional economic unit.

Industrial complex is "a group of industries linked by important flows of goods and services, showing, moreover, significant similarities in their location [13].

Industrial cluster district is a geographically concentrated group of companies that either work directly or indirectly for the same final market, share the same values and knowledge, so important that they determine the cultural environment, and are especially connected to each other in a complex mixture of competition and cooperation [14]. A key source of competitiveness is the elements of trust, solidarity, and cooperation between companies, the result of a closed interweaving of economic and social relations [15].

Another distinctive feature of cluster structures is ***the process principle of association***. The cluster is united by "Buyer-Supplier" relations, or by common technologies, common Buyers or distribution channels, or common funds of unskilled labor with uniform requirements for the quality of the management system in all elements of the cluster. In this case, there is usually a clearly expressed factor of the leading (integrating) product or service.

An industrial cluster as a chain of added value implementation implements ***the economic principle of association*** [16].

Here, an industrial cluster is identified by the extended method of "cost-output" or the chain "Buyer-Supplier". It includes final market producers, and suppliers of the first, second and third levels, who are directly and indirectly engaged in trade. It consists of numerous sectors or manufactures.

Unlike the usual forms of cooperative and economic interactions of small, medium and large businesses, cluster systems are characterized by the following features:

- the stability of economic relations of economic entities participating in the cluster system, the dominant importance of these relations for the majority of its participants;
- long-term coordination of the interaction of the participants of the system within the framework of its production programs, innovation processes; basic management systems, quality control, etc.

An important distinguishing feature of a cluster in the general model of production and cooperation and other interactions of business entities is the factor of innovation orientation. Clusters, as a rule, are formed where a “breakthrough" advancement in the field of production techniques and technologies is carried out or is expected and the clusters further entry into new "market niches". In this regard, many countries - both economically developed and just beginning to form a market economy - are increasingly using the "cluster approach" in supporting the most promising areas and forms of entrepreneurial activity, in the formation and regulation of their national innovation systems.

In some cases, clusters also include strategic alliances of enterprises with universities, research institutions, consumers, technology brokers and consultants.

If we proceed from the economic principle of association, the cluster strategy is best carried out, perhaps, at the level at which the greatest competitive advantage is achieved, but at the lowest possible level. Thus, local, regional, national or international strategies are suitable for different levels.

1.1.3. Formation of the cluster structure

The formation of the cluster structure is associated with the basic principles of association of participants listed above and, as world experience has shown, is determined by the following aspects:

- geographical i.e. represented through regional clustering of economic activity;
- vertical, determined by connections of the "supplier - buyer" type. In this vertical aspect, it is important who exactly among the network participants is the initiator and final embodiment of activity within the cluster;
- horizontal i.e. cooperative and other economic ties, characterized by common technologies, common buyers or distribution channels, or common funds of unskilled labor;
- technological, represented by clusters whose participants use the same technology (such as, for example, a biological technology cluster);

- focal, characteristic of cluster structures in which participants are concentrated around one center - a company, a branched family of enterprises, a scientific organization or an educational institution;

- lateral, uniting different sectors that can use common opportunities to expand the boundaries of the cluster and provide economy due to a scale, as a result of which new combinations may arise (for example, a multimedia cluster that is being formed now);

- the quality of the network, which shows whether companies really cooperate, and how they manage to do it well.

A network is not always an idyllic gathering of companies where all kinds of renewal are automatically stimulated. On the contrary, networks can suppress innovation and encourage defensive behavior. Supplier relationships can stimulate innovation, but they can also be used to shift costs to partners and limit them financially. In the latter case, networks are neither stable nor stimulating.

1.1.4. The role of clusters in industrial policy

The cluster structure model most fully takes into account the changing forms of competition and the main sources of competitive advantages. The cluster method allows realizing the most important relationships in technologies, skills, information, marketing and consumer demands, which are characteristic of a whole complex of companies and industries. These relationships affect the direction and pace of innovations, and even the competitiveness of the final product. It is no coincidence that in many countries cluster analysis (approach) has become actively used for the formation and implementation of national industrial policy.

The cluster approach allows increasing the efficiency of interaction between private sector, state, trade associations, research and educational institutions in the innovation process. The cluster approach can be the basis for a constructive dialogue between representatives of the business sector and the state in order to identify problems of development of science and production, ways of most effectively implementing available investment opportunities and necessary state policy measures. The cluster approach, as world practice shows, not only serves as a means of achieving industrial policy goals (structural changes, increasing competitiveness, strengthening innovation orientation, etc.), but is also a powerful tool for stimulating regional development, which ultimately can consist in increasing employment, wages, contributions to budgets of various levels, increasing the sustainability and competitiveness of regional industry.

The possibilities of the cluster approach for solving the tasks involved in the economic recovery of individual industries and regions are also demonstrated by foreign experience. Thus, Finnish and Scandinavian industry are completely clustered, even in the USA more than half of enterprises work according to such a production model, namely, cluster enterprises are located in one region and use the most of its natural, personnel and integration potential. As a rule, cluster products are export-oriented or import substitution.

The countries of the European Union have adopted the Scottish cluster model, in which the core of such joint production becomes a large enterprise that unites small companies around itself. There is also the Italian model, which represents more flexible and “equal” cooperation of small, medium and large businesses. For countries with economies in transition, this form of cluster organization of production is the most suitable, since it allows increasing the efficiency of small and medium businesses [17].

A specific industry, which attracts large domestic and foreign investments as an object of investment, cannot be considered in isolation and must develop within a cluster of vertically interconnected sectors. Large and diversified economies will increase competitiveness faster if they can improve the state of industries and supplier enterprises. The formation of a basic industry will serve as an impetus for the development of supplier and consumer industries, as well as service segments that “belong” to the cluster. In the service sector, new forms of distribution and sale of products will increase to meet increased demand. Within clusters, strong enterprises can increase production efficiency only by using vertical integration strategies, which are expressed, in particular, in the acquisition of majority stakes in related enterprises and in providing them with various forms of support (financial, technical, managerial, etc.).

Large developed countries provide many examples that highlight the social, political and economic significance of clusters. With the beginning of the formation of key industrial clusters in leading economies, such as Germany (chemistry, mechanical engineering) and France (food production, cosmetics) in the 50s and 60s, entire groups of industries began to interact within clusters, contributing to a multiplier effect on employment growth, investment, and acceleration of advanced technology transfers in the national economy.

American know-how in the consumer goods sector ensured the country's leadership in agriculture, packaging and machinery (supplier industries) along with success in advertising and the financial sector (consumer industries). Japan's strength in the consumer electronics sector allowed it to successfully develop the production of memory chips and microcircuits, while the United States maintained its leadership in the manufacture of logic micro components used in computers, telecommunication equipment and military electronics.

No country can be competitive in all areas. In developed countries, international competitiveness was initially located and strengthened within certain clusters. Sweden's competitiveness in the pulp and paper sector extends to woodworking and papermaking equipment, assembly lines and some related consumer industries (e.g. matchmaking). Denmark has developed specific industrial technologies for agricultural business and the food industry. Likewise, German machine builders and automobile manufacturers benefit from the presence of highly developed production of components for these industries in Germany. In Italy, special clusters have formed in industrial areas, in which industry combinations have developed: metalworking - cutting tools, fashion - design, leather - footwear, woodworking - furniture. It took China almost 15 years and huge external investments to create competitive clusters around the export textile industry, factories of sporting goods, clothing, toys, tableware, etc.

Experience shows that some highly competitive key industries, as a result of intra-cluster interaction, contribute to the development of the network of their suppliers and customers to the greatest extent. Medium and small enterprises form satellite formations around large groups and become their suppliers. Diversification of key enterprises of the cluster allows the creation of new industries, using the technologies and “know-how” of parent companies.

A trend has emerged in world practice, which is characteristic even of large companies, to concentrate on the main directions with delegation of production of intermediate goods of good quality and the sphere of key services to other, including small, enterprises. Therefore, the creation of clusters has a strong impact on small businesses, contributing to their industrial and innovative orientation and their achievement of a qualitatively new level of technology, organization and management of production in all other spheres of economic activity.

Since the competitiveness of modern economies is associated with the presence of close ties between their sectors, it is advisable to systematically form clusters around key industries. They should include the sphere of services (modern distribution and banking systems), which allows bringing products and technologies closer to the end consumer.

In recent decades, effective "cluster strategies" have been given considerable attention in many countries, due to the orientation of governments in the development of strong industries of their country, instead of copying other people's achievements in the field of high technologies. The starting point for a realistic cluster strategy is the strengths of the economy. Such a strategy is built on centers of business activity that have already proven their strength and competitiveness in the world market. But there are some differences here from traditional approaches focused on certain sectors. First, the interrelationship between the strengths inherent in different industries is emphasized, for example, the interrelationship between some industrial or even agricultural and service specializations. Second, (partly in connection with this), in these "strong" clusters the emphasis is on the active use of knowledge and on the strengthening of constructive interaction between the different participants in the network. This can lead to new and promising combinations (as, for example, in the multimedia industry), but such combinations are always built on the basis of existing strengths. The prevalence of cluster strategies is very uneven between countries; the practice of their implementation also varies. The same concepts are not always used, but most European countries have developed some kind of cluster strategy. The countries that most clearly form such a strategy are Denmark, the Netherlands, the Flemish region of Belgium, Quebec (Canada), Finland, and South Africa (under the new government). France and Italy can be examples of countries that have long practiced a kind of cluster strategy, albeit under a different name.

It is known that each country or each region has its own specialization profile, and the main emphasis of cluster strategy is usually made on competition based on differentiation and specialization. Industrial policy with a focus on clusters can stimulate the emergence of "new combinations" and indirectly support them, especially in the field of education and scientific research, as well as through implementing intermediary centers. For example, cooperation programs such as "Eureka" play a very important role at the European level. They bring together potential partners who could not find the additional knowledge they need locally. Of course, large demonstration programs also play a role in the formation of new combinations. As mentioned above, the European level is particularly relevant and provides added value in cases where clusters are already transnational or are associated with huge economies due to the scale of production.

A number of systems that facilitate forming clusters have already been tested in practice and can be identified:

programs aimed at bringing together business people (sometimes in a particular field of technology) in the hope that the expansion of networks will lead to increased cooperation;

- partner selection initiatives, for example, the creation of databases that can be consulted by companies looking for partners in their field of activity;
- financing intermediary (agency) initiatives, an example of which is the program organized by the DTI in Denmark and later extended to other countries;
- sponsorship initiatives, when consultants are paid to monitor the process of cluster formation from the very beginning of the first steps of cooperation. And this is where an example is the DTI initiative. In the Flemish project Plato, which originated in Belgium and has been extended to some regions of the Netherlands, large companies are given public funds to sponsor a group of smaller companies. In this case, representatives of different cooperation projects can apply for subsidies, with the best projects (partly) only receiving public funds. In such competition, the net innovation effect of subsidies can be very high.

However, it is important to emphasize the importance of companies themselves recognizing these opportunities for cluster strategies within their own strategies. Governments at all levels can draw attention to potential threats and opportunities, and support initiatives in this direction to varying degrees. They can help remove barriers to cooperation by providing advisory services and by disseminating best practices in the formation and functioning of cluster industrial and innovation systems. Companies should take responsibility for the processes that arise from these measures and their successful implementation.

1.2. World experience in creating cluster systems

1.2.1. General provisions

The analysis of the survey results of declared cluster structures in the countries of the world was conducted by various authors until mid-2003. This analysis allowed, within the framework of this research work, to obtain refined data and to build a rating of countries for the development of cluster structures of various types in them.

Table 1 shows the refined number of clusters in developed and developing countries.

Table 1. Number of clusters (Q) in developed and developing countries.

Developed Countries	**Q**	**Developed Countries**	**Q**	**Developing Countries**	**Q**	**Developing Countries**	**Q**
Andorra	2	Italy	72	Brazil	3	Morocco	5
Australia	4	Japan	4	Chile	1	Nepal	1
Austria	7	Netherlands	6	Colombia	1	Pakistan	1
Belgium	1	New Zealand	10	Costa Rica	2	South Africa	2
Bermuda	1	Norway	1	Ecuador	3	Poland	1
Canada	13	Portugal	4	Estonia	1	Palestine	9
Denmark	34	Singapore	3	Ghana	1	Taiwan	1
Finland	11	Spain	6	India	106	Thailand	1
France	96	Sweden	5	Jordan	4	Turkey	1
Germany	32	Switzerland	13	Kenya	4	Venezuela	2
Hong Kong	11	England	168	Libya	3	Russia	8
Ireland	2	USA	152	Malaysia	2	Ukraine	3
Israel	6			Mexico	8	Georgia	1
Total	**664**			**Total**	**181**		

There are 664 clusters in 25 developed countries (with a gross national income per capita of over $15,000) and 181 clusters in 27 developing countries. The United Kingdom has the largest number of clusters (168 cluster structures or 19.9% of the total). The United States of America (USA), India, France, Italy, Denmark, and Germany have 152, 106, 96, 72, 34, and 32 clusters, respectively [18].

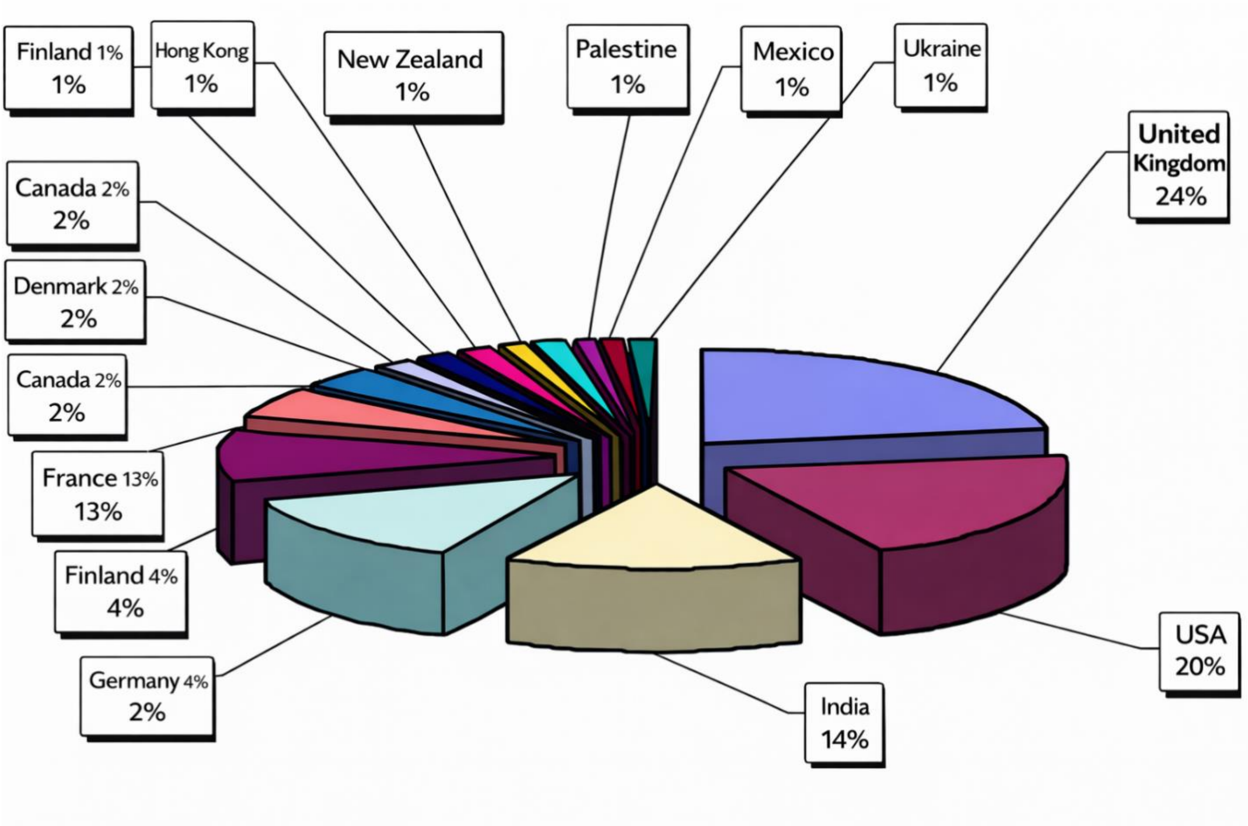

Fig. 1. Statistical distribution of the number of clusters in countries around the world

Figure 1 shows the statistical distribution of the number of clusters in countries around the world, ranked from 1 to 15.

Table 2 provides summary data on the number of clusters in developed and developing countries, as well as the country's ranking in the general list of countries with clusters.

Figure 2 shows the distribution of active clusters depending on their time of origin.

It is possible that some difference in the data provided by different authors reflects to some extent their approach to defining cluster boundaries. However, the discrepancy between the data from different sources did not exceed 5% error, which allowed them to be used for further analysis.

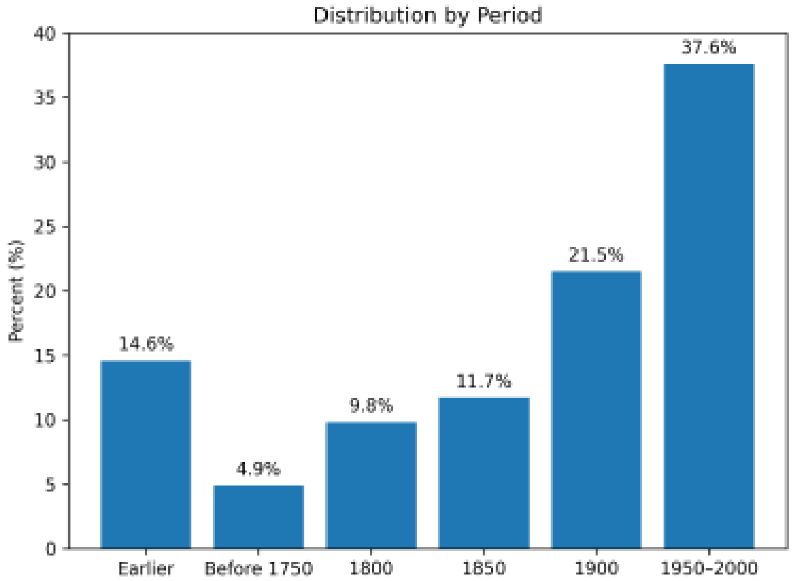

Figure 2. Distribution of active clusters depending on their time of origin.

In the course of this work, the time of origin of clusters and conceptual approaches to building national cluster structures that currently exist in a number of foreign countries were considered. Fig. 2 shows the distribution of active clusters depending on their time of origin.

Table 2. Overall ranking of countries by the number of active clusters

Country	Q	R	Country	Q	R
Australia	4	23	Mexico	8	14
Austria	7	16	Nepal	1	46
United Kingdom	168	1	Netherlands	6	18
Andorra	2	33	New Zealand	10	12
Belgium	1	39	Norway	1	41
Bermuda	1	40	Pakistan	1	47
Brazil	3	29	Palestine	9	13
Venezuela	2	38	Poland	1	48
Ghana	1	45	Portugal	4	25
Germany	32	7	Romania	8	15
Hong Kong	11	11	Singapore	3	28
Georgia	1	52	USA	152	2
Denmark	34	6	Thailand	1	50
Israel	6	17	Taiwan	1	49
India	106	3	Turkey	1	51
Jordan	4	26	Ukraine	3	32
Ireland	2	34	Philippines	6	20
Spain	6	19	Finland	11	10

Country	Q	R	Country	Q	R
Italy	72	5	France	96	4
Canada	13	8	Chile	1	42
Kenya	4	27	Switzerland	13	9
Colombia	1	43	Sweden	5	21
Costa Rica	2	35	Ecuador	3	30
Libya	3	31	Estonia	1	44
Malaysia	2	36	South Africa	2	37
Morocco	5	22	Japan	4	24

The results show that the development of cluster systems as a new form of interaction between economic entities, state, non-state and various social structures, is strengthened together with the developing world economy, involving developed countries in the clustering process.

The analysis of approaches to building cluster systems was conducted on the basis of 15 countries included in the priority list by the number of clusters and/or their competitiveness, namely: Great Britain, USA, India, Italy, France, Denmark, Canada, Finland, Ireland, Portugal, Switzerland, Belgium, Mexico, Ukraine, Georgia.

1.2.2. Analysis of cluster approaches using the example of a number of developed and developing countries

When analyzing cluster approaches in different countries, the following factors were taken into account:

1. Location (country: region, city);
2. Number of cluster structures;
3. Kinds of clusters (name of the type of product or service);
4. Description of clusters;
5. Level of economic development;
6. Competitiveness of the cluster structure;
7. Reasons for the emergence and development of cluster structures;
8. Types of support for cluster structures.

Great Britain

Great Britain ranks first in terms of the number of clusters - 168 structures. Great Britain is in third place after Canada and the USA in terms of the average number of employees in one cluster (21,000) and in fifth place after Canada, the USA, Italy and India in terms of the number of companies in one cluster (173).

The statistical distributions of the average number of employees in one cluster and the number of companies in one cluster are shown in Figures 3 and 4, respectively.

In terms of the competitiveness of its clusters, the UK is in the eighth place in the world; while in terms of gross income per capita it is the fifteenth (see Table 3). Traditions, the state's industrial policy and regional characteristics have left a certain imprint on the distribution of clusters in the country.

The largest number of clusters is located in London (England) - 18, Scotland - 15, Wales - 14.

The UK government has identified the areas around Edinburgh, Oxford and South East England as main regions for the location of biotechnology companies. Therefore, the main 11 biopharmaceutical clusters are located in these areas. Due to the high population density, a large number of entertainment and food clusters have formed here.

The largest number of clusters, 13, is in information technology. Three areas of the UK can demonstrate sustainable clusters in information and communication technology (ICT) that make a significant contribution to the country's competitive economy. These are the Scottish cluster, the Cambridge cluster and the Thames Valley. Each area has common features and strong differences in the reasons for the formation and growth of the cluster. Each of the three clusters has government support.

In Scotland, a large information industry cluster generates 4% of the country's total gross domestic product and has 70,000 jobs, while the electronics and whisky clusters have 45,000 and 55,000 jobs respectively. Scotland's clusters gained their development during the Second World War, as these areas were not bombed. And after the war they continued to develop.

The development of clusters in the Thames Valley (including London) is associated with the influence of the government, which directed funds from the activities of London Airport and the entertainment complexes of the London Green Belt to its development. This region is home to most of the educational and scientific centers, which contributed to the rapid development of the ICT cluster.

Table 3. Ranking of countries that apply the cluster approach by gross income per capita

Country	**C.C.**	**GDP per capita, $**	**Rank**	**Country**	**C.C.**	**GDP per capita, $**	**Rank**
Australia	4	27,756	7	New Zealand	10	20,455	22
Austria	7	28,611	5	Norway	1	36,047	1
United Kingdom	144	25,672	15	Poland	1	10,187	26
Belgium	1	26,695	10	Portugal	4	17,808	24
Brazil	3	7,516	33	Romania	—	7,926	32
Venezuela	2	5,226	37	Singapore	3	23,393	20
Germany	29	26,324	11	USA	141	35,158	2
Hong Kong	11	26,235	12	Thailand	1	6,788	34

Country	**C.C.**	**GDP per capita, $**	**Rank**	**Country**	**C.C.**	**GDP per capita, $**	**Rank**
Denmark	34	29,975	3	Taiwan	1	23,420	19
Israel	6	19,382	23	Turkey	1	6,176	35
India	106	2,571	43	Ukraine	—	4,714	38
Jordan	4	4,106	39	Philippines	6	4,021	40
Ireland	2	27,642	8	Finland	11	25,859	14
Spain	6	20,697	21	France	82	26,151	13
Italy	72	25,570	17	Chile	1	9,561	28
Canada	13	28,699	4	Switzerland	13	28,359	6
Colombia	1	6,068	36	Sweden	5	25,315	18
Costa Rica	2	8,470	31	Ecuador	3	3,357	42
Malaysia	1	8,922	29	Estonia	1	11,712	25
Morocco	5	3,767	41	South Africa	2	10,132	27
Mexico	8	8,707	30	Japan	4	25,650	16
Netherlands	6	27,275	9				

In the UK, the highly educated population and most universities are grouped into 3 educational clusters. There are 8 clusters in the financial sector and 8 clusters in furniture production, and 7 clusters in tourism, 7 clusters in clothing production, and 7 clusters in metalworking.

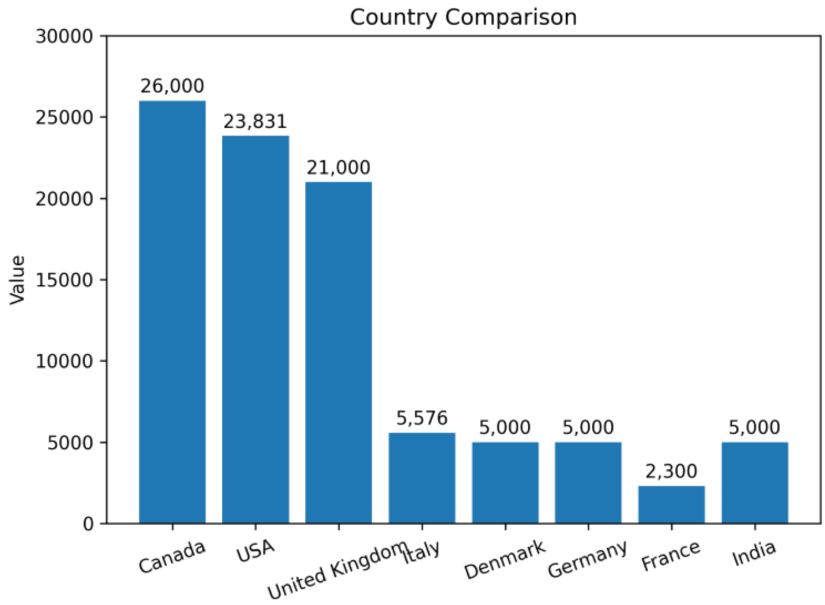

Fig. 3. Average number of employees in one cluster

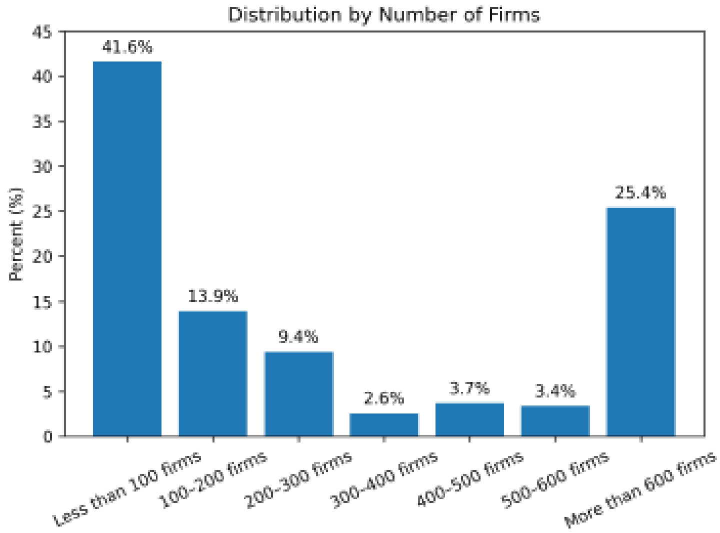

Fig. 4. Statistical distribution of the number of companies in one cluster

Other examples of British clusters are:

Clothing cluster in London.

Employment 87,000 employees. 23% of employment in the industry in the country. 2% of the employed population in London. Almost 50% share in national production/exports. Strong ties with the advertising business, photography, television. Growing cluster.

Publishing cluster.

Employment 55,000 employees. Among the top 3 in the world in terms of competitiveness. Almost 50% share in national production/exports. Has international significance. 40% employment in the industry in the country. 1.4% of the employed population in London. Strong ties with creative clusters. Established and developed cluster.

Oil and gas cluster (London)

Headquarters of oil companies, wholesale market of oil and gas.

Number of companies in the cluster 100. Employment 4000 people. Has international significance. Neutral growth. Formed and developed cluster.

The automotive industry cluster in Wales is one of the most dynamically developing sectors. It is about 170 suppliers, 40 of which are level 1 and 2, over 25 thousand employees. The most famous companies are Ford, Toyota, TRW, Showa and Caisonic. The growth of the industry is increasing due to foreign investment.

The Welsh Automotive Forum is an informal organization of suppliers, the initial funding was provided by the UK Department for Industry and Trade.

Other regional initiatives include the M4 network and the WDA (Welsh Development Agency) supplier association. The association is a group of suppliers vertically united by existing ties in the supplier networks. Often at the request of leading companies, the association helps to introduce new technologies and systems into the supply chain, improving the quality and reliability of supply.

The main tasks of the Forum are to act as an intermediary between suppliers and policy and decision-makers, to create a platform for exchanging experience and to unite all those involved in the supply chain. In its activities, the Forum is closely linked to the AUTOREG project, which is funded by the European Union. The main task of the project is R&D and the development of new technologies in cooperation with European partners. Since 1999, a manager has been appointed to manage the Forum, working on a permanent basis. In 1999, the Forum had 70 members, 60% of which were small and medium-sized. 35 centers of expertise provide their services for research and technology. The leading one is the Engineering Centre of the University of Wales, which specializes in new manufacturing technologies and rapid prototyping.

Funding from the Welsh Development Agency and the UK Department for Industry and Trade ceased in 1999 and was provided by Forum members and technical education centers. Contributions account for up to 70% of the budget. In addition, there was support within the framework of the AUTOREG project. For small and medium-sized enterprises, the annual contribution depends on the number of employees and is 5 euros per employee; large companies make a fixed contribution of about 15 thousand euros per year.

The activities of the Forum are supervised by a Committee consisting of managers from car manufacturers (Ford and Toyota), leading level 1 suppliers, small and medium-sized enterprises, representatives of the university and the development agency. It meets twice a year. Day-to-day management is carried out by a Council of representatives of small and medium-sized enterprises, the business development department of the development agency, an industry advisor and an official from the Forum. There are also the following sections: Education and advanced training, Exchange of experience, Directions of the automotive industry, AUTOREG, Innovation and business development. Thanks to cooperation with the AUTOREG project, there is access to its resources, such as seminars. Topics include familiarization with the technical requirements of car manufacturers, interaction with technology centers, and application of new materials. In addition, the Forum is an information and communication platform in the following areas: Innovation. One of the main areas is technology transfer. In connection with requests from enterprises, meetings and seminars, for example, on robots and surface condition monitoring were held during the year. Business development. Improvement of quality systems, delivery and issues of technological limitations.

United States of America

In the field of cluster approaches development, as well as in the field of various innovative technologies in general, the richest and most open to innovative ways and solutions space is the United States of America. The cluster approach exists in 22 states, and without excluding the specifics of defining clusters in each state, we will give examples of cluster analysis in some of them.

Now in the USA, all economic policy for the development of individual states is largely based on the cluster approach and there are even special rules for governors that allow the governor of any state to make the necessary decisions on the formation and development of a cluster [19].

In the USA, industrial clusters have become very popular, since American scientists began to study the principles of regional economic development earlier than others, and M. Porter was a pioneer - the developer of the cluster model. The states of Arizona, California, Connecticut, Florida, Minnesota, North Carolina, Ohio, Oregon, and Washington led this process and adopted relevant programs, hundreds of cities and territories have developed their own cluster strategies. A vivid example of a cluster is Silicon Valley, where the salary of specialists is 125 thousand per year. 2.5 million people are employed. Venture investments in 2001 amounted to 68.8 billion dollars (1991 - 2 billion dollars).

Committees are created in the states to initiate the creation of clusters. Analytical work is carried out by research centers and universities. A committee distributes shares of cluster participants, helps to overcome obstacles, and takes care of strengthening clusters. Initial capital is allocated by the state, and then funds from private companies are attracted. A characteristic feature of American clusters is that they participate in global competition. Innovative approaches are considered priorities, and the work is based on the principles of partnership.

Since there is no single model to determine the necessary and appropriate structure of the cluster that is being formed in the USA, large and in-depth studies of cluster complexes are being conducted. Using the components of the factor and matrix analysis methodology, researchers from the US Institute for Regional Studies attempted to examine the problem of the national economy through the prism of existing cluster associations. In the course of studies of the intensity of ties between industries, clusters, and cluster sectors, 23 production cluster groups were identified, united in 4 blocks, which united from 5 to 116 participating sectors; they included from 82 to 102 thousand enterprises with the number of employees from 38 thousand to 4.5 million people, creating added value from 4.5 billion dollars to 324 billion dollars.

According to [7], in November 2021, 152 clusters have been identified in the USA, with the largest number of clusters in California (17), Arizona(14), Connecticut(13), Minnesota(11), Massachusetts(10), New York(8), North Carolina(5), Washington(5).

The largest cluster by the number of employees is located in Silicon Valley; this is the computer and communications cluster, which has 1 million employees. The Detroit automotive cluster has about 250 thousand employees.

Among the smallest clusters is the ion implantation equipment manufacturing cluster in Boston, Massachusetts, with only 3 companies in the cluster. Despite the presence of three companies with a combined global share of almost 90%, several hundred qualified employees, world leadership in research, work with specialized suppliers and in conditions of strong competition, this cluster is known only in its industry.

On average, one cluster in the USA has 23,831 employees. The average number of companies in a cluster is 228. In terms of competitiveness, US clusters are in fourth place after Sweden, Italy and Germany, although the average age of American clusters is quite young, they were mainly formed in 1949-1955.

In Boston and Massachusetts, there are many clusters (from consulting technologies to healthcare), which are known throughout the world.

The formation of industrial clusters is currently one of the general directions in the innovation sphere. These directions are highlighted by the National Association of US Governors, within the framework of state policy to support entrepreneurship [20,21].

The experience of the United States shows that the economic development of regions depends on a complex system of interrelated factors, among which territorial location and highly qualified personnel play an important, but not exclusive role. In addition, neither the industry structure nor the presence of new high-tech industries fully determines the economic growth of the region. The most dynamic development is achieved by those regions where industrial or innovation clusters have been formed.

The task of forming and strengthening regional innovation clusters in the United States was put among the most important national priorities in the 2001 report of the Competitiveness Council. It states: "In an era when national borders are becoming less important as capital, technology and talent move globally, the engines of innovation are more local than ever before" [22].

The economic development of a number of US regions was based precisely on clusters. The Example of Silicon Valley is the most famous, interesting and fascinating of all the experience of working with clusters in the United States. This experience was applied to the development of other regions of the world, less developed than the Silicon Valley region. All economic projects: in Silicon Valley, Arizona, Connecticut, are based on the idea of clustering.

To overcome the crisis that arose in Silicon Valley in 1992, a project related to the development of clusters was launched. In "Silicon Valley" there were two prerequisites for the beginning of reforms: the interaction of the university (Stanford) with the leading enterprise Hewlett-Packard (HP); the interaction and stimulation of the HP enterprise with those who wanted to increase the activity of entrepreneurial and academic activities with it.

Many people have the impression that Silicon Valley is a region that has always developed very successfully. But there were also ups and downs in its development. In 1992, 100,000 people lost their jobs in this region. And many companies considered moving their business outside the region, because Silicon Valley offered very expensive labor, the highest-paid engineers were there. In addition, the cost of housing and transportation was very high. To overcome the crisis, a project related to the development of clusters was launched. 12 clusters were identified in the region and working groups were created. These groups came up with initiatives and quite interesting solutions. What really changed was the mentality. The president of Silicon Graphics, which is the largest company in the region, once complained at one of the work meetings that he was unable to cope with the problems of rent, etc., but, in his opinion, for the simple reason that he was not personally acquainted with the mayor. "I don't even know his name," he said. Someone in the audience corrected him: "It's not a man, it's a woman." That is, he had no idea who his real partner in this structure was, who was involved in education, services, roads, and so on. The economic crisis was the impetus that forced them to change and strive to work together. The organizations and communities that were formed in the working groups for this project are still quite strong and are still in working order.

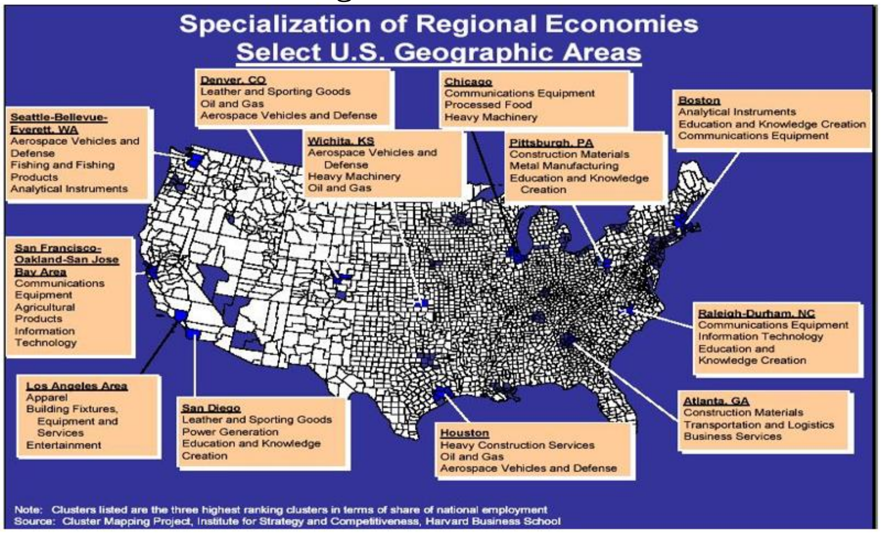

Figure 5. Map of US clusters.

The cluster map shown in Figure 5 illustrates the geographical distribution of clusters in the United States as a highly developed economy. This map shows only a few of the entire array of geographically concentrated clusters present in the United States, starting with well-known ones, such as the entertainment industry cluster in Hollywood, the financial cluster in New York, and the household furniture cluster in High Point, Northern California, and ending with less well-known ones, such as the golf equipment cluster in Carlsbad, California, and the optics cluster in Arizona.

A thriving cluster working in the field of photonics (or electro-optical instrument development) in Massachusetts, located on the outskirts of Sturbridge, extends into Connecticut, where another 135 companies are located, with about 50 of them located in the area adjacent to the Massachusetts border.

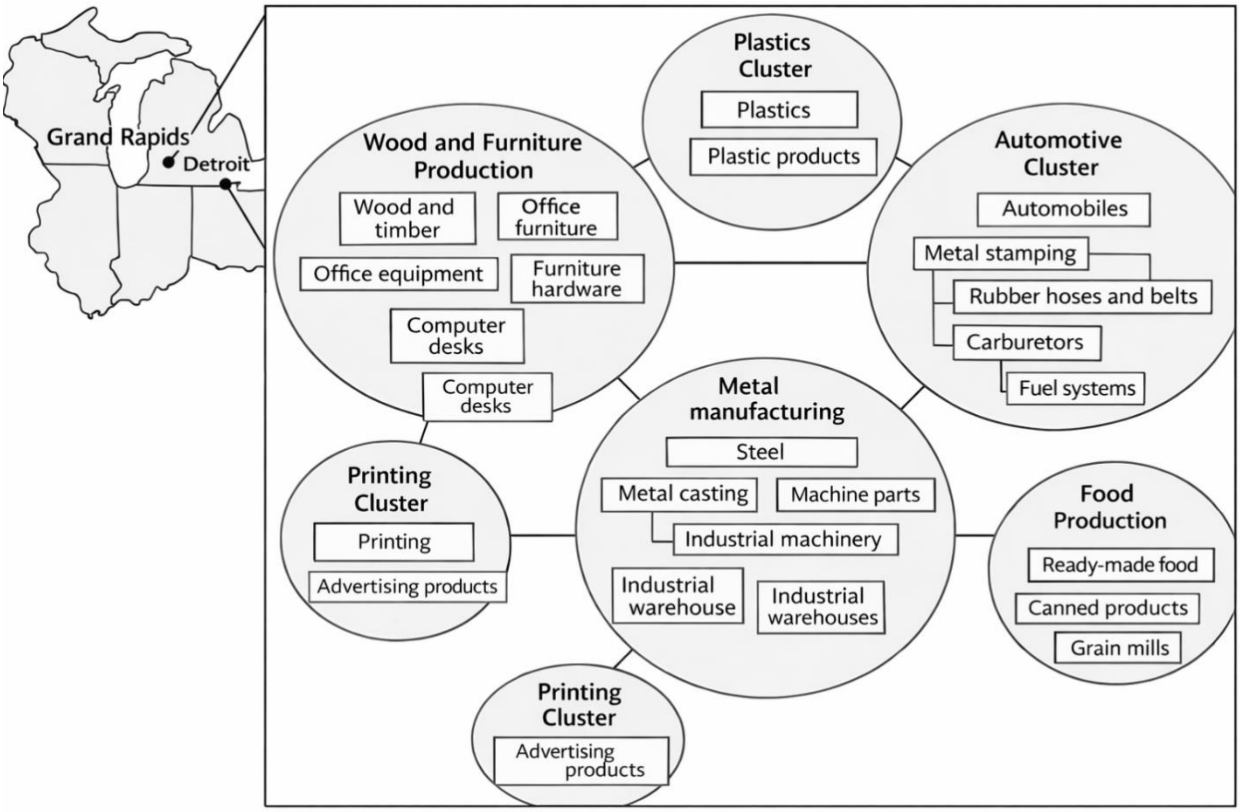

Figure 6. Major clusters located in the Grand Rapids, Michigan area

Figure 6. shows the major clusters located in the Grand Rapids area, Michigan. As can be seen from the figure, the furniture cluster includes manufacturers of office furniture and partitions, stadium benches, classrooms and vehicle seats. In Michigan, a special zoning program has been created to assist emerging advanced clusters, with special funds allocated for the creation of which amount to 50% of the property tax.

In 1999, Pennsylvania founded a chip manufacturing company (PDG), which has become the center of a large computer manufacturing cluster. In Kansas, the government supports clusters: aviation, biomedical/pharmaceutical, information technology/communications, polymer and composite materials. At the center of these clusters is the local university (NIAR), founded in 1985 and located in Wichita, which provides 47 full-time weeks for employees, more than 100 students and graduates in 16 applied laboratories for testing materials research for the space cluster.

In California, there is a cluster related to the aerospace and military industries, a wine cluster, an entertainment cluster, etc. There could be many of them. The California wine cluster is an example of how a cluster can be created artificially. Thirty to forty years ago, Californian winemaking was not even listed in the world rankings. That is, it could not even compete closely with France or even Italy.

The Californian winemaking group includes a wide range of related industries that provide support for both winemaking and grape growing. In terms of winemaking, there are strong connections important to the cluster with both the

California restaurant and food preparation industry (by-products) and the tourism cluster in Napa and other wine regions of the state.

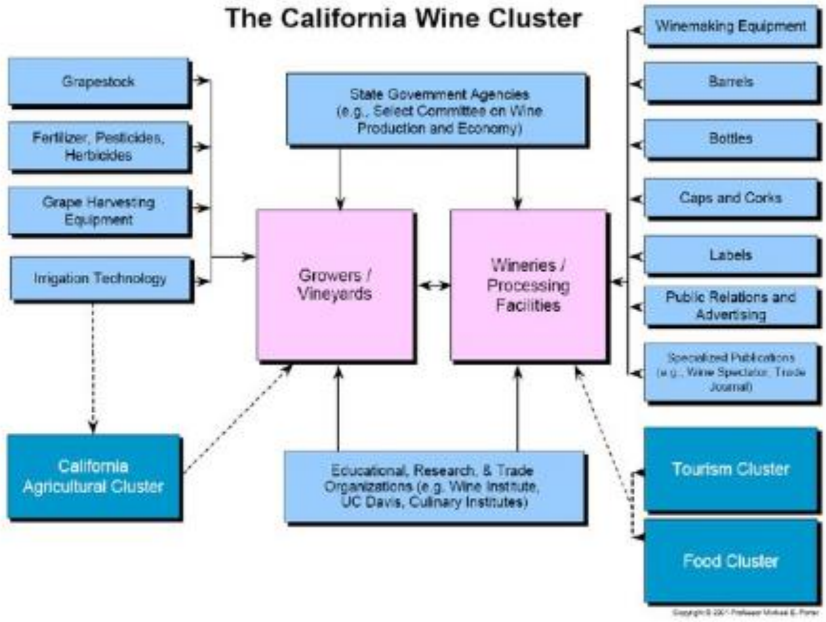

Figure 7 also shows which local organizations are involved in working with winemakers, such as the University of California, Davis, whose viticulture program is internationally renowned, and special committees of the California Senate and Assembly [23].

Figure 7 shows schematic diagrams of the California wine cluster.

In the late 1950s, San Diego transferred property taxes to the University of California to support research and development in the pharmaceutical biotechnology industry, resulting in a strong cluster with over 400 technology organizations manufacturing comsumer products. Consider the forestry cluster. If we take the American education system, then in order to create some kind of joint research center on forest industry issues at an American university, certain steps need to be taken. For example, it is only necessary for the president of the university or even the dean to agree with an entrepreneur, or with the governor, or with some regional development corporation. This center will arise, and tomorrow it will begin to train specialists for the forest cluster, and the day after tomorrow it will become the best program for training specialists in the field of the forest cluster.

One of the conditions for the formation of a cluster is certain individuals who want to grow within the framework of this cluster project. In America, the term "social entrepreneurs" is used, and this means a certain shift in mentality, a transition from "cowboy business" to public business, a transition to public, social interests, and not just a concentration on one's own private ones.

In the chain of causes that lead to the formation of clusters, random events are important. An example of such a cluster is the telemarketing cluster in Omaha, Nebraska, which was largely due to the decision of the US Air Force to locate the Strategic Air Command (SAC) there. Due to the leading role assigned to the nuclear deterrence strategy, the SAC center was the first place in the United States where fiber-optic cable equipment was installed.

In addition, the local company under the control of Bell (now called US West) developed quite unusual capabilities through cooperation with such a demanding customer. The extremely high-quality telecommunications infrastructure developed later in Omaha, along with other favorable factors, such as location in the Central time zone and an easy-to-understand local accent, provided the starting points for the emergence of a telecommunications cluster in this region.

Much work on the identification, description and analysis of cluster structures has been carried out in Virginia. In the work [24] based on the Virginia cluster studies it is stated that such studies are a relatively new analytical method and there is no single approach or methodology for cluster identification. Cluster studies have been conducted both by individual authors and organizations: (Humphrey Institute, 1998 [25,26];, Glasmeier and Harrison, 1997 [27]; Bergman, Feser and Sweeney, 1996; Bosworth, Brian and Broun, 1996 [28]; Held, 1996 [29]; Jacobs, Dany and Ard-Dieter De Man, 1996; Rosenfeld, 1996; Doeringer, Terkla, 1995; Rosenfeld, 1995; Saxenian, 1994; Sternberg,1991; Porter, 1990).

The Virginia clusters were studied with the use of quantitative approaches that typically analyze industrial sectors, using methods that depend on the size of the industrial sector and changes in production indicators (e.g., employment, wage levels, number of establishments and related dynamics), as well as the cross-industry general balance method (e.g., input-output models). Qualitative analysis (interviews, surveys at enterprises) was also conducted, which is necessary, first of all, for the analysis of the structure of supply chains and the description of infrastructure (see, for example, Stough, et.al., [30]). The analysis was carried out on three types of clusters - natural resources, manufacturing and services. 4 resource clusters, 5 manufacturing ones and 11 service ones were identified.

The cluster assessment was carried out on 15 assessment criteria: 1. Employment 2. Change in employment. 3. Annual average wage, 4. Change in annual average wage. 5. Number of establishments, 6. Change in number of establishments. 7. Wage level relative to national wage in industry. 8. Changes in relative wage. 9. Inter-industry dependence. 10. Productivity. 11. Change in productivity. 12. Contribution to gross production. 13. Changes in contribution to gross national product. 14. Location factor. 15. Change in location factor (1992-1998).

To facilitate analysis, all data were presented in the form of star (spider) diagrams, an example of which for the clothing and textiles cluster is given in Fig. 8 (The numbers in the figure correspond to the number of the assessment criterion.

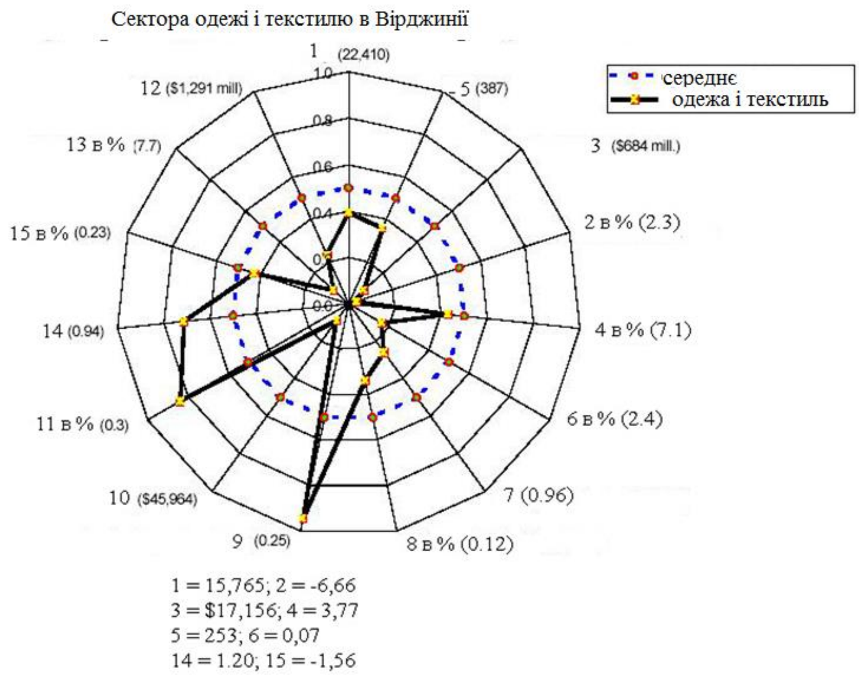

Fig.8 The clothing and textile sector in Virginia.

About 100 clusters have been identified in Appalachia, one of the eight US provinces where the territory is divided according to the features of the terrain [31]. By technological processes, all clusters are divided into 8 main groups: chemical and plastic production, automotive, mechanical engineering, information technology and equipment, space technology, communication and software services, pharmacology and medical care. This region is home to 6 leading educational institutions. The uneven geographical location of the clusters is emphasized: almost half (45) are located in the northern part of the region (New York, Pennsylvania, and northern Ohio).

Only nineteen clusters were identified for the central part of Appalachia (the area that includes southern Ohio, West Virginia, Virginia, and Kentucky), together with Cincinnati and Washington. Sixteen out of the 29 clusters of the south were identified in one third of the southern region - Atlanta, Greenville, Spartanburg, and Huntsville.

In seven regions of North Carolina, 28 major classical and 8 technological clusters were identified using input-output table analysis, ranging from vehicle manufacturing, metalworking, chemical products, rubber, as well as meat and dairy production. It is shown that enterprises in the industry can be included in different clusters. As a result, two types of clusters were analyzed: the first includes only the most strongly connected sectors, the second includes both strongly and moderately connected sectors (data were taken from input-output tables compiled in the USA since 1987) [32,33,34].

Clustering of many industries in Arizona was carried out. One of the oldest clusters in Arizona was formed on the basis of an observatory founded in 1894, and the year of the birth of the optical cluster is considered to be 1942, the creation of the production of micrometric heads for aircraft construction. In 1967, an optical research center was opened at the university. In 1994, the cluster had 57 companies and 3,190 jobs, in 1995 the number of jobs increased to 4,103, and in 1999 - 5,382.

Currently, the cluster unites 83 optical companies, 7 observatories and 2 faculties for training optical engineers at universities [35].

The software cluster - as one of the most dynamic and promising components of the development of the Arizona economy, was created in 1991 by the union of 400 companies and by 2000 there were already about 2,400 companies, representing more than 28,000 jobs, which is 2% of jobs in all of Arizona with wages significantly higher than the average in the region. In general, the information technology megacluster has more than 101 thousand jobs in the state of Arizona [36].

A large megacluster of mining and minerals in Arizona is described. The copper cluster is a part of it including 21 companies and 2,200 jobs in 1990, and its origin is attributed to 1854, the time of opening of the first copper mine [37].

As a rule, in order to understand the strengths and weaknesses of the region at the initial stage, it is necessary to conduct an analysis in four directions:

to find out the number of employees and institutions participating in this sector of the proposed cluster;

to identify the specific weight of local sectors in the cluster and its specific weight in the region and country;

to determine the ratio of costs and revenues along the entire chain of the technological process, from the supply of raw materials and materials to the sale of products;

to determine the growth rate of the cluster.

Examples of such analysis in the regions are quite well-known. For example, the experience of the state of Arizona is indicative, where; with the participation of the M. Porter center, a program of strategic partnership for economic development was developed.

As a result, 9 cluster models were identified and a regional structure was created, which includes groups of consultants in the areas and the work of a group to create 6 support funds. The task was to develop a map of the location and distribution of capacities, prospects for their development and methods of achieving results.

Activities during 1991-1999 demonstrated clusters ability to survive and improve. They functioned as network structures with certain requirements for membership in them and intentions that must meet the goals of the structures: to train jointly, conduct marketing, purchase, produce and create economic structures and funds.

In 1995, at the National Cluster Conference in Arizona, a formula was proposed for determining dominant clusters, where the concentration of production should reach 40%, growth - 10%, and cooperation ties - 10% among the enterprises participating in the cluster. This allowed us to identify 380 of the largest clusters in the United States in the areas of high technology, consumer goods, service industries, and natural resource extraction. These clusters employed 57% of the country's total labor force and produced 61% of GDP [38].

Well-developed Internet cluster, the main centers of which are shown in Fig. 9.

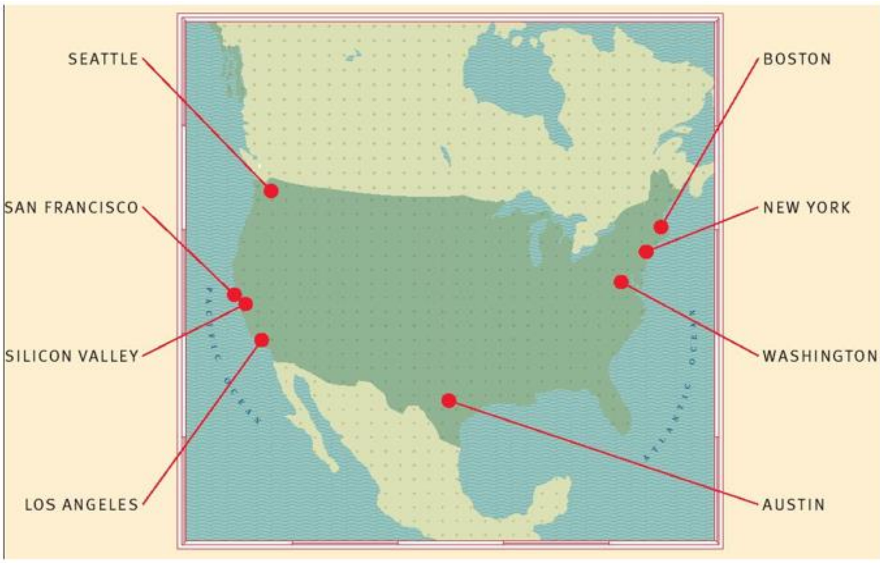

Fig. 9. Internet - clusters in the US

In 1998, the Internet industry accounted for 1.2 million jobs and $300 billion in US national income; in 2000, these figures had grown to 2.5 million and $524 billion [39,40].

Mexico

Mexico is an example of a cluster approach that is completely opposite in characteristics to the American one [41]. This is a region located on the northern border of the Mexican States with the United States. This region has a strong presence of industrial sectors and clusters based on natural resources, and a very small but developing business services sector.

Porter identified 8 clusters in Mexico: 2 related to the automotive industry, 3 clusters for the production of footwear, a food cluster, a furniture cluster, and an oil cluster.

As a result of the cluster analysis conducted by a group of researchers led by Hansen, 19 clusters were identified and about 80 initiatives were put forward in 8 months, most of which were addressed to the problems of individual clusters. 22 projects completely penetrated the entire system of clusters of the camps and covered such services as, for example, education. The projects were part of the Mexican state program for industrial restructuring.

In the state of Chihuahua, the largest in northern Mexico, 9 clusters were identified. In Chihuahua, there are clusters for the production of electronics. This state was at the bottom of all rankings among all states in Mexico in terms of growth rates and unemployment. After steps were taken to implement the cluster strategy, it moved up to the top five. In addition, this state occupies the first position in attracting foreign direct investment compared to other states. The small region of Chihuahua receives more investment than Mexico City. The competitiveness of the region has increased significantly in a short period of time. This is such a unity in the field of low technology. This state has manufacturing, a natural industry sector and a very small service sector. This region, which is economically backward, was able to attract a sufficient number of advanced research centers. And this was achieved largely because it was shown how eager the residents of the Chihuahua region were for these scientific centers to help the development of the region. General Motors, for example, created a scientific center that employed about 180 thousand engineers and gave preference to this region of Mexico, bringing this scientific potential out of Detroit. The results were enormous. The competitiveness of the region has increased significantly in a very short period of time, a great effect was achieved through the intervention of NAFTA [42,43,44,45,46,47].

Canada

Toronto is the economic capital of Canada, a leading city in terms of the number of advanced national and international companies located in it [48].

Unlike many cities whose economic position is based on one or two industries, the Toronto region has a wide range of successful industrial and service clusters. And these clusters are often the leaders in North America in terms of employment growth (relative to the average level). 13 clusters have been identified in Canada and one cluster contains the largest number of companies - 500 (compared to the US - 228) and the largest average number of employees in one cluster - 26,000 (US - 23,831). In terms of cluster competitiveness, Canada ranks sixth after Switzerland, Italy, Germany, the US and India. Most clusters in Canada are from French-speaking Quebec, while most clusters in the world are English-speaking.

An international team of experts brought to Toronto assessed the state of major industrial clusters and compared Toronto's economy with the city's main competitors in the world.

The report, entitled "Toronto Competes: Assessing Toronto's Global Competitiveness," was the result of the study and became a significant contribution to the development of the Economic Development Strategy.

In order to generate and implement ideas in a number of industrial strategic clusters, Toronto has a highly developed network of cultural institutions, world-class institutions, internationally competitive financial and professional services, and the necessary level of industrial specialization. The surrounding region participates in the production and distribution of these results. Toronto's real competitors are not the municipalities that make up the Greater Toronto Area, but such urban agglomerations as New York, Chicago, Boston, and Los Angeles.

Export clusters bring external resources to the region, but the main employment of the population is provided by local businesses. The quality, diversification and viability of local businesses are the foundation of a city's overall economic and social well-being.

Ireland

Ireland can be described as an emerging knowledge-based economy. Ireland's clustering map includes clusters, clustering initiatives and networks across the island. They benefit from being part of a growing cluster community.

Ireland has one of the highest concentrations of information and communications technology (ICT) industry and employment in the Commonwealth. The Dublin-based ICT cluster has 483 companies with 11,784 employees. The overall gross domestic product (GDP) per capita is very high at $21,600. Ireland’s ICT cluster is second only to the US in terms of software exports [49].

When looking at the main characteristics of the Irish ICT sector, it can be mentioned that there is a spontaneous development of the software (SW) cluster in and around Galway city, and the contribution of well-considered public policy and local initiatives. This regional cluster should be considered a “borderless cluster” in the sense that its global nature ignores traditional stereotypes of competition and cooperation within the country.

For the purposes of analysis, the ICT sector in Ireland can be divided into: a) a large industry producing standardized electronic equipment, including computers, computer components and office equipment; b) a small but rapidly growing software industry, which combines elements of standardization and differentiation in a constantly evolving product mix; and c) telecommunications services or request processing centres related to computers and software, which provide a range of services from routine inquiries to problem solving, covering both domestic and European markets. These ICT elements are increasingly linked both by producer-user links and by joint innovation processes and skilled labor markets.

There are also several sectors related to software and multimedia development in the entertainment, education and tourism sectors and telecommunications services.

Ireland is now the world's fifth largest exporter of computers according to the OECD (2000). This accounts for a third of Ireland's exports. One in three computers sold in Europe is made in Ireland. In addition, Ireland is the world's largest exporter of software products. International demand is a major driver of export growth not only for multinational companies in Ireland, but also for local software companies, which export almost 60% of their output. While the manufacturing of electronic equipment is spread throughout Ireland, software development is concentrated mainly in Dublin, with small and medium-sized clusters in cities such as Galway, Cork, Limerick and Galway itself. The Galway regional software cluster includes 3 large North American companies, the largest of which is Nortel, and over 50 small and medium-sized companies, many of which are locally based. It is noted that the competitiveness of such companies stems from Ireland's specific conditions: the prevalence of the English language and the high level of computer and engineering education. While domestic demand is important for local companies through links with large computer, software and telecommunications companies, the multinational sector itself and most national companies are almost exclusively focused on the global market.

The commitment to the policy of "promoting the development of clusters in regional centres" recognizes the fact that "clusters in industry are the driving force of economic development". The nature of clusters gives impetus to innovation, encourages renewal, gives rise to the birth of new companies and industries, and stimulates demand for local industry.

The regional growth of clusters is illustrated by the emergence and development of the software cluster in Galway. The emergence of the cluster is associated with the collapse of the company Digital, which was closed in 1993 and a large number of highly qualified specialists appeared on the labor market. The company Digital organized programs for retraining, job search, starting a new business. Together with local authorities and business representatives, with the support of the government, a Technology Center was established in Galway to help with employment and organizing new businesses. This led to the transformation of the local economy, the creation of new companies with the involvement of investing companies. This is how the chemical cluster and the medical equipment cluster emerged in Galway.

Scale and proximity are factors of competitive advantage, although in the software sector these factors should not matter. Nevertheless, for software development they have become a limiting factor. The second limiting factor is associated with poor access to venture capital. The prevailing factors are the flexibility of small companies, which creates virtual proximity. Another limiting factor has been the lack of highly qualified personnel. This problem has been successfully solved by the organization of business and technical schools.

The uniqueness of the Irish is characterized by the following characteristics. Firstly, the rhomboid model, which implies the participation of only local companies, cannot be applied to the formation of an ICT cluster in a small regional economy. The globalized nature of Irish ICT, the influence of the multinational sector implies the need for a new theoretical approach to the development of a cluster "without borders". Secondly, the presence of ICT production allows it to be used as a useful catalyst and a focus in the development of the cluster.

Thirdly, this is the development of a regional base of qualified specialists, adequate to the scale and complexity of the industrial cluster. Fourthly, the experience of Galway implies appropriate support by business structures as one of the local components of the successful development of the cluster. Fifthly, this is political initiatives to support regional business and innovation at both the national and EU levels: "commitment to the policy of cluster development in regional centers". Sixth, the sustainable development of an ICT cluster depends on continuous innovation, which in turn is based on advanced research and training of scientists, for example, research funding according to the National Development Plan for 2000-2030.

Spain

Clusters in Spain (Microclusters in Catalonia).

Two large territorial ICT clusters have been identified, i.e., one in Madrid, the other in Catalonia. 20% of all innovation in Spain is accounted for by the industrial cluster of information and communication technologies (ICT). In the Basque Country, three ICT clusters were identified in 1993 - electronics, telecommunications and computers. However, only the telecommunications cluster proved to be competitive [50].

Clusters have been studied in the most detail in Catalonia, where 13% of the population of Spain (a total of 17 autonomous regions) is located, accounting for almost 20% of the gross national product and about 40% of industrial exports [51].

The history of clusters in Catalonia is associated with Spain's entry into the European Common Market.

On the eve of Spain's expected entry into the European Common Market in 1992, the head of the Ministry of Industry, Labor and Trade developed a new approach to industrial policy in Catalonia. Clusters were chosen as the main element. Since then, about twenty Catalan clusters have been studied in detail. As of 1997, clusters continued to be used in Catalonia as the main method of achieving competitiveness for a given region and identifying areas in which the government can improve the environment for companies.

The study provided a description of the strengths and weaknesses of the Catalan economy, identified groups of clusters and allowed for the development of some common measures necessary to strengthen their competitive advantages. The proposals of the Ministry of Industry, Labour and Trade were implemented by a local consultancy company, CLUSTER Competitiveness. A request was sent by the ministry for a number of cluster-related projects. Each study involved companies, suppliers, trade associations, business schools, universities and many government departments [52].

The clusters located in Catalonia comprised about 20 regional clusters, including the production of wooden toys, agricultural machinery, bijouterie, manufactured leather, knitted goods, prepared meat, a publishing cluster, a cluster for the production of consumer electronics, and also for the production of furniture. The specific clusters were defined quite narrowly. For example, in the production of furniture, three separate clusters were identified in different parts of Catalonia, each of which participated in the competition in a specific industry and had its own developments and tasks. The assessment showed that Catalonia had more than a hundred such narrowly defined clusters, or microclusters. Each microcluster study looked at companies, suppliers, universities and a range of other stakeholders. The principle of self-identification was adopted as a rule: all companies interested in participating in the cluster were considered a part of it.

All clusters were considered equally important. However, for practical purposes, the cluster study was structured in a certain order. Some clusters were initially better organized than others. The aim of this process was to create effective trade organizations to serve each cluster.

The cluster study in Catalonia took place in three stages. The first stage identified the problems and opportunities that the cluster had and developed a basic concept for improving the cluster, with the aim of strengthening, rather than weakening, competition. In some cases, the study provided a different view of the cluster’s problems than was commonly thought. For example, members of the Catalan leather tanning cluster attributed their reduced competitiveness to the lack of clarity in environmental legislation for the region. The study, however, showed that legislative regulation of environmental protection issues has the strongest impact on competitors, Italians, was actually even stricter than in Catalonia. As a result, the Catalan tanners, who had initially appealed to the government to relax environmental laws and regulations, decided to set up a joint tannery and tannery waste treatment plant and a research and development center. The processes taking place in the cluster convinced them that caring for the environment would lead to a real increase in their competitiveness.

The second stage of the research process attempted to achieve a coherent vision of the future of the cluster, in which all participants could unite for the purpose of positive change.

In the third stage, the cluster participants developed a strategy and concrete measures to implement the recommendations described above. Specific people were appointed to lead the proposed actions.

The processes taking place in the clusters gave the Catalan government an idea of what was needed to more effectively influence public policy in Spain. More importantly, however, it has also led to a new and more effective dialogue between the government and the business community in Catalonia. Knowledge of the processes taking place in the cluster has enabled businesses to achieve a competitive edge in a specific and effective way.

Companies have asked the government for more specific and competitive support, such as assistance in setting up research laboratories and promoting foreign trade. Previously, broad sector-wide organizations had taken general measures such as subsidies or tax reductions.

The cluster approach has helped many companies (among which there are a significant number of small and medium-sized ones) to look at their problems from a strategic perspective.

The analysis identified the measures needed to improve the competitiveness of the clusters:

relocating the leather research centre from the University of Barcelona to a location closer to the cluster, in Igualdo;

a series of seminars were held to help textile workers shift their focus from production to resale;

a project was developed to create joint pre-assembly facilities to service local factories producing Honda, Yamaha and Derbi motorcycles.

The motorcycle assembly cluster currently includes three companies and is among the top ten clusters in the world in terms of competitiveness and ranks second in Europe (except Italy). A distinctive feature of this cluster is that 85% of it is owned by foreign companies. The year of the cluster's creation is 1949, while the first motorcycle was created in Spain in 1905. The cluster was created as a result of the government's facilitation of access to foreign direct investment, based on enterprises producing bicycles.

Some clusters initially lacked effective associations (for example, the furniture cluster in Mogcia); others were part of organizations that had too strong selectivity (for example, lathe operators); thirdly, ineffective associations operated (as, for example, in the case of the tanners cluster in Igualada). The tanners cluster in Igualada contains 50 companies, with a total of about 1,000 employees. It is the oldest cluster in Spain, dating back to 1450. 95% of leather production and tanning companies are located in Igualada.

Following efforts to improve clusters, new and more cluster-specific associations were created, and previously existing associations were reorganized.

The policy pursued by the Catalan government has shifted towards improving clusters: greater emphasis was placed on improving the market access of clusters; facilitating foreign direct investment; introducing product certification programs; and implementing policies aimed at improving technology. For example, based on cluster studies, the government provided assistance to the cork research and application center in Parafrugell (where an international cork quality standard was developed).

In one of the main processes ensuring the advantages of clusters, government representatives acted as an informed audience for companies. The dialogue between different agencies and departments in the Catalan government was also intensified, and their interaction improved.

The experience of Catalonia provides many lessons for the application of the cluster method.

First, one of the main advantages of increasing the organization of a cluster is to explore common opportunities, rather than simply discussing common problems.

Second, leaders noted the great importance for the formation of clusters was the absence of excessive concentration on its outlines; limiting publicity in the early stages avoids untimely maturation, unrealistic expectations and helps to reduce formation of political and other opposition.

Thirdly, specific leaders who appear in this cluster must do a lot for its success and improvement [53].

Portugal

Regional clusters of Portugal are shown in Fig. 10.

Sources: Monitor Company, Cambridge, Massachussets and Forum para a Competitividade (1994); Adapted from Porter (2008, p. 246)

Fig. 10. Regional clusters of Portugal [54].

In Portugal, the most interesting cluster is the forestry and woodworking industry. Portuguese factories suffered from low quality wood, since landowners did not invest in forestry. Since wood was mostly processed for use in containers and boxes, and this application was less profitable, the prices paid to landowners were also limited. A significant increase in work efficiency was possible, but only in the case of simultaneous changes in several parts of the cluster. For example, in the logging process, it is necessary to change the cutting and sorting procedures, and sawmills had to provide for the possibility of processing wood with more progressive methods. An important step that allowed these changes to be made was the coordination of efforts to develop classification standards for wood. Such connections can be more easily perceived and established within a cluster, rather than among separate participants.

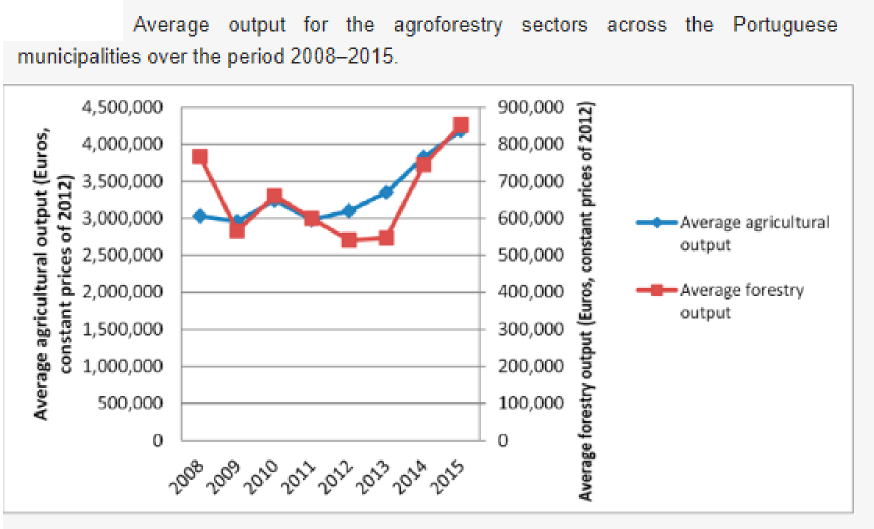

Fig. 11. Forestry production in Portugal [55]

Fig. 11 shows a forest industry cluster in Portugal, in a middle-income economy [56].

Denmark

The cluster study in Denmark was conducted in two stages. First, an analysis of clusters of competitive industries was conducted, which showed that competitive industries are not evenly distributed in the national economy. The systemic nature of the "rhombus" contributes to the creation of clusters of national competitive industries. Thriving industries are usually linked by vertical (buyer-supplier) or horizontal (common customers, technologies, intermediaries, etc.) relationships.

Fig. 12 Clusters in Denmark

Figure 12 shows a number of globally competitive Danish industries, which are interconnected. 34 clusters have been identified in Denmark. In terms of the number of companies (94) and the average number of employees per cluster (5,000), Denmark ranks 5th after Canada, America, England and Italy. The communications equipment cluster in Aalborg (Jylland district), Northern Denmark, for example, was established in 1949 after an increase in demand for specialized communications equipment by the Danish fishing fleet and shipping industry. This cluster includes 27 companies and is closely linked to the Aalborg Institute of Electronic Systems and its research center.

In Denmark, there are clusters of competitive industries related to the production of household goods (furniture and household goods) and health care (pharmaceuticals, vitamin production equipment, medical equipment, etc.). The healthcare cluster is linked to the agricultural cluster through technology and raw material requirements.

The Danish transport cluster arose from its central location in Europe, its well-developed water transport network, the efficiency of the port of Rotterdam and the skills accumulated by the Danes through their historical maritime experience.

In the second stage, a megacluster analysis was carried out - the matrix of which included four horizontal segments and three vertical areas: information technology/electronics, telecommunications, broadcasting, and infotainment.

The studies carried out in Denmark were funded by the National Agency for Industry and Trade, the Danish Civil Servants' Pension Fund, the Research and Planning Council, the Danish Society of Chemical, Electrical, Mechanical and Civil Service Employees, and the stock exchange newspaper Borsen Daily. A description of cluster policy in Denmark in the early stages of development (1980s) using examples of the development of the agro-industrial complex, textiles, environmental protection, and office equipment ones was given in OECD reports.

In Denmark, the government launched a large-scale project aimed at creating officially registered clusters. Within the framework of this project, "network brokers" try to unite companies into a network. At various stages of creating networks, it receives financial support from the Danish government. For example, the furniture production cluster, which includes 134 companies, is closely connected with the Academy of Arts and the School of Design, and was supported by the government in preparing goods for export, and the government also financed scientific research conducted at the School of Design.

Finland

One of the most efficient and competitive economies in the world is the Finnish economy, which offered the world the Finnish model of the information society, which is significantly different from the models of Silicon Valley and Asian countries. In Finland, 11 different cluster structures have been identified.

In Finland, a country that actively uses the cluster concept, the effectiveness of targeted programs has become one of the key elements of the success of cluster projects. A number of very strong Finnish clusters arose due to the presence of natural resources. Finland has a very good experience of how clusters were created, in particular, largely on the initiative of the state.

The basis of the Finnish information economy is its exceptional role as a producer of information technologies. The information technology cluster has become the most dynamic and competitive, export-oriented sector of the Finnish economy. This cluster creates 45% of Finland's GDP, 85% of the information technology equipment produced is exported.

Finland uses the concept of clusters to form its own technological development policy.

The Finns have identified key clusters in the country's economy that will determine the future in the coming years. A business portfolio for the Finnish economy has been defined. An analysis of the world market has been conducted: how fast the international market is growing, how quickly it is possible to get the necessary money on this market and stimulate the development of your country through this, and an analysis has also been made of how Finland's share in this international market is changing. The most priority areas have been identified where the market is growing intensively, and at the same time Finland's share is constantly increasing. Clusters located in this area will bring more profit and more employment to the country's economy in the near future.

There are clusters in which Finland occupies a fairly strong position in the international market, and the situation is such that growth is very high. Therefore, these industries will bring stable income to Finland, but they must be used as cash cows, receiving the necessary level of employment and profit for the economy. This is primarily energetics and everything related to metallurgy.

The Finns consider the structure of the forestry cluster in the following directions. The cluster breaks up into small pieces, and the most priority segment for Finland, in terms of global market growth, is forest chemical products. Similarly, in terms of equipment, Finland occupies a very strong position, but growth is quite limited. Finland is losing its positions in paper and pulp production, forest harvesting and logistics, and building materials. Thus, these examples provide an opportunity to understand how the cluster concept can be used to develop a strategy for the economic development of the territory.

The telecommunications cluster in the Helsinki area competes with the cluster in Silicon Valley for Nokia to locate its research center not in Silicon Valley, but in this telecommunications cluster. Therefore, for example, for the city of Espoo and the city of Helsinki, it is not very important that there is a company called Nokia and that it has a large number of different divisions in different countries; for these cities it is very important how many people work for Nokia in a given specific territory. When it comes to regional strategy, it is very important for the region not only that the headquarters of a huge company with huge sales is located in this region. It is important for the region that this company locates its production centers, its research and development centers in this region and that a large number of employees of this company live in this region, so that salaries grow in this region, and not in another one. How do the Finns plan to use the results of cluster analysis to make decisions at their level? In Finland, one of the powerful tools for stimulating the development of industries is technology programs implemented by the state technology agency. The main idea is to invest certain amounts of money in certain industries. In other words, 30% to be given to information technology, and 70% to other places, or vice versa? Cluster analysis suggests that in the near future in Finland the largest share of added value will be in two sectors: technologies related to the environment and the information and telecommunications industries. Therefore, quite a majority of resources in the next 5-10 years will be directed to these industries.

As a result of environmental pollution by manufacturing industries (for example, metalworking and forestry, chemical production, energy), an environmental protection cluster has emerged in Finland. This cluster is an example of a cluster that arose at the initiative of the government.

Finland has a developed forest industry cluster, which includes the production of wood and wood products, paper, furniture, printing and related equipment. Close interaction of companies in this cluster in the dissemination of knowledge provides competitive advantages over major trade rivals. According to experts, Finland leads in terms of both research and technological cooperation.

The countries have entered a period of competition not of enterprises, but of cluster competition, and Ukraine's closest competitor is exactly the Finnish forest cluster.

If we take the Finnish and North-West forest clusters, it is clear that in Karelia, for example, the forest cluster is included in the Finnish forest cluster.

Italy

The earliest research on clusters was conducted in Italy, a European country, but with a rather weak currency and state regulation. The idea of clusters, the use of clusters appeared in Italy earlier than in all other countries, because the Italian government does not fully fulfill its functions. And companies were able to compete in the markets only because they were able to organize themselves. These companies are small enterprises, but they were able to compete in the international market precisely because they are elements of a cluster.

The dominance of small and medium-sized companies in the local economy of industrial areas is sometimes called Italian-type clusters. Currently, 72 clusters have been identified in Italy, and Italy ranks fifth in terms of the number of registered clusters, after England, the USA, India and France. In terms of the average number of companies in one cluster (400) and the average number of employees in one cluster (5,576), Italy ranks fourth after Canada, the USA and England, and in terms of cluster competitiveness, it ranks second after Switzerland. Italy also has the largest cluster in terms of the number of companies in it - the textile cluster in Prato, which includes over 9,000 companies. The largest number of clusters is associated with the production of clothing - 14, footwear - 10, furniture - 7, ceramics - 5.

A small example can be provided. Hostelgofredo is a small town with a population of seven thousand people, where sixty percent of hosiery sold in Europe is produced. This is specialization. In this regard, the experience of Italy is very characteristic because the furniture companies, which are alone unable to enter the foreign market by themselves, and their associations, their cooperatives (regional, industry or all-Italian) help them enter the foreign market. There is an Italian furniture store in Kyiv, where at the entrance there is a list of companies that supply furniture there from Italy. About a hundred companies are listed. None of them alone could enter the world market. All together they can do it due to cooperation.

In *Italy*, special clusters have formed in industrial areas, in which industry combinations have developed: metalworking - cutting tools, fashion - design, leather - footwear, woodworking - furniture.

Italy, for example, has achieved a strong position in fashion and design, which creates certain advantages for companies that produce shoes, leather goods, jewelry and accessories. This position is to some extent a common property of all Italian companies working in the fashion industry.

When forming clusters, the experience of Europe and especially Italy has shown that the presence of a large parent company is not mandatory. Sustainable industry agglomerations (industrial districts or clusters) can be formed taking into account small enterprises, especially in industries such as light industry, instrument making, information technology, agriculture and others. In this case the industrial district acts as a collective entrepreneur.

Footwear clusters: The footwear industry specializes in the manufacture of luxury footwear and sports shoes. The footwear tradition is over 700 years old, the foundation of the Brotherhood of Shoemakers ("Calegheri") in Venice dates back to 1268. There are about a thousand companies in the luxury goods supply chain, they employ over 20,000 people and produce over 55 million pairs of shoes per year for international brands, especially for women. Most of them are located near Venice, along the Brenta River. There are over 400 companies in the sports system, with over 8,000 employees and a total production volume of 1.5 billion euros. These companies are located throughout the Treviso area, north of Venice.

Fig. 13 Clusters of Italian footwear manufacturers and designers

Fig. 13. shows schematic diagrams of the cluster of Italian footwear manufacturers and designers, showing several chains of related industries involved in the Italian footwear manufacturers and designers group, including industries involved in the production of different types of leather goods (by-products, common factors of production, similar technologies), producing different types of footwear (overlapping distribution channels, similar factors of production and technologies), and different types of fashion goods (by-products), such as the cluster for buttons, dolls. These industries also share a common market environment and compete in similar brand images and consumer segments. The extraordinary strength of the Italian cluster can be attributed in part to the numerous cross-links between companies and the commonality of development processes.

An example of a poorly developed cluster is the car industry in Turin, where a third of the FIAT Group's production is concentrated, as well as the Pinifarina and Bertone companies that produce special purpose vehicles, coupes and convertibles. The main areas of specialization are design, styling, prototyping, production of bodies and components. Over 50% of the turnover of the production of automotive components in Italy 300-400 companies are suppliers of level 1 and 2, 2000 small and medium-sized subcontractors. The cluster accounts about 63.5 thousand employees. In the field of technology there is a polytechnic institute and a technical university in Turin, over 80 technology centers. However, the connections between them are quite weak, especially in the field of work on joint research projects in the automotive industry. The Consortium for Internationalization, Development and Training - C.I.S.F.I. is the center of the network of subcontractors. It was created by related enterprises to enter foreign markets and operates on a non-profit basis, has a network of offices abroad. The Consortium provides services in marketing research, consulting, training in the creation and development of joint projects, and internationalization of projects. However, by its status, the Consortium is primarily a trade association with the potential to transform into a full-fledged cluster organization. Not receiving significant political and financial support from the regional administration, the Consortium lacks resources to develop activities in the field of cooperation and technology exchange, and to provide services to suppliers. There are also a number of other organizations in the region that provide services in the automotive sector. These include the Chamber of Auto Components, the Automotive Section of the Innovation Center for Technology Exchange, the Association of Metal Products Manufacturers (AMMA), the Association of Small and Medium-sized Enterprises of Turin and the Province (API Torino), and the Trade Association of the Automotive Industry (ANFIA). API Torino and ANFIA provide quality services to companies, representing their interests, but do not coordinate and cooperate at the necessary level.

None of the regional organizations is engaged in uniting research and technology institutes to carry out joint projects, collect and disseminate information necessary for suppliers, organize the exchange of experience. Moreover, these organizations even compete with each other. This is partly due to the fact that politicians are not involved in this process, which would help create a network under the management of an independent agency. In this regard, the automotive industry in Turin is not yet a well-structured cluster.

Belgium

The appearance of clusters in Belgium, as in many European countries, is associated with the peculiarities of economic development and traditions of different regions of the country.

The emergence of clusters in Flanders proceeded in two ways. Some clusters formed spontaneously, others were created specifically with the help of government cluster support programs, especially in the information and communication sector. The Flemish ICT cluster has received great development with the support of the Belgian government.

Typically, the economy in Flanders is based on agglomeration, i.e. a combination of different industries, such as petrochemicals in Antwerp or carpet production in the Kortrijk region. The carpet cluster has 140 companies, more than 45% of its products are exported, and it has original technologies and use new materials, sometimes of foreign origin. The cluster was born after the Second World War in 1950.

Flanders was a pioneer in the application of the theory of cluster development. The first experiments in the development of cluster policy were related to the textile industry. The government allocated funds for the organization of clusters in the sectors of textile machinery, steel plate applications, electrical equipment assembly, synthetic products, furniture, digital signal processing, telemechanics in road transport, speech recognition technologies, aeronautics and the space industry.

The second period of development of the Flemish economy is associated with the new government, which since 1995 has increased innovation in scientific research. In the second period, a policy of creating an alternative to clusters as an industry-specific approach was developed.

The third period began in 1999, the current Belgian government returned to the cluster approach, which ensures high efficiency, and cluster programs began to be supported again.

For example, Table 4 shows data on the structure of some sub-clusters in Flanders in 1999.

Table 4. Content of sub-clusters in Flanders in 1999 (data from the National Bank of Belgium)

Sector	**Number of Enterprises**	**Number of Employees**	**Value Added Created, million USD**
Publishing	493	5,000	20
Printing	1,574	17,000	45
Advertising	1,646	4,000	15
Photo and Film	323	2,000	4

Sector	Number of Enterprises	Number of Employees	Value Added Created, million USD
Laboratories			
Cinema	470	1,000	4
Radio/TV	104	4,000	8
Other Sectors	104	2,000	4
Total	**4,862**	**35,000**	**100**

Of particular interest in the development of the Belgian cluster system is the formation of small clusters in Flanders.

Thus, DSP Valley was organized on the private initiative of the University of Louvain in 1993-1994.

Using the method of economic analysis of enterprises' input-output, the mega-clusters of Flanders were analyzed, using the cluster identification methodology "maxim method" (M-method). The analysis was conducted at the macro level, examining supplier-customer relationships. The M-method classifies sectors by suppliers and consumers in two phases. In the first phase, suppliers are analyzed that are important initially in the production process, have connections with the following elements, i.e. suppliers are important for production itself and product quality. In the second phase, the connections with the products manufactured (packaging, delivery, etc.) are considered, i.e. the suppliers, that are important for the consumer, are identified.

In 1995, five mega-clusters were identified in Flanders:

1. Agro-food
2. Construction and metallurgy
3. Chemical
4. Transport and storage
5. Service.

There is some overlap between mega-clusters due to connections between sectors of different clusters.

Brief description of the clusters.

The agro-food cluster is a very compact mega-cluster, weakly connected to other clusters and it includes: agricultural, forest and fish products [57], meat products and meat, as well as tobacco products

Cluster Construction and metallurgy.

This is a very large Mega-cluster in which the sectors "construction and structures" and sectors related to metallurgy "iron and steel products", "metal products" prevail. Around these main sectors there is a network consisting of suppliers and consumers. The cluster is very connected to other mega-clusters; therefore it is an open cluster.

The analysis of economic indicators of cluster development shows that the greatest added value is created in three clusters - Construction and metallurgy-27.9%, transport-29.7% and service-28.3%, the service cluster provides the greatest employment of the population-49.2%.

Chemical cluster is a small cluster in which there are only four sectors. In this cluster, the sectors "chemical products" and "plastics" are at the center. Both sectors have strong internal connections. The "chemical products" sector is strongly connected with other clusters - construction, metallurgy and service. Two sectors of this cluster stand out separately - "rubber" and "other manufacturing".

Switzerland

13 clusters have been identified in Switzerland, which are defined as the most competitive in the world. This is, first of all, the cluster of Swiss banks, insurance companies, dyestuff, and two clusters for the production of watches.

In Switzerland, five pure (profitable) progressive clusters and seven lagging in the development (unprofitable) clusters were identified using the "input - output" method. The merger of these two types of clusters gave five mega-clusters:

1. Agro-food.
2. Industrial service.
3. Construction-service-metal-electrical equipment.
4. Metal-machinery-electrical equipment-chemistry.
5. Textile.

All mega-clusters have strong internal connections with sub-clusters and they are not perfect and overlap with each other. For example, the metallurgical cluster consists of 11 sectors; it is the second largest cluster.

Compared to other clusters, the textile cluster is a very compact cluster, consisting only of "Textile Industry" and "Ready-made women's clothing", between which there is a strong mutual connection. This mega-cluster reveals, as it were, "wrapped inside" dependencies. Despite its small economic importance, the textile industry sector has high external cooperation with research associations and is constantly developing new production (has constant innovations).

India

Among the developing countries, India can be singled out.

About 106 clusters have been identified in India. Such a large number of identified clusters is due to the fact that from 1996 to 2001, a project to build and develop industrial clusters with a total cost of $ 1.8 million was implemented in India with the financing of the World Bank for Reconstruction and Development.

The goal of the project was to increase the competitiveness of small and medium-sized enterprises by organizing industrial clusters.

Small and medium-sized clusters in India have existed for several decades; there were about 350 urban and 2,000 rural clusters. They produced 60% of Indian industrial exports, and most of them had effective economic performance indicators.

Having become acquainted with their economic potential, the government decided to ensure the successful development of clusters. Based on a comparative analysis of existing clusters in India, four of them were selected for development assistance: hand-dyed fabrics in Jaipur, knitwear in Tirunelveli, woollen knitwear in Ludhiana, and food processing in Pune. In 1999, three additional clusters were identified: machine tool manufacturing in Bangamore, leather manufacturing in Ranipet, and pharmaceuticals in Ahmedabad.

Each cluster was carefully studied, its needs assessed, and objectives for further development were set. To broaden the scope and increase the significance of the project, a national cluster program for the development of small and medium enterprises was developed, support for cluster initiatives was organized, and cooperation with key national institutions and development banks such as the Small Enterprise Development Bank of India, the State Bank of India, and the National Enterprise Associations was organized. The project also assists the Ministry of Industries in ensuring coordination and development of synergistic systems at the national, state and cluster levels.

Four clusters have been selected for assistance in various forms.

1. Handloom Fabrics in Jaipur

The Calico Producers' Society - comprising 126 artisans - has been revived and joint initiatives including joint marketing have been taken up. 15 exporters, who formed the Textile Exporters' Consortium, have joined forces to improve the quality of their products for export and expand access to external markets up to the Japanese market.

2. Knitwear in Tirupur: 10 companies and 12 entrepreneurs who have obtained international certification for yarn and knitwear have entered into subcontracts.

3. Woollen knitwear in Ludhiana. The cluster includes 12 related companies, created a development group that organizes the preparation of courses and the search for export markets. 30 companies received international assistance through the project, 40 exporters were helped to create the Ludhiana Garment Exporters Association, which organizes the training for specialists and coordinates exports.

4. Food industry in Pune. A Consortium of Food Industry and Trade was created. 250 entrepreneurs participated in the preparation of the program. An information center was organized and equipped with computer equipment.

Indian cities are characterized by the presence of clusters - groups of houses with a common yard and garden, connected by local economic activities within one district. Such local production areas are concentrated around centers of production and services. As a rule, they are associated with the satisfaction of everyday needs: the manufacture of dishes, household electrical appliances, simple washing machines, sanitary equipment, electrical cables, car repair, etc. For example, Viswas Nager in Delhi is one of such enterprises, specializing in the production of electrical cables and wires. As one of the largest clusters in India with 2,000 enterprises, this company accounts for 25 to 40% of all domestic electrical cable production. In 1991, Viswas Nager provided direct employment to about 25,000 people and indirect employment to 30,000. There are at least 15 such large industrial clusters in Delhi and about 60 smaller ones.

It is striking that the government investment that stimulates this economic activity does not come from specialized business development programs or even from special funds. Instead, support is provided through land use regulation, which provides people with access to basic infrastructure, and through the application of new regulations that allow residents to develop land plots gradually, depending on the opportunity that arises, and to give a part of it for rent to a new company or new entrepreneurs.

The relevant land use regulations are also characterized by a variety of tenure systems that allow groups with different incomes to settle in close proximity to each other. Thanks to this, groups of poor people gain access to new jobs not only through their functional economic ties, but also through participation in the work of regional economic development bodies.

Georgia

In Georgia, cluster analysis identified 5 agricultural centers, one of which is involved in the production of nuts. This production is the second largest export item in the country. A rough picture of the cluster structure in Georgia is given for the nut processing project. Some elements of the cluster are currently operating, and some elements of the cluster will be operating soon. In accordance with the recommendations of the cluster program, a special nut processing center was established, as well as several nut growing associations, in order to improve the organization of the work within the cluster.

The organization "CERMA", which helps to carry out this work, is a center for the rehabilitation of enterprises and assistance to the management of these enterprises. It was established five years ago by the World Bank. The company "CERMA" was engaged in identifying enterprises that are particularly in need of assistance. Special cluster meetings are held, in which suppliers, customers and government representatives participate. It is this kind of work that allows using the scarce resources that exist more efficiently.

The results of studying international experience in the field of creating effective industrial cluster systems and analyzing existing international and European approaches to building effective industrial clusters and megacluster management systems are given in the summary table 5.

Table 5. Level of analysis, cluster technique and cluster concept adopted in different countries.

Country	**Micro**	**Meso**	**Macro**	**I/O**	**Graph**	**Corr.**	**Other**	**Cluster Concept**
Austria		X	X	X	X	X	X	Production networks, innovation networks, interaction networks
Australia		X	X				X	Marshallian industrial districts
Belgium	X			X				Production networks or chains, innovation and cooperation
Canada		X	X	X			X	Innovation systems
Denmark	X	X		X	X		X	Localized resource

Country	Micro	Meso	Macro	I/O	Graph	Corr.	Other	Cluster Concept
								base
Finland	X	X					X	Clusters as a unique combination of firms united by common knowledge
Germany	X	X		X		X		Similar firms and innovation styles
Italy		X		X				Production networks, innovation networks, interaction networks
Mexico		X	X				X	Innovation systems
Netherlands		X	X	X			X	Value chains and production networks
Spain		X		X			X	Innovation systems
Sweden		X					X	Systems of internal interdependence of firms in different industries
Switzerland	X	X				X	X	Innovation networks
United Kingdom	X	X					X	Regional innovation systems
USA		X		X			X	Production chains and networks

Notes
Levels of Analysis
- Micro – one or several companies
- Meso – regional level
- Macro – mega-clusters at the national or international level

Cluster Techniques
- I/O – *Input–Output method*
- Graph – graph-analysis method
- Corr. – correlation analysis method
- Other – other analytical methods

Ukraine

In Ukraine, the concept of an industrial cluster is used in state documents. Thus, the Law of Ukraine “On the State Privatization Program” states "Chapter XII Market Transformation and Privatization of Particularly Important National Economic Complexes - Art. 168.2": The main requirements for the program of market transformation and privatization of the aircraft manufacturing complex: - state aid and political measures should contribute to the formation of an industrial cluster that can generate innovations, develop and realize competitive advantages [58].

The study of positive world experience determines the conduct of a comparative analysis of privatization processes in countries with economies in transition. This analysis concerns the prospects for the development of individual sectors and types of economic activity. The criteria analysis should be the following:

Profitability and efficiency of state-owned enterprises abroad. In what legal form do state-owned enterprises, analogues of Ukrainian state-owned enterprises, state joint-stock and holding companies exist [59].

When planning privatization and preparing for privatization, cluster analysis is used, taking into account comparative competitive advantages that can be obtained when entering foreign markets. The use of cluster analysis as a descriptive method for economic relations gives a clearer and more comprehensive picture of the growth points of local industry, as well as the dynamics of the region, than traditional descriptive methods. An industrial cluster differs from a formal classical association of enterprises in that it represents the entire chain of added value creation in a broad sense from the supplier to the final product, taking into account the provision of services and specialized infrastructure. Clusters can be geographically concentrated and interconnected by flows of goods and services that are stronger than the flow connecting the cluster entities with other economic entities [60].

It is necessary to stimulate the formation of competitive clusters and growth chains through privatization. This requires the support of design bureaus, research and development institutes that have found themselves in a market economy. The use of cluster analysis in privatization will make it possible to determine which chain of the cluster needs investments that contribute to strengthening the synergy effect.

For many years, Ukrainian IT clusters have continued their work improving the IT sector, education and the economy of cities. We will talk about clusters, cluster organizations and the value they bring to their regions.

List of IT clusters

Clusters are associations that promote information exchange, networking and the development of new ideas. Such a mechanism of innovative development has a positive impact on the economy, labor market, development of IT and other industries (Fig. 14). It is important to remember that clusters are not communities, but rather enterprises, and therefore can exist in a region even if there are no formal organizations uniting their members. But cluster organizations are just communities of companies and unions that unite entrepreneurs from clusters. There can be several cluster organizations in one cluster. They are created and closed while the clusters remain.

IT clusters are engaged in the development of the IT ecosystem, unite leading companies and partners working in the field of software development and export outsourcing. In recent years, Ukraine has been steadily advancing as a player in the global technology market. According to various sources, in 2021 the Ukrainian IT services market grew by 20% and has from 3,000 to 5,000 IT companies and over 200,000 technical specialists.

According to the latest data, Ukraine ranks 24th in the world in terms of attractiveness of software development, is one of the largest exporters of IT services in Europe, at the same time Ukrainian developers rank 11th in the ranking of 50 countries with the best programmers according to HackerRank. According to the 2021 Tech Market Report from Beetroot Academy, there are 1,142 product and 858 outsourcing companies in Ukraine, about 100 R&D centers, including Google, Samsung, Siemens, ABBY and Huawei. The main markets remain the USA and Europe [61].

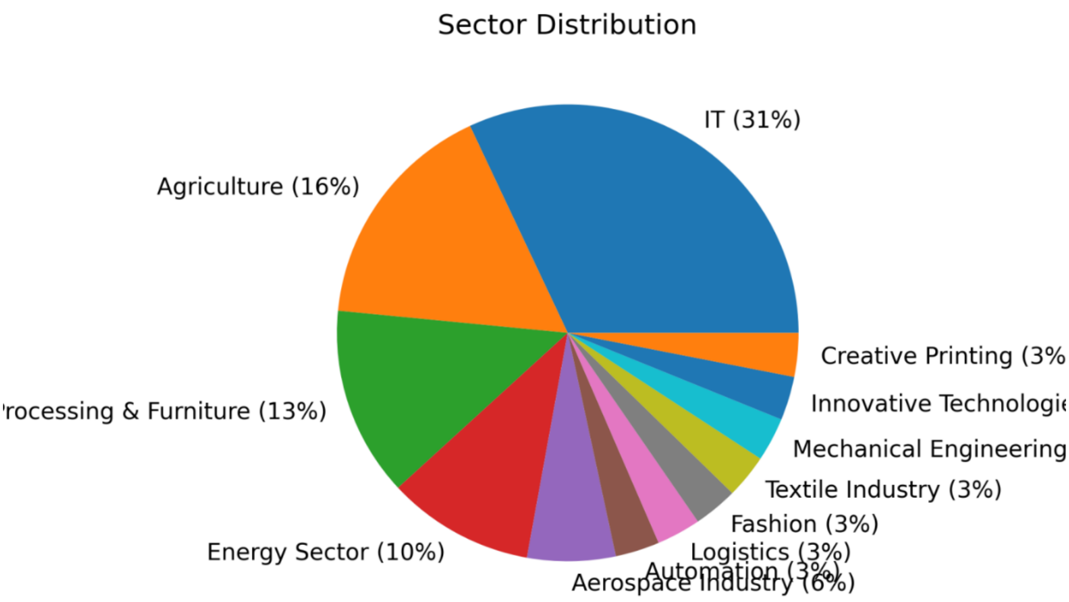

Fig.14 Distribution of clusters of Ukraine by types of economic activity [62].

Despite rather high activity of the created clusters at the local, national and international levels (in particular, participation in the European Cluster Community - European Cluster Collaboration Platform - cooperation with European clusters in the exchange of experience, best practices and joint cross-border projects), Ukraine lags significantly behind in the direction of implementing state policy and strategy.

Thanks to cooperation with educational institutions, young specialists can find practice, internships and work. Students can learn more about the companies of their city and choose a direction of activity. In turn, the search for new specialists becomes much easier for companies, because students are potential employees. In addition, cluster organizations often hold conferences, meetups, publish educational materials to help students master their profession better.

Usually, cluster organizations conduct analytical research on the IT industry in the city and conduct an active dialogue with the authorities to ensure comfortable conditions for companies and employees.

Cluster organizations provide support and assistance to community members, as well as create comfortable conditions for networking to promote new acquaintances, the development of startups and other ecosystems. More than 22 cities in Ukraine have active IT clusters. However, there are five leading clusters - Kyiv, Kharkiv, Lviv, Dnipro, Odesa, and this advantage of large cities has been going on for at least 10 years. Interestingly, clusters in the regions have begun to become more active, for example, in Ternopil, Rivne, Kryvyi Rih. We assume that within 2-3 years some of these clusters may claim to be among the top largest.

Clusters in Ukraine.

Industrial or commercial clusters are developed economic areas that contribute to the development of an industry through:

1. Productivity growth
2. Stimulating innovation
3. Stimulating competition
4. Promoting the formation of new enterprises

A cluster is an association of enterprises and institutions that cooperate to provide enterprises with greater profits compared to what they could receive without cooperation, working separately. Clusters allow companies to respond more flexibly to constantly changing business conditions and at the same time retain all the advantages of specialization.

In Soviet times, enterprises in one industry were scattered throughout the country and supply chains, customers and sales markets were deliberately fragmented. Regional centers specializing in individual types of products did not develop.

At the same time, associations similar to clusters were formed in some industries. Such an example of a vertical cluster arose in agriculture, where large cooperatives prevailed. These huge enterprises were clusters of a large number of smaller enterprises that produced various agricultural products.

The evolution of the cluster model has a long history. Its most valuable feature is its natural origin. Expanding knowledge about the economic advantages of the cluster model led to attempts to clone it. The first attempts consisted in expanding already existing interconnected regional groups of enterprises; often such actions were accompanied by the beginning of regional reformation programs. Later, understanding the prospects of cluster development formed the basis for the creation of clusters from scratch, where a certain institution or natural resource was used as the core. This region has advantages in terms of infrastructure, which was the basis for the creation of a cluster.

The restoration of Ukraine's industry requires the unification of the remnants of all-Union industries into clusters on a regional basis. For example, Podillia was known as a region with extensive light industry, where not only clothes were sewn, but also textiles were produced. Experts believe that more than 100 individual factories provided about 10 thousand jobs. Only 30 out of 100 factories survived and are working on the verge of closure, using cheap labor and free raw materials. Some enterprises tried to compete with imports. But neither prices nor quality give any advantage to local industry.

Exploitation of cheap labor is the direct antithesis of clusters, which increase their competitiveness through activities that create greater added value. Therefore, cheap labor has ceased to be a factor of competitiveness for industrial clusters.

In the period 1998-2000. in Khmelnytskyi region the first six clusters were created with the support of the “Podillia Pershyi” Association and the United States Agency for International Development. Garment, construction, food, tourism, food clusters and a rural tourism cluster were formed. The centers of clustering were the city of Khmelnytskyi, the city of Kamianets-Podilskyi and the village of Hrytsiv. To spread the experience of clustering in Ukraine, the first center for training specialists was created in Khmelnytskyi. Although not all clusters developed successfully, some, such as the construction, clothing and rural tourism ones, have demonstrated high viability [63].

Clusters accelerate specialization, which in turn contributes to an increase in the quality and quantity of products. Textile production in Podillia has no specialization. Each company produces any product that can provide instant income.

The regional economic development program "Podillia Pershyi" is an attempt to break the model of enterprise isolation. The program stimulates the association of enterprises to jointly discuss business issues, for example, in the light industry cluster these issues are:

1. Efforts that need to be made to achieve competitive advantages with imported products,

2. Is there a finished product of the cluster that can be presented on the world market?

Clusters include numerous enterprises from various industries and organizations that play an important role in creating a competitive environment: universities, standardization bodies, research institutions, trade associations, training institutions responsible for information, research and technical support.

Clusters contribute to increasing competitiveness in three ways.

1. Clusters increase the productivity of enterprises in the area where they are created through the following factors:

a) Better access to labor and suppliers,

b) Access to specialized information,

c) Product complementarity, which makes them more attractive to consumers,

d) Access to institutions and public goods,

e) Better motivation of managers who want to gain the respect of local colleagues.

2. Clusters increase the pace of innovations and determine their directions, and thereby form the foundation for future economic growth. This effect is achieved by:

a) Better vision and understanding of the market;

b) Ability to quickly implement changes and sufficient flexibility;

c) Low cost of experimentation;

d) Pressure from competitors and other cluster manufacturers.

3. Clusters stimulate the formation of new enterprises, and this circumstance contributes to the growth and strengthening of the cluster.

These processes occur due to the following factors:

a) Niches for new enterprises are more visible,

b) The need for raw materials, components and labor becomes more obvious,

c) The creation of a new business is part of a positive feedback loop.

Economic prerequisites for the creation of the first cluster in the Khmelnytskyi region.

Enterprises inherited from Soviet times are characterized by a great poverty of the assortment, lack of specialization and spirit of competition. Newly created enterprises are oriented towards creating products for the local market, but the region is saturated with cheap imported goods. In addition, local factories cannot compete with imported clothing in terms of quality, since they do not have access to the best fabrics and technologies for the production of high-quality modern models.

At the same time, the enterprises employ qualified craftsmen who are able to master the production of goods of proper quality and style. Educational institutions of the region (Podillia Technological University) train designers, constructors and technologists of garment production. These facts indicate the presence of a large human resource potential capable of solving many problems.

Analysis of the state of the textile and garment industry of the region gives reason to believe that the growth of the industry is possible under the condition of:

unification into clusters and cooperation focused on the prospect of entering new markets,

offering models that are in demand,

obtaining benefits from general purchases and sales, and establishing specialization.

The logical conclusion of the work was the formation of a garment and textile industry cluster, which included 24 enterprises of various forms of ownership.

To solve the strategic objectives of the program, ties were established with the following organizations: Khmelnytskyi branch of the State Investment Fund of Ukraine. UNIDO-SME, with regional financial enterprises, with future wholesalers for the sale of ready-made clothing manufactured by cluster companies.

Combining such connections enables enterprises included in the cluster to gain access to expert advice, information on various issues (material resources, wholesalers, standards, export requirements), to capital investments (to increase productivity and competitiveness), joint purchase and sale of fabrics (bigger choice and lower price due to increased volume), access to legal advice on trademark registration, participation of businessmen in trips abroad to familiarize themselves with the specifics of a particular business.

Such assistance has been provided to 24 companies, and applications from 7 more companies to join the cluster have been received. In 2003, a conclusion was made - the first textile cluster of Ukraine exists, combines the production of the textile and clothing industries, is functioning, has reliable financing and technical assistance.

1.3. The Role Of Clusters In Industrial Policy

The cluster structure model most fully takes into account the changing forms of competition and the main sources of competitive advantages. The cluster method allows realizing the most important relationships in technologies, skills, information, marketing and consumer demands, which are characteristic of a whole complex of companies and industries. These relationships affect the direction and pace of innovation, and even the competitiveness of the final product.

It is no coincidence that in many countries cluster analysis (approach) has become actively used to form and implement national industrial policy.

The cluster approach allows increasing the effectiveness of interaction between the private sector, the state, trade associations, research and educational institutions in the innovation process.

The cluster approach can be the basis for a constructive dialogue between representatives of the business sector and the state in order to identify problems in the development of science and production, ways to most effectively implement existing investment opportunities and necessary state policy measures.

The cluster approach, as world practice shows, not only serves as a means of achieving industrial policy goals (structural changes, increasing competitiveness, strengthening innovation orientation, etc.), but is also a powerful tool for stimulating regional development, which ultimately can consist in increasing employment, wages, contributions to budgets of various levels, increasing the sustainability and competitiveness of regional industry.

The possibilities of the cluster approach for solving the tasks involved in the economic recovery of individual industries and regions are also demonstrated by foreign experience. Thus, Finnish and Scandinavian industry are completely clustered, even in the USA more than half of enterprises work according to such a production model - cluster enterprises are located in one region and make the most of its natural, personnel and integration potential. As a rule, cluster products are export-oriented or import substitution.

The countries of the European Union have adopted the Scottish cluster model, in which the core of such joint production becomes a large enterprise that unites small companies around itself. There is also an Italian model - more flexible and "equal" cooperation of small, medium and large businesses. For countries with economies in transition, this form of cluster organization of production is most suitable, since it allows increasing the efficiency of small and medium businesses.

A specific industry that attracts large domestic and foreign investments as an object of investment cannot be considered in isolation and must develop within a cluster of vertically interconnected sectors.

Large and diversified economies will increase competitiveness faster if they can improve the state of industries and supplier enterprises.

The formation of a basic industry will serve as an impetus for the development of supplier and consumer industries, as well as service segments that "belong" to the cluster. In the service sector, new forms of distribution and sale of products will increase to meet increased demand.

Within clusters, strong enterprises can increase production efficiency only by using vertical integration strategies, which are expressed, in particular, in the acquisition of majority stakes in related enterprises and in providing them with various forms of support (financial, technical, managerial, etc.).

Large developed countries provide many examples that highlight the socio-political and economic significance of clusters. With the beginning of the formation of key industrial clusters in leading economies, such as Germany (chemistry, mechanical engineering) and France (food production, cosmetics) in the 1950s and 1960s, entire groups of industries began to interact within clusters, contributing to a multiplier effect in terms of employment growth, investment and acceleration of transfers of advanced technologies in the national economy.

American know-how in the consumer goods sector ensured the country's leadership in agriculture, packaging and machinery (supplier industries) along with success in advertising and the financial sector (consumer industries). Japan's strength in the consumer electronics sector allowed it to successfully develop the production of memory chips and microcircuits, while the United States maintained its leadership in the manufacture of logic microcomponents used in computers, telecommunications equipment and military electronics.

No country can be competitive in all areas. In developed countries, international competitiveness was initially located and strengthened within individual clusters. Sweden's competitiveness in the pulp and paper sector extends to woodworking and papermaking equipment, assembly lines and some related consumer industries (e.g. matchmaking). Denmark has developed specific industrial technologies for agribusiness and the food industry. Similarly, German machine builders and automakers benefit from the presence of highly developed production of components of these industries in Germany. In Italy, special clusters have been formed in industrial areas, in which industry combinations have developed: metalworking - cutting tools, fashion - design, leather - footwear, woodworking - furniture.

It took China almost 15 years and huge external investments to create competitive clusters around the exported textile industry, factories of sporting goods, clothing, toys, tableware, etc.

Experience shows that some highly competitive key industries, as a result of intra-cluster interaction, contribute to the development of the network of their suppliers and customers to the greatest extent. Medium and small enterprises form satellite formations around large groups and become their suppliers. Diversification of key enterprises of the cluster allows the creation of new industries, using the technologies and “know-how” of parent companies.

In world practice, a trend has emerged, characteristic even of large companies, - concentration on the main directions with delegation of production of intermediate goods of good quality and the sphere of key services to other, including small, enterprises. Therefore, the creation of clusters has a strong impact on small business, contributing to its industrial and innovative orientation and their achievement of a qualitatively new level of technology, organization and management of production in all other spheres of economic activity.

Since the competitiveness of modern economies is associated with the presence of close ties between their sectors, it is advisable to systematically form clusters around key industries. They should include the sphere of services (modern distribution and banking systems), which allows bringing products and technologies closer to the end consumer.

In recent decades, effective "cluster strategies" have been given considerable attention in many countries, due to the orientation of governments in the development of strong industries of their country, instead of copying other people's achievements in the field of high technologies.

The starting point for a realistic cluster strategy is the strengths of the economy. Such a strategy is built on centers of business activity that have already proven their strength and competitiveness in the world market. But there are some differences here from traditional approaches focused on individual sectors.

First, the interrelationship between the strengths inherent in different industries is emphasized, for example, the interrelationship between some industrial or even agricultural and service specializations.

Second, (partly in connection with this), in these "strong" clusters the emphasis is on the active use of knowledge and on the strengthening of constructive interaction between the different participants in the network. This can lead to new and promising combinations (as, for example, in the multimedia industry), but such combinations are always built on the basis of existing strengths.

The prevalence of cluster strategies is very uneven between countries; the practice of their implementation also varies. The same concepts are not always used, but most European countries have developed some kind of cluster strategy. The countries that most clearly form such a strategy are Denmark, the Netherlands, the Flemish region of Belgium, Quebec (Canada), Finland, and South Africa (under the new government). France and Italy can be examples of countries that have long practiced a kind of cluster strategy, albeit under a different name.

It is known that each country or each region has its own specialization profile, and the main emphasis of a cluster strategy is usually on competition based on differentiation and specialization.

Industrial policy with a focus on clusters can stimulate the emergence of “new combinations” and indirectly support them, especially in the field of education and scientific research, as well as through implementing intermediary centers.

For example, cooperation programs such as Eureka play a very important role at the European level. They bring together potential partners who have not been able to find the additional knowledge they need locally. Of course, large demonstration programs also play a role in the formation of new combinations. As mentioned above, the European level is particularly relevant and provides added value in cases where clusters are already transnational or are associated with huge economies based on the scale of production.

A number of systems that have already been tested in practice to promote cluster formation can be identified:

* programmes designed to bring together business people (sometimes in a particular field of technology) so that the expansion of networks will lead to increased cooperation;

* partner selection initiatives, for example, the creation of databases where companies looking for partners in their field can consult;

* funding intermediary (agency) initiatives, an example of which is the programme organised by the DTI in Denmark and later extended to other countries;

* mentoring initiatives, when consultants are paid to monitor the process of cluster formation from the very beginning of the first steps of cooperation.

And in this case, an example can be a DTI initiative. In the Flemish project Plato, which appeared in Belgium and was also extended to some regions of the Netherlands, large companies are allocated state funds so that they patronize a group of smaller companies;

* state funding of some cluster projects on a competitive basis. In this case, representatives of various cooperation projects can apply for subsidies, and only the best projects receive (partly) state funds. With such competition, the net innovation result of subsidies can be very high.

In world practice, the following main forms of stimulating small innovative enterprises have developed, including within the framework of cluster industrial systems:

* Direct financing (subsidies, loans), which reach 50% of the costs of creating new products and technologies (France, the USA and other countries);

* Provision of loans, including interest-free ones (Sweden);

* Targeted subsidies for R&D (in almost all developed countries);

* Creation of innovation implementation funds taking into account possible commercial risk (England, Germany, France, Switzerland, Netherlands);

* Free loans, reaching 50% of the costs of using innovations (Germany);

* Reduction of state duties for individual inventors (Austria, Germany, USA, etc.);

* Deferral of payment of duties or exemption from them if the invention concerns energy saving (Austria);

* Free administration of records on applications of individual inventors, free services of patent attorneys, exemption from payment of duties (Netherlands, Germany).

However, it is necessary to emphasize the importance of awareness by the companies themselves of these opportunities of cluster strategies within the framework of their own strategies. Governments at all levels can draw attention to potential threats and opportunities, as well as to a certain degree support initiatives in this direction. They can help remove barriers to cooperation by providing consulting services, as well as by disseminating best practices in the formation and functioning of cluster industrial and innovation systems. Companies should assume responsibility for the processes that result from these measures and their successful implementation.

Thus, from the analysis of methodological approaches to the development of national cluster systems listed above and a number of other countries, it follows that there is no unambiguous solution to the problem of a cluster approach to economic development.

There are systems and approaches that describe the same subject from different angles focusing on its different sides. Each country or each region has its own specialization profile, in a cluster strategy the main emphasis is usually on competition built on differentiation and specialization. The prevalence of cluster strategies is very uneven between countries; the practice of their implementation is also different. The same concepts are not always used, but most European countries have developed some kind of cluster strategy.

In many countries, the cluster approach has been adopted only at the level of public policy. The countries that most clearly form such a strategy are Denmark, the Netherlands, the Flemish region of Belgium, Quebec (Canada), Finland, and South Africa (under the new government). France and Italy are examples of countries that have long practiced a kind of cluster strategy, albeit under a different name.

The development of cluster classification systems is taking place in two main directions: cluster identification in the context of constant dynamic economic development and analysis of relationships and description of clusters in the context of the content of production and services.

Conclusions in chapter 1.

The analysis of methodological approaches to the development of national clustering systems in a number of foreign countries, conducted during the implementation of this work, allows us to draw the following general conclusions:

1. All existing approaches to clustering reflect the attempts of countries over the past decades to find a unified approach to effective economic development on an international scale.

The mechanical transfer of Western experience to Ukrainian conditions is impossible for many reasons. (For example, business incubation programs offer unstable or inapplicable models; attempts to blindly copy networks and develop business clusters based on the Northern Italian model have led to more than modest results in many developing countries; the model of the UK Local Enterprise Agency, which has been transferred to a number of countries with economies in transition, has not yet gained stability in "native conditions") [64]).

2. From the analysis of methodological approaches to the national cluster systems development of the above-mentioned and other countries, it follows that there is no unambiguous solution to the problem of the cluster approach to economic development.

3. Relevant directions of state policy in the implementation of clustering

The analysis of methodological approaches to the development of national clustering systems in several foreign countries, conducted within the framework of this Project, makes it possible to formulate the following general conclusions.

Variety of approaches. Different countries apply various clustering models, including statistical, expert-based, and hybrid approaches. The choice of methodology depends on the level of economic development and the strategic objectives of cluster policy. Nevertheless, most approaches share a common goal — strengthening national and regional economic competitiveness.

Role of the state. Effective cluster development requires active state participation in establishing a methodological framework, developing statistical monitoring systems, and providing financial and institutional support. At the same time, public policy should encourage business self-organization and promote cooperation and partnerships among economic actors.

Need for adaptation. The direct transfer of foreign clustering models without considering national economic structures, institutional conditions, and development priorities is unlikely to be effective. Therefore, it is necessary to develop a national clustering methodology adapted to domestic conditions.

The results of this analysis provide the basis for formulating recommendations aimed at creating and implementing a national clustering system.

2. CHAPTER II CRITERIA FOR CLASSIFICATION OF CLUSTER SYSTEMS

2.1. Competitiveness of clusters

The development of an algorithm and criteria for the classification of clusters is inextricably linked with a certain model of the cluster structure, built on the basis of an analysis of the competitiveness of a cluster developing in a specific "business" environment, taking into account the economic, geographical and social components of this environment.

It is the "business" environment that defines the determinants of competitiveness and external factors relative to the local business environment.

In Section 1, it was shown that there is a correlation between the size of a cluster in terms of employment and the competitiveness of a cluster. Clusters with fewer than 15,000 employees were slightly less competitive than clusters with more than 15,000 employees (see Figure 10). However, it cannot be said that clusters become more competitive with increasing size. In fact, the least competitive clusters in the analysis were those with 10,000 to 30,000 employees, while clusters employing fewer employees (less than 5,000) were more competitive.

Clusters with more than 30,000 employees were the most competitive, but their sample was not statistically representative compared to other (sized) clusters.

The reasons that could lead to this correlation between size and competitiveness may be that clusters need a certain size (in terms of producers and suppliers) to fully function and be competitive at the international level.

The studies of the correlation between cluster age and its competitiveness have shown that clusters can go through a typical life cycle, where they reach their maximum competitiveness after a period of maturation, and then degrade and decline. However, the data show that the largest number of clusters (37.6%) created between 1950 and 2000 are now part of successfully operating competitive clusters. The results show a steady increase in the number of clusters after a decline of 4.9% in 1750-1800. The data presented show that a cluster with a century of history is just as likely to be a world-leading cluster as a cluster that was created only a decade or two ago.

2.2. Determinants of competitiveness and criteria for cluster classification

2.2.1. Determinants of cluster competitiveness

One of the most important questions that needs to be answered is what is the driving force of cluster competitiveness. Porter's "Rhombus Model" (Cluster Production and Environment Diagram), which was developed in 1991, was used to analyze competitiveness. Activity [7] showed that factor conditions were the most important determinant for 43.0% of cluster structures. Determinants related to demand conditions accounted for 24.7%, with supporting industries – 13.3%, with the environment for strategy and competition – 13.3%. Other reasons, including cases of interaction with individual entrepreneurs, and early start advantages – 5.7%.

The analysis shows that uncompetitive (usually nascent) clusters rely primarily on only 2 determinants: factor conditions and demand conditions, while competitive clusters rely on all determinants of the diamond. It is clear that on the one hand, competition is an important determinant in competitive clusters, while it plays a role in uncompetitive clusters. Random events or government influence, on the other hand, are the least important determinants in competitive clusters, while they play a much more important role in uncompetitive clusters.

To answer this question, we examined cluster competitiveness as a function of the most important causes of competitiveness. The analysis suggests a hierarchy of determinants of competitiveness.

Clusters that base their competitiveness primarily on factor or demand conditions are significantly less competitive than clusters that rely on related and supporting industries or on the environment for strategy and competition.

Clusters whose success is determined primarily by "other reasons" such as chance advantages were the least competitive. However, this difference was significant only in relation to the context for strategy and competition, and was not related to other determinants of competitiveness.

It is known that cluster structures can emerge and develop in a particular economic, production and social environment.

Successful economic development is a process of consistent economic improvement in which the business environment in a country helps to encourage and support increasingly demanding methods of competition.

The local business environment is formed by:

- Local conditions and local and/or national legislation that encourages investment and continuous development;
- The incentive system in the cluster structures themselves and their innovative capacity;
- Strong competition between local rivals, cluster participants.

The local environment also defines the determinants of competition:

- The cluster development strategy and the strategy of rivalry within it (innovation and internal competition);
- The state of demand (experienced and demanding local consumer; needs that are ahead of consumer needs in other places; demand in specific segments);
- Factor production conditions and costs (natural resources, human resources, capital resources, physical, administrative, scientific and technological infrastructure);
- Related and supporting industries (access to reliable local suppliers and companies in related industries, the presence of clusters instead of isolated industries).

The cluster development strategy includes, along with the analysis of the other three determinants, an analysis of the cluster's innovativeness based on indicators of innovative capacity.

2.2.2. Criteria for classifying cluster structures

The classification criteria, based on the determinants of competitiveness, describe the assessment methods and characteristics by which different cluster structures can be classified.

The choice of classification criteria and its distribution by classification levels are associated with a substantive (qualitative) analysis of classified objects taking into account the determinants of competitiveness. Such analysis makes it possible to build a model of any cluster structure.

In the case of hierarchical classification, two types of criteria can be used: "independent" and “embedded". Independent criteria are interconnected taking into account the properties of classified objects, which are fundamentally different. Independent criteria of cluster systems include:

- Territorial criterion;
- Economic criterion;
- Process (technological) criterion.

Embedded classification criteria involve the sequential refinement of some characteristics of the cluster in the direction of detailing their features. In this regard, the weight coefficient of a particular criterion may change without violating their general correlation.

The territorial criterion, which forms the 1st level of classification of cluster structures, includes 4 positions, namely: interstate clusters; clusters within the country; clusters within the province/region; clusters within the city/district.

The second level of classification is determined by the economic criterion and includes the following positions: competitiveness; innovation; formation of added value of products/services.

The process (technological) criterion forms the 3rd, 4th and 5th classification levels.

At the 3rd level, the main indicators of the cluster structure are formed: horizontal structure; vertical structure; focal; lateral.

At this level of association, four types of general clusters can be distinguished: basic goods (essential goods); industrial machines (machines and equipment); special range of goods; related services or the ones taken all together.

At the 4th level, the standardized quantitative clustering method identifies 16 possible basic cluster associations, including:

4 leading industries (materials/metals, wood, oil/chemicals, semiconductors/computers);

6 sectors of life support industry (complex business: equipment related to security; transport, energy, offices, telecommunications, defense);

6 sectors engaged in the production of finished consumer goods and the provision of services (food/beverages, fabrics/clothing, housing/construction, healthcare, training, entertainment/leisure).

At the 5th level, general clusters are presented, combined into 43 groups. The list of general clusters according to the accepted international cluster classification is given in Table 7.

The identification of a specific cluster within this general cluster is carried out by the type of products and services according to the codes of the All-Ukrainian Product Classifier; All-Ukrainian Classifier of Economic Activities; General classification of economic activities in the EU (NACE - Nomenclature General des Activites Economiques dans les Communautes Europeennes, Rev.1, 1990 with additions of 1993 of the United Nations Economic Commission for Europe).

The qualitative and quantitative composition of the structure and elements of a particular cluster is determined by the set of its characteristics, covering all aspects of the origin and activity of the cluster.

Table 7. List of general clusters according to the accepted international cluster classification /../

No.	**Sector**
0	Other
1	Building Materials
2	Metal Production
3	Forest Products

No.	Sector
4	Oil and Gas
5	Chemical Products
6	Plastics
7	Information Technology
8	Education and Knowledge Creation
9	Heavy Machinery
10	Financial Services
11	Prefabricated Structures
12	Production Technologies
13	Analytical Instruments
14	Large-Scale Construction
15	Business Services
16	Distribution Services
17	Automotive Industry
18	Engine-Driven Products
19	Transportation and Logistics
20	Energy Generation and Transmission
21	Publishing and Printing
22	Communications Equipment
23	Aerospace Engines
24	Aerospace Systems and Defense
25	Agricultural Products
26	Food Products
27	Fishing and Fish Products
28	Construction Fixtures, Equipment and Services
29	Lighting and Electrical Equipment
30	Furniture
31	Sporting Goods, Recreation and Children's Products
32	Textiles
33	Apparel
34	Leather Products
35	Footwear
36	Medical Devices
37	Biopharmaceutical Products

No.	Sector
38	Tobacco
39	Jewelry and Precious Metals
40	Entertainment
41	Hotels and Tourism
42	Waste and Environmental Services
43	Marine Equipment

2.2.3. Quality of cluster structure

The quality of the cluster structure is a general cluster aspect and determines the criterion of commonality of requirements for the cluster management system and the quality of products/services (level of standardization) in the cluster.

It is known that in the development of industry clusters, one of the supporting factors is the minimization of logistics costs and the introduction of modern management technologies.

The creation of any cluster is based, first of all, on uniform requirements for suppliers: standardization and certification of products manufactured by them, improving their quality.

Product quality is a certain level of the cluster's technical base, technology, economy, production organization and culture, but also the corresponding level of professionalism and culture of management relations. Insufficient attention to the methodology and management process can reduce or nullify the effect of using the most modern cluster technology. The quality of management activity in a cluster is the degree of its compliance with generally accepted or global requirements or standards.

Management activity in cluster companies is part of the management system, which began to be studied relatively recently, although the practice of managing organizations has ancient roots. Elements of the management system have varying complexity and degree of development. The most developed parameters that form the basis of any management system are the goals and objectives of the activity, main functions, functional structures, organizational structures, information support. Laws and principles, means and methods, management technology and practice, communications, organizational relationship schemes require significant scientific and practical improvements for use in cluster structures. Such elements as process schemes and properties, development and implementation of solutions, and personnel professionalism require a unified approach, most often completely new for companies that are part of the cluster or interact with it.

Traditionally, product quality is associated primarily with the technology of its production and the qualifications of personnel, that is, with some statics. However, achieving the required quality in a cluster is associated with a constant, dynamic process of improving this quality, which has been called "quality management".

"Quality Management" has three implementation options: A-systemic, B-comprehensive, C-local.

The first option "A" involves a systemic approach, when the primary importance is given to the overall quality of management activities in the cluster and all its structures, and then the quality of production technology.

The second option "B" involves a comprehensive approach. It is based on the priority of the quality of those elements of production and management that directly affect product quality. For it, there is a set of standards for both production technology and the product quality management system, for example, DSTU EN ISO 9001:2018.

The third option "C" is a local approach, in which the main attention is paid to production technology. Option “C" is the most common and methodologically well developed.

Table 8 presents qualitative data on the use of standards in the field of management activities to ensure quality in cluster structures.

Table 8. Standardization of activities in the cluster

Activity Type	**Activity Components**	**Availability of Standards**	**Use of Standards**
Core organizational activities and their components	ISO 9000:2000, ISO 9001:2000, ISO 100XX:2000	Standards are available	Standards are applied
General management activities	Management of administrative processes	Well developed	Not used
	Management of service and production operations	Well developed	Used by a limited number of firms
Support (service) activities	Engineering, technological, economic support and staff training	Well developed	Used by a limited number of firms
	Accounting (financial, inventory, bookkeeping, etc.)	Well developed	Used by a limited number of firms
	Human resource management	Well developed	Not used
Production of goods and services	Manufacturing, sales (distribution), and disposal	Well developed	Used by a limited number of firms

2.2.4. Coding of the classification object

The full digital code of the cluster consists of two parts: the cluster identification code and the description of the characteristics of the cluster structure, separated by dashes:

XXXX.YYY.PP - ZZZZZZZZZ

The identification code of the profession implements the hierarchical classification method, and the facet method is used in the descriptions of the characteristics.

The full digital code of the classifier allows for automated solution of the tasks of in-depth comparison of the competitiveness of clusters in one classification group, identification of strengths and weaknesses, element-by-element comparison of cluster structures, and can also be used to solve other analytical tasks. This code allows doing it with the help of a unified methodology.

The cluster identification code, the principle of formation of which is presented in Figure 15, consists of three code groups X, Y and P, separated for ease of visual perception by service symbols - dots and contains 9 characters (natural numbers are used as the code alphabet):

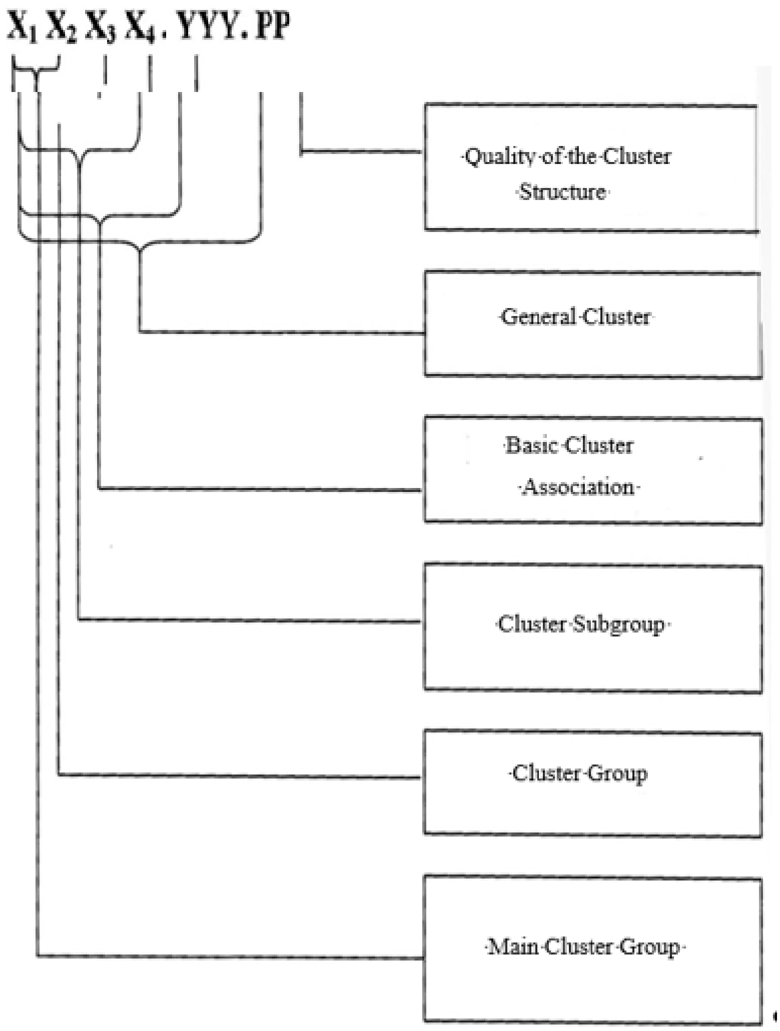

Fig. 15. Formation of the cluster identification code

The higher classification groupings formed by the first code group (X1X2X3X4) contain four digits of the profession identification code, where X1 defines the main cluster group, X1X2 - a cluster group within this main cluster group, X1X2X3 - a cluster subgroup X3 a cluster within this cluster subgroup in accordance with the hierarchical classification method described above.

The first level of the L1 hierarchy includes 4 main cluster groups united by a territorial criterion:

(1) - interstate clusters;

(2) - clusters within the city/district.

(3) – - clusters within the country;

(4) - clusters within the province/region;

II level of the L2 hierarchy includes 3 cluster groups with consistent detailing and taking into account the specifics of the corresponding main cluster groups, united by an economic criterion:

(1) – competitiveness;

(2) – innovation;

(3) – formation of added value of products/services.

III and IV levels of the L3 and L4 hierarchy are combined on the basis of a process (technological) criterion into cluster subgroups and basic cluster associations regarding the commonality of the sphere of activity.

III level of the L3 hierarchy includes 6 cluster subgroups:

(1) - basic goods (essential goods);

(2) – basic services;

(3) – industrial machines (machines and equipment);

(4) – special range of goods;

(5) – related services;

(6) – all together.

Level IV of the L4 hierarchy includes general clusters, united within 16 industrial sectors:

- 4 leading industries:

(1) - materials/metals;

(2) - wood;

(3) - oil/chemicals;

(4) - semiconductors/computers).

- 6 industries of life support industry:

(5) - transport;

(6) - energy;

(7) - offices;

(8) - telecommunications;

(9) - defense;

(10) - complex business (equipment related to security)

- 6 industries engaged in the production of finished consumer goods and the provision of services:

(11) - food/beverages;

(12) fabrics/clothing;

(13) construction/housing;

(14) healthcare;

(15) training;

(16) entertainment/leisure.

The V level of the L5 hierarchy includes the general cluster as a specific cluster structure, distributed within the framework of 43 main associations (see Table 7).

The oyher code group (YYY) is given by the fifth, sixth and seventh digits of the classifier identification code, which are perceived as a single designation, defining a specific cluster within this general cluster by type of service product.

When describing elements from the code group (YYY), the following should be used:

- All-Ukrainian product classifier OK 005-93; - All-Ukrainian classifier of economic activities, which contains 99 positions;

- the General Classification of Economic Activities of the EU (NACE - Nomenclature General des Activites Economiques dans les Communautes Europeennes, Rev. 1, 1990 with additions of 1993 of the United Nations Economic Commission for Europe).

NACE contains codes of types of economic activities in accordance with the statistical requirements of the EU in a single interpretation in the five main European languages (German, English, French, Italian and Spanish). The structure of NACE provides for the main sections given in Table 9.

The main sections of NACE are divided into sections and subsections, each of which is given a numerical index.

The third code group (PP) is given by the eighth and ninth digits of the classifier identification code, which are also perceived as a single designation, determines the quality of the cluster structure, i.e. the level of commonality of requirements for the cluster management system and the quality of manufactured products/services (level of standardization) in the cluster derived from this one, and is selected in accordance with Table 8.

Unstructured descriptions of cluster structure characteristics are not included in the cluster classification coding system, but allow, taking into account all classification levels in which the cluster is located, to build a structural model of any cluster and, as a result, to develop a creation mechanism.

Table 9. – Main sections of the General Industrial Classification of Economic Activities of the EU (NACE)

Code	**Sector**
A	Agriculture and Forestry
B	Fishing and Aquaculture
C	Mining and Quarrying
D	Food Industry
DB	Textile Industry
DE	Paper Industry and Publishing
DI	Glass Industry, Ceramics, and Stone Processing
DJ	Metal Production and Processing; Manufacture of Metal Products

Code	Sector
DM	Automotive Industry
DN	Manufacture of Furniture, Jewelry, Musical Instruments, Sports Equipment, Toys and Other Products
E	Electricity and Water Supply
G	Trade, Vehicle Service, and Repair of Household Appliances
H	Hotels and Restaurants
I	Transport and Communications
J	Financial and Insurance Services
K	Real Estate, Renting, and Business Services
L	Public Administration, Public Order Services, and Social Security
M	Education
N	Health Care, Veterinary Services, and Social Welfare
O	Other Community and Personal Services
P	Households
Q	Extraterritorial Organizations and Bodies

2.3. Modeling cluster structures

2.3.1. Modeling of cluster initiatives

The modeling of cluster initiatives is based on the formulation and justification of the cluster association model.

Basically, the cluster association model consists of a specific cluster structure that interacts with the government through current legislation, or within the framework of government programs, financial institutions that support organizations (companies), scientific and educational institutions. (See Fig. 16)

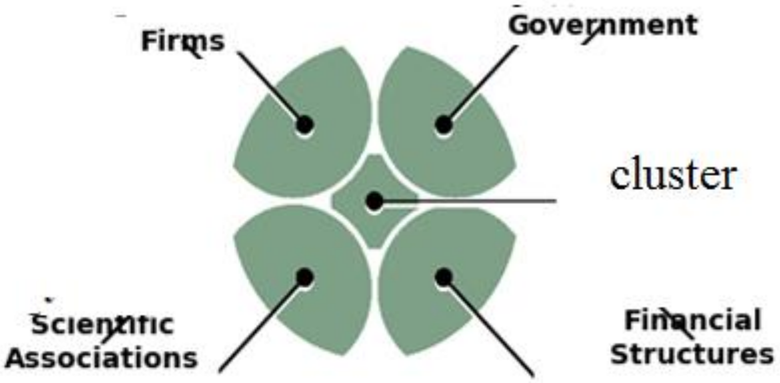

Fig. 16 Cluster structure model

When creating a specific cluster, all of the above components are subject to analysis and formalization. The initial stage of developing a cluster structure is the model for creating a cluster initiative.

The model for creating cluster initiatives is based on four components. Three components are the leading ones: social, political and economic regulation within the country; goals of cluster initiatives; processes through which cluster initiatives develop. The fourth component is the result of the action of cluster initiatives. Each of these four components includes several factors.

The social, political and economic regulation within the country includes the business environment; policy; cluster efforts.

The goals of cluster initiatives include: research and organization of the network, political action, commercial cooperation, education and training, innovation and technology, cluster expansion.

The processes, by which cluster initiatives develop, consist of initiation and planning, management and financing, resources and facilitators, structure, interaction and driving force.

2.3.2. Matrix of industrial cluster formation

The description of cluster characteristics, the principle of formation of which is presented in Fig. 17, contains 9 groups, each of them has an independent importance and determines the characteristics of the cluster.

The general characteristics of the cluster include the main content of professional activity in the cluster and the characteristics of the local business environment (strategy, goals, objectives, processes, demand status, related and supporting industries, conditions for factors of production).

Territorial localization (Z1) includes country, region, city, geographical borders, latitude and longitude of the cluster center, cluster area.

Basic association (Z2) is a list of types of economic activity in which this profession is used (according to the All-Ukrainian Classifier of Types of Economic Activities, Products and Services).

Types of products or services of the cluster (Z3) are a list of types of products and services according to the All-Ukrainian Classifier of Types of Economic Activities.

Number of companies in the cluster (Z4).

Number of employees in the cluster (Z5).

Competitiveness (Z6): competitiveness of the cluster in relation to other clusters in the world, rating based on world production or share of exports, share of national or local market.

Rhombus analysis (Z7): The scheme of the rhombus is shown in Figure 18.

- The main reason for competitiveness;
- Indicators (determinants) of competitiveness.

Factor conditions (Z8):

- Basic and specialized factors;
- Demand conditions i.e. volume of local demand, indicators of local demand;

Description of cluster characteristics, the principle of formation of which is presented in Figure 16, contains 9 symbolic code groups, each of which is an independent function of several variables and determines the general characteristic of the classifier.

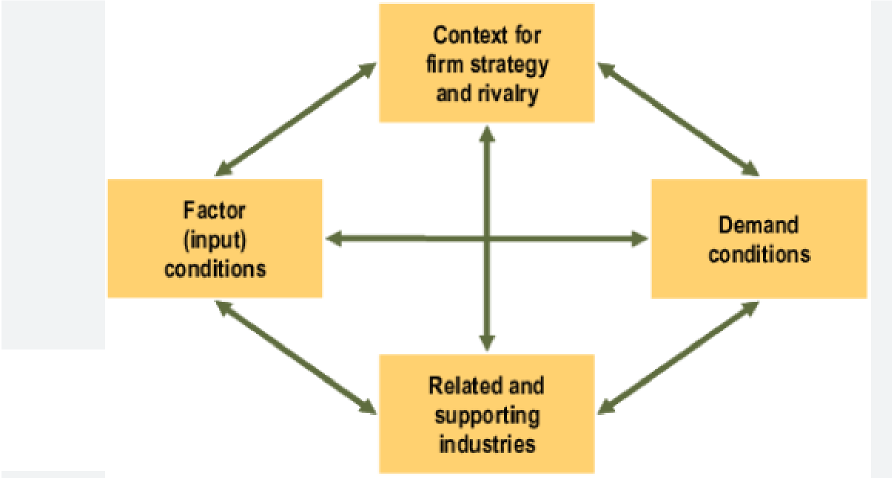

Fig. 17 Scheme of rhombus analysis [65]

- Description of classifier's characteristics: related and supporting industries – suppliers, related industries, etc.;

- Company strategy and rivals – rivalry, cooperation, strategy and structure, local investment environment, other advantages.

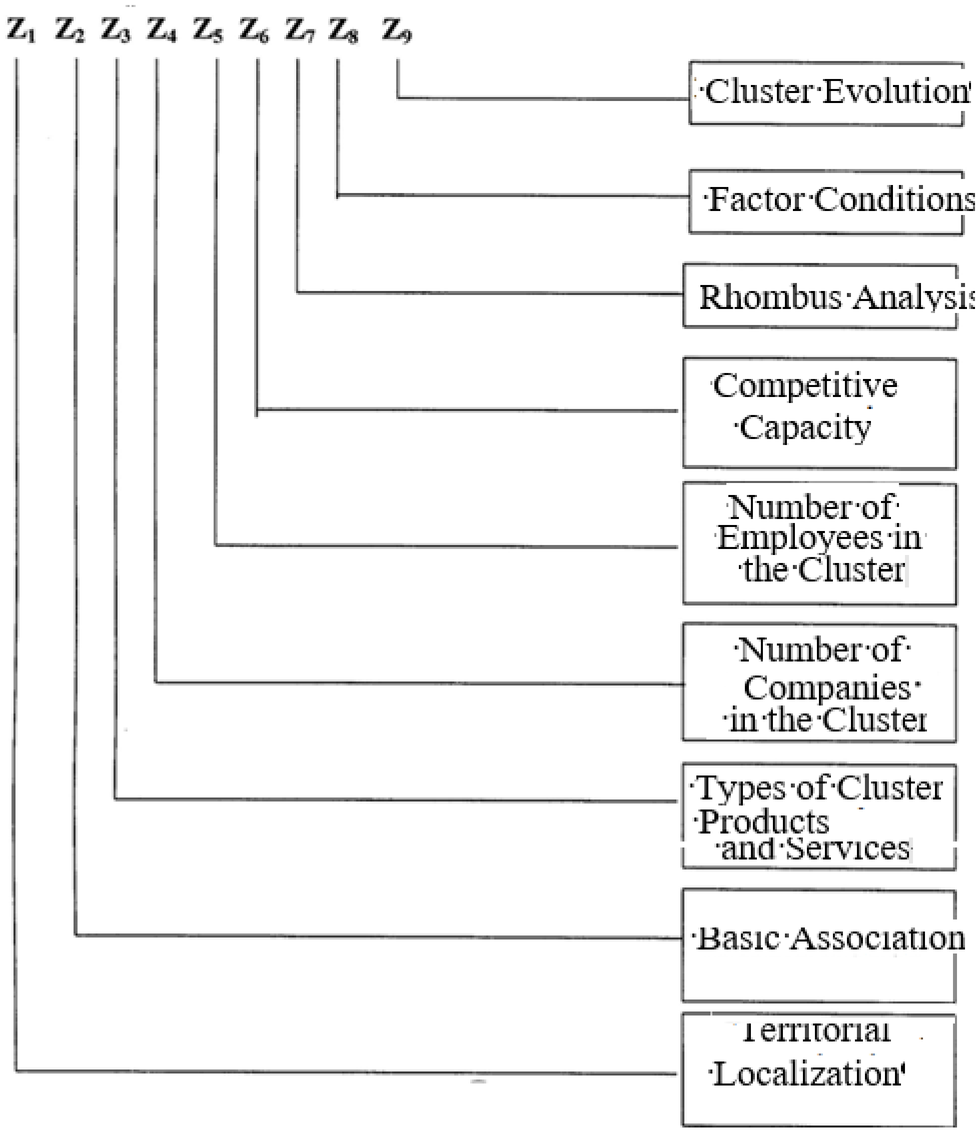

Fig. 18. Formation of a description of cluster characteristics

Cluster evolution (Z9):

- Origin: - reason for origin, year, uniqueness of origin due to factor circumstances, unique conditions of domestic demand, related industries, origin due to strategy, company structure, competition, due to government initiative, individual company or enterprise.

- Decline - the main reason for decline, beginning (year) of decline, decline due to changing factor conditions, changing customer needs, loss of suppliers, lack of rivalry, decline due to government intervention.

Conclusions in chapter 2

1. The competitiveness of a cluster developing in a specific "business" environment, taking into account the economic, geographical and social components of this environment, forms the model and criteria of the cluster structure.

2. The following 7 aspects were selected for the structural and quantitative comparison of international and national cluster classifications and their comparative analysis:

1) Geographic: the construction of spatial clusters of economic activity, ranging from purely local to truly global (spatial clustering of economic activity);

2) Horizontal: the classic division of sectors located at certain levels of a conglomerate (for example, as in the classification of industries). Several industries/sectors can be part of one larger cluster;

3) Vertical: clusters can have adjacent stages of the production process (similar to the concepts of value systems, supply chains). In this vertical aspect, it is important which among the network participants is the initiator of innovative activity;

4) Lateral: different sectors that may have common capabilities and are able to provide economies due to scaling, which leads to new combinations (for example, the multimedia cluster that is currently being formed);

5) Technological: a set of industries that use the same basic technology (such as, for example, the biotechnology cluster);

6) focal: a cluster of companies concentrated around one center - a company, a family consisting of several generations, a research institute or an educational institution;

7) quality of the network: here the important question is not whether the companies actually cooperate, but also how well they manage to do it. A network is not always an idyllic gathering of companies where all kinds of renewal are automatically stimulated. It happens that innovative processes are suppressed in networks and defensive behavior is encouraged. Relationships with suppliers can stimulate innovation processes, but they can be used to shift costs to partners and limit them in financial terms. In this case networks are neither stable nor stimulating.

The criteria listed above allow for a full or partial (depending on the amount of information) analysis to identify similarities and differences in the construction of the considered national clusters.

3. A classification and coding system for cluster structures has been developed based on a 3-criteria analysis, which includes territorial, process and economic criteria.

4. It has been established that the quality of management activities in the cluster must meet uniform standardized requirements.

3. CHAPTER III INDUSTRIAL CLUSTERS IN UKRAINE

3.1. Creating a matrix of the cluster formation process

The model for creating cluster initiatives was described above. It is clear that initiating and planning a cluster is impossible without prior detailed research into the main characteristics of the future cluster. Each study involves companies, suppliers, trade associations, business schools, universities, and many government departments.

Cluster boundaries and participation are identified during the research process. The rule is usually taken as a self-determination principle: all companies interested in participating in the cluster are considered part of it.

All clusters are considered equally important. However, for practical purposes, cluster research should be structured in a certain sequence. Some clusters are initially better organized than others. The goals of this process include the creation of effective trade organizations to serve each cluster.

Cluster research occurs in three stages.

The first stage identifies the problems and opportunities that the cluster has, and also builds a basic concept for improving the cluster, which includes such goals as strengthening, rather than weakening, competition.

In one of the main processes that ensure the advantages of clusters, government representatives act as an informed audience for companies. Clusters vary in size, breadth, and level of development. Some clusters consist mainly of small and medium-sized companies, for example, in the case of clusters of Italian shoe manufacturers. In Italy, such clusters are quite common, this circumstance led to the emergence of works from industrial districts. Industrial districts are special cases of clusters.

Approaches to the formation of industrial clusters can be determined using statistical analysis methods from various economic indicators for industries in accordance with the All-Ukrainian Classifier of Economic Activities. With the help of these indicators, it is possible to identify how concentrated certain industries (types of activity) are in a particular region.

Another direction is the use of a system of expert surveys and expert assessments, where the experts can be heads of enterprises and organizations and leading industry specialists.

Analysis of clusters in different countries has shown that a cluster has three main interdependent elements in its composition, namely: key companies that export their products, goods or services outside the region; networks of suppliers that supply raw materials, components, products, spare parts, repairs, services, etc.; business climate, including technology, human resources, administrative, physical infrastructure.

There are four main strategies that can be used in Ukraine to increase the competitiveness of the supply system:

- increasing the efficiency of the existing supplier system;
- attracting suppliers from other countries and other regions;
- separating suppliers from the core business;
- targeted incubation of new business.

The use of any of the above strategies assumes the presence of both supporting and restraining factors.

The first supporting factor is the participation of the administration and business in the development of industry clusters. In Ukraine, unlike other countries, it can consist in supporting and initiating the processes of cluster activation.

An important aspect is both the participation of the administration in cluster meetings and decision-making on cluster development, and the use of the key cluster development tool that the administrations have, i.e. re-profiling, creating new and improving the efficiency of existing target programs within the administration. The administration can now actively work to build communication between educational institutions, research institutes and business, ensure the settlement of various cluster issues between other levels of government and international cooperation.

Compared to many developing countries, Ukraine has a high degree of availability of local suppliers of equipment and components for root businesses in the cluster.

The second supporting factor is the availability of engineering and scientific personnel.

The third supporting factor is the availability of R&D opportunities.

The fourth supporting factor is the existence in Ukraine of certain traditions in the field of production cooperation.

And another factor that stimulates the development of clusters in Ukraine is related to the development of technological infrastructure in Ukraine, which allows for more effective implementation of various cluster development tools.

Restraining factors. First, despite the availability of suppliers, an important and serious problem for Ukraine is the low quality of their products and services, low competitiveness, and low efficiency of the supply management system.

Second, a major problem in Ukraine is the inadequacy of educational and research programs in the field of vocational training and preparation of requirements for the qualification of personnel of industrial clusters.

Third, there are weak ties between secondary and higher professional educational institutions, research institutes, and business.

Different levels of analysis use variations of the concept of a cluster and emphasize certain factors. Some studies focus only on the company level and analyze the competitiveness of the supplier network around the core enterprise.

Levels of cluster analysis:

National level (macro- or mega-), when industrial groups are linked to the economic structure. Research focuses on the connection within and between industrial groups (mega-groups), reflecting the specific aspects of the economy of a country or region (macro-level).

Sectoral or industrial level (meso-, sub-) intra- and inter-industry connections at different stages of the industrial chain of obtaining similar products; Batch marketing analysis of production.

Company level (micro-) association of specialized suppliers around one or more core enterprises. This type of analysis is used for strategic analysis of the company and determines the loss of connections or strategic partners when implementing new projects.

The next level of analysis is the use of various methodological approaches to determining the levels and characteristics of the cluster, which are given in section 4.1.

The presented approach to clusters differs from the classical division of sectors into primary, secondary and tertiary. Instead of considering agriculture, industry and services separately, it should be recognized that all these areas play a certain practical role and depend on each other. Trying to focus on any of them separately does not make much sense. Conversely, of particular interest is the fact in which sectors agriculture, industry and the service sector of a country or region complement and mutually reinforce each other. In the Netherlands, according to this clustering method, the strongest clusters are food/beverages, oil/chemicals, transport and materials/metals.

3.2. Selection of industries. General provisions

The justification for the selection of industries was made based on the precondition that the results obtained during the study should apply to the whole of Ukraine. Therefore, the selected industry surveys were supposed to be unique, but typical, that is, in terms of basic parameters, to reflect the situation in a whole group of regions.

It is obvious that when analyzing any objects and processes in Ukraine, Kyiv, the most politically and economically developed region of Ukraine, should be included in the study. The development of entrepreneurship, small and medium-sized businesses in Kyiv is going on at the most rapid pace and has a number of specific features.

When choosing industries, the interest is not in stagnant or depressed sectors, but in actively developing sectors, in which it will be most clearly possible to see ways to overcome administrative and economic barriers.

Due to the fact that in Ukraine the analysis of mega-clusters was conducted in the North-Western Economic Region, it was decided to conduct this study at the level of a subcluster and a simple cluster. Such clusters are usually formed by medium-sized and small enterprises. The industry specialization of small enterprises in the regions was considered. In all regions, the largest industry group is trade and catering (on average 44-45% of all small enterprises in each region). In Kyiv and some regions, the highest share of construction small businesses can be observed. Industrial enterprises account for 15% of all small enterprises in the most developed regions.

The paper [66] analyzed and summarized international experience in the development of cluster structures and provided proposals for its possible application in the industrial regions of Ukraine. A comprehensive approach to assessing the effectiveness of cluster formations was proposed and tested. Proposals were made for the regulatory and legal regulation of the development of cluster structures in the economy of Ukraine.

Light industry of Ukraine is a large national economic complex consisting of 17 subsectors and has about 22 thousand fully privatized enterprises, with an average number of employees per large enterprise of 300 people.

Institutional transformations in the industry have become one of the effective elements of the light industry strategy. The "Strategy for the Development of Light Industry for the Period Until 2010" states that instead of large ones, burdened with huge funds that are poorly used, and numerous service and auxiliary services, holding-type structures will be created, the production, service and auxiliary divisions of which should be allocated to separate productions which independently earn funds for their development. Such separate productions, when united into clusters, will have synergistic advantages in creating added value. The general management company solves the problems of marketing and sales of products, financial management and investment development, legal support and advertising.

An example of such holdings, which work effectively, already exists, namely, joint-stock companies "Yakovlovsky", "Tchaikovsky Textile", "Paris Commune", "Sava Chemical Group of Companies". Among the measures taken during the reorganization was the introduction of a work motivation system, namely, a system of incentives based on a weekly assessment of the activities of employees of each section, this principle is also the basis for the creation of clusters.

An example of the formation of a cluster is the creation of corporate associations from enterprises that produce the same type of products (for example, "Kvarton"), from the international classification of industrial clusters, these are Italian-type clusters. The advantage of such a cluster is the rapid optimization of the product range in accordance with changing market requirements and improving product quality due to narrow specialization. There are corporate associations that include industrial and agricultural enterprises, they are ordinary industrial clusters. An example of such an association is a flax complex, which includes farms and organizations that perform all work from sowing flax (suppliers) to the production of clothing, which include the entire production chain, forming network connections. The main advantage of such a cluster, in addition to the rest of the classic ones, is the exclusion of the purchase and sale of intermediate products, which reduces the cost of finished products and increases their competitiveness.

The formation of industrial clusters contributes to the activation of innovative activity. If it is difficult for an individual enterprise to allocate financial and technical resources for implementing innovative projects, then an industrial cluster, which includes industry research organizations and industrial enterprises, is quite capable to ensure the implementation of the entire cycle of work on the development and adoption of innovations in production.

One of the advantages of clusters is access to the foreign market; if it is difficult for an individual enterprise to access the foreign market, then an industrial cluster can do this. At the same time, the costs of providing enterprises that are part of the cluster with imported raw materials and materials (for example, cotton and chemical fibers, wool, fur raw materials, dyes and textile auxiliary materials) are also reduced.

Today, there are several regions in Ukraine where there are prerequisites for the creation of clusters formed around key industries (for example, mechanical engineering and light industry in Kyiv, Kharkiv, Dnipro, chemical production in Cherkasy, Zaporizhia and Kryvyi Rih) [67]. However, the existing connections are still comparable to real clusters, which are formed from a well-established system of competitive suppliers and customers.

Despite the widespread use of the cluster approach in the economies of foreign countries, their serious differentiation is noted in terms of the principles, forms and methods of clustering policy, the degree of state regulation of the activities of cluster formations, and industry advantages in organizing clusters (Table 10). Thus, the greatest influence on the implementation of cluster initiatives in EU countries is played by supranational regional and industrial policy and the differentiation of member states by the level of development of the national innovation system [68,69].

Table 10 Sectoral orientation of cluster structures in foreign countries

Country	Main types of economic activity												
	1	2	3	4	5	6	7	8	9	10	11	12	13
United Kingdom										+			
Denmark									+	+			
Estonia	+				+				+	+			+
Italy			+				+						
Latvia	+	+					+			+	+	+	
Lithuania	+	+		+	+	+	+					+	+
Netherlands			+				+	+	+	+			
Germany				+			+			+			
Norway					+		+		+	+			
Poland	+		+	+	+		+	+		+	+		
Romania	+	+	+				+			+	+	+	+
Slovakia	+	+		+	+					+	+	+	

Notes: IT sector and cybersecurity (1); smart specializations (2); agricultural sector (3); chemical industry (4); energy and eco-energy efficiency (5); metalworking (6); mechanical engineering and engineering (7); construction (8); transport (usually aviation and maritime) and logistics (9); biotechnology and medicine (10); tourism and recreation (11); woodworking (12); creative industries (13). Source: compiled on the basis of [70].

3.3. Biotechnology clusters

3.3.1. Development of modern biotechnology and prospects of the biomedical cluster of the NAS of Ukraine

Komisarenko Serhiy Vasylyovych, Academician of the NAS of Ukraine, Acting Academician-Secretary of the Department of Biochemistry, Physiology and Molecular Biology of the NAS of Ukraine, Director of the O.V. Palladin Institute of Biochemistry of the NAS of Ukraine reports on the development of modern biotechnology from the point of view of strategic planning and determining priorities that should be laid as the basis for the post-war recovery of the Ukrainian economy [71]. Today we are witnesses of the rapid, unprecedented development of biological sciences in the world. The results obtained by biologists in recent years lay the foundations of new medicine, and this is undoubtedly a strategic trend that can no longer be neglected. There are several examples of the successful use of biotechnology in recent times.

This is the creation and use of therapeutic proteins, in particular antibodies, for the needs of medical practice; the development and use of vaccines against the SARS-CoV-2 coronavirus, other viruses, as well as against malaria; genome editing; deciphering the fine conformation of proteins; creating peptidomimetics (with a 3D conformation similar to natural proteins); using nucleic acids, microRNAs, mRNAs, aptamers (SELEX) in medicine; developing artificial (non-natural) proteins to create vaccines and drugs based on them; a sharp increase (more than 1000 times) in the use of single-cell RNA sequencing (transcriptomics) and genomic technologies; achieving atomic resolution in cryo-electron microscopy.

Modern biotechnology is also developing in Ukraine, but due to the lack of an effective innovation policy and an unfavorable investment climate, many fundamental achievements of Ukrainian scientists in the field of life sciences remain unclaimed by the domestic pharmaceutical industry. Despite this, Ukraine has created the first therapeutic proteins for pharmaceuticals, developed modern diagnostic drugs, in particular based on biosensors, as well as methods for immuno-, enzyme- and PCR-diagnostics of infectious diseases. In addition, four types of vaccines against SARS-CoV-2 and several original medicines have been created.

The global biotechnology market is showing rapid growth. In 2021, its volume was $617.98 billion, and by 2027, according to forecasts, it will reach $964.96 billion. An important segment of this market is the production of therapeutic proteins, in particular insulin, as well as oncological, immunosuppressive, immunostimulating agents, interferons, vaccines and other agents for the treatment of various diseases. Particular attention is currently being paid to the development of monoclonal antibodies and their fragments, which are used in personalized medicine, especially for the treatment of oncological and cardiovascular diseases. In 2022, the global therapeutic protein market was worth $112.17 billion, and by 2026, it is projected to grow to $177.3 billion, of which about 50% will be accounted for by the production of monoclonal antibodies.

During the COVID-19 pandemic, the creation of mRNA vaccines became a key factor in stopping the spread of the virus and saving lives. According to WHO, about 700 million people have fallen ill with COVID-19, of whom 7 million have died. However, without timely vaccination, these losses could have been much higher. mRNA-based vaccines against SARS-CoV-2 were quickly developed by Moderna and Pfizer in collaboration with BioNTech, which emphasizes the importance of having a strong biotechnology sector in the country.

Given that pandemics, unfortunately, will become more frequent, the development of domestic production of mRNA vaccines is a strategic task for Ukraine in the process of post-war recovery. The global vaccine market in 2022 was $52.5 billion and is projected to grow to $86.2 billion by 2027. In particular, the production of mRNA vaccines and nucleic acid-based products could reach $34.1 billion in 2026 and grow to $85.3 billion by 2030.

Ukraine has already begun work on creating its own mRNA vaccines, in particular with the support of international partners in the Republic of South Africa, but due to funding problems and the outbreak of war, these projects were suspended. Given the difficult situation with innovation and investments, the National Academy of Sciences of Ukraine initiated the creation of innovation clusters within its structure, in particular the biomedical cluster.

The biomedical cluster of the NAS of Ukraine is being created as an innovative research center based on the association of participants for the development and implementation of modern medical, veterinary and environmental technologies. An important direction is the preparation of high-level qualified personnel. Today, the cluster unites 16 organizations, including 12 scientific institutions of the National Academy of Sciences of Ukraine (in particular, the O.V. Palladin Institute of Biochemistry, the O.O. Bogomolets Institute of Physiology, the Institute of Molecular Biology and Genetics, the Institute of Organic Chemistry), as well as NTU "Igor Sikorsky Kyiv Polytechnic Institute", pharmaceutical companies "Darnytsia", "YuriaPharm" and PrJSC "Indar". It is planned to join new participants, including the Institute of High Technologies of the Taras Shevchenko Kyiv National University and pharmaceutical companies "Diaprofmed", "Khema" and ALT-Ukraine.

The creation of an innovative biomedical cluster will take place in two stages. The first stage involves organizational work on the implementation of already completed scientific developments. The second stage will focus on the development of modern biotechnologies, such as: therapeutic proteins, mRNA vaccines, nucleic acid-based drugs, diagnostics and biosensors, as well as new-generation drugs using artificial intelligence and synthetic biology.

The first results have already been achieved; an agreement has been signed with the company "Yuria-Pharm" on the introduction into production of autologous fibrin gel, developed by the O.V. Palladin Institute of Biochemistry of the NAS of Ukraine. As a legal form of the cluster, it is proposed to create an association, which will allow receiving grants at the initial stage with the possibility of further transformation into a limited liability company.

Most publications focus on individual aspects of cluster formation, such as the prerequisites for uniting enterprises into regional clusters, or on the results of the activities of already existing cluster formations, often emphasizing the successful experience of the most progressive of them (for example, the biotechnology clusters of Silicon Valley, Boston, Great Britain, Germany, France or China). Given this, research into the possibilities of forming and developing technological, in particular biotechnology clusters, in the conditions of the Ukrainian economy remains extremely relevant.

Biotechnology clusters are actively developing in EU countries. For example, 40 clusters have been created in Poland in 30 areas of economic activity. In 2019, 15 National Key Clusters were selected, most of which are concentrated in biotechnology, aerospace, electronics and energy industries.

Biotechnology cluster programs are focused on the geographical location of companies. To strengthen cooperation between the research sector and industry, the Polish government focuses on the creation of clusters to promote new technologies. These clusters unite industrial enterprises, research centers and higher education institutions with the aim of producing and commercializing innovative technologies.

In most developed countries, clusters receive direct funding from the state. For example, in Germany, the BioRegio, InnoRegio and "Best Clusters" programs are implemented, and in France, there is "Competitive Poles" program. These programs demonstrate high efficiency. Thanks to the BioRegio program, the number of biotechnology companies in Germany has tripled, creating more than 9 thousand jobs. This allowed Germany to significantly overtake Great Britain in the field of biotechnology and become a European leader in this sector [72].

Research on the development of innovation clusters in the EU biotechnology sector is considered in the work [73]. The growing role of innovation clusters and the peculiarities of the formation of a new mentality of their participants, characterized by a high level of trust in partners based on new technologies and knowledge, are shown. The biotechnology industry in Europe ranks second after the world leader, the United States, which has the largest biotechnology sector in medicine and biotechnology. The place of the leaders in the process of forming cluster policy has been analyzed and their success factors in the biotechnology sector have been identified, namely: Germany, Great Britain and France. The prospect of further research in this direction lies in the formation of innovative models of cluster development in Ukraine, as well as in identifying the strengths of EU countries. The possibilities of forming innovative clusters in Ukraine and the development of the information and legal environment to support the implementation of cluster policy have been characterized.

3.3.2. Biotechnology cluster at Lviv Polytechnic

The emergence of the idea of creating a biotechnology cluster is a natural continuation of the best achievements of Lviv Polytechnic over the last decade. In the ancient university libraries of Europe, where knowledge from the times of Greek scientific thought is preserved, which was based on the physical, mathematical, and astronomical discoveries of previous Mediterranean civilizations, one can often see eloquent slogans: Hic mortui vivunt, hic muti loquuntur (here the dead come to life, here the mute speak). The Scientific Library of Lviv Polytechnic is no exception [74].

So what scientific directions of Lviv Polytechnic led to the synthesis of technical, natural, and biological sciences? One cannot fail to mention the rapid development of information technologies, which integrate technical achievements in the fields of sensor and semiconductor electronics, organic electronics, chemistry of macromolecular compounds, solid-state physics and nanotechnology. Successes in the development of bioactive compounds also play an important role. Artificial intelligence systems are one of the most dynamic and scientifically rich areas of modern science.

One of the interesting concepts, the significance of which will become apparent in the future, is the intensification of project activities aimed at uniting scientists for innovation, with an emphasis on the commercialization of solutions in the short term.

This includes the creation and development of creative spaces. One of such projects, which has made it possible to effectively involve leading stakeholders, including the state, in the development of the university's scientific and innovative potential, is the arrangement of research laboratories and information and communication platforms for their interaction within the framework of an innovative (scientific) park based on the university.

In fact, only the natural combination of the three mentioned fields can lead to the progress of scientific thought over the next 20-30 years and create the prerequisites for improving the scientific positions of Lviv Polytechnic for several generations to come.

For those who were interested in the history of domestic science, it is no secret that when DNA was discovered with the participation of leading American scientists, domestic genetics was recognized in the Soviet space as the result of the wrong and dead-end direction of scientific development. However, modern biotechnological research has made it possible to develop a number of medical products that allow you to successfully fight rare and more common diseases, in particular those of a genetic nature. A striking example is the drug Zongelsma from Novartis AG, a means for introducing an artificial virus into the body of children with spinal muscular dystrophy, which directly replaces the malfunctioning SMN1 gene. This allows the child to develop properly and increases the chances of a normal life in the future. However, the development of the drug, which began in the 1990s, together with the accompanying research over a decade and the low demand for it, has led to the fact that the cost of one dose is measured at approximately two million US dollars. This is the price of progress and the cost, which, according to the manufacturer, compensates for the costs of research and development (we will leave the ethical side of this issue out of discussion).

Academic institutions are successfully operating in Lviv as part of the Western Scientific Center of the National Academy of Sciences of Ukraine, but the issue of creating a platform for collaboration between scientists is one of the key ones for the successful development of a number of scientific areas. It is clear that some tasks of the nanotechnological profile can now be performed by numerical modeling. This includes the study of electronic, optical and magnetic materials using modeling of electronic systems by quantum-mechanical, or so-called ab initio methods, which are successfully used by some scientific groups of the university.

The range of materials studied includes nanostructures, metal-organic complexes, porous structures, optical and magnetic crystals. The research has a wide range of applications at the interface of such scientific areas as nanomaterials science, semiconductor electronics, solid-state physics and physical chemistry. Using specialized software (ABINIT, The Exciting program, The AtomPAW program) and the power of a modern computer cluster, it is possible to study molecular dynamics, structural optimization processes, mechanical, electronic, optical and magnetic properties of crystalline and amorphous substances. In the laboratories of the Scientific and Educational Center for Innovative Technologies (SEC IT), effects predicted on the basis of complex calculations can be empirically confirmed.

Today, the SEC IT has brought together more than 40 scientists who work in close cooperation with the staff of the Department of Artificial Intelligence Systems. This can contribute to the development of scientific topics related to the analysis of large volumes of data and the prediction of the development of cyber-physical and biological systems both on a micro- and macroscale.

The development of biotechnology requires significant capital investments, but such a choice opens up the possibility of creating a new niche that complements nanomaterials science and artificial intelligence systems, bringing the concept of "smart materials" to a level close to "smart matter".

Modern science recognizes organic life forms as one of the peaks of natural evolution. If we abstract from the meaning of the word "natural", we can say that objective reality provides researchers with two unique opportunities: nanomaterials and organic macromolecular compounds. Their integration can lead to the creation of materials that, in terms of their properties, significantly surpass modern achievements. Controlling these properties using cyber-physical methods and artificial intelligence will allow people to more effectively influence materials and their properties.

Smart matter, probably as a highly emergent substance, similar to superheavy atoms of radioactive materials, can open up new opportunities for the use of metal-organic compounds and high-molecular chains supplemented with functional molecules sensitive to external physical fields. Such materials in the future will be able to respond to external influences, form their own configurations of physical fields in dynamics and provide new tools for proactive interaction with the world in real time.

The synthesis of such compounds is terra incognita, requiring not only modern laboratory facilities and computing complexes, but also highly qualified scientists capable of working in a team and bringing significant results to Lviv Polytechnic. This is a real challenge that involves a transition from an empirical approach to targeted design. It is also a transition from using matter as a tool for research (for example, organic lamps or quantum energy conversion systems) to means of precise energy ordering according to the researcher's plan.

In the future, such projections of the logic, thoughts and intentions of the researcher may find their reflection in the "smart" substances created by him, which will manifest and develop useful properties in real time. Analytical equipment for studying the structure of matter, such as an X-ray diffractometer, will become an important tool for supporting the university's already successful projects. The expansion of analytical equipment for organic chemistry (liquid and gas chromatographs with mass spectrometers, NMR spectrometry, etc.) will provide the most modern equipment for scientific laboratories, facilitate the receipt of grants and the implementation of scientific projects, and also lay the foundation for the preservation and development of the scientific potential of future generations of polytechnics, directing their development in a promising and commercially profitable direction for decades to come.

The direction of smart drug delivery systems based on nanotechnology is well-known [75] and Lviv Polytechnics already have relevant, world-renowned developments (it is enough to mention at least hydrogel systems), but today these achievements are overshadowed by the inability to overcome viral RNA-biological programs that the external environment imposes on the human body.

There is a noticeable lack of young scientists in this direction, because understanding the mechanisms of a living cell is a rather difficult task. However, this is critically important for further development, since understanding the "mechanism of work" of a cell determines its behavior. Mathematical modeling of the properties of dynamic biological systems is one of the applied trends in the field of artificial intelligence, which allows predicting how cells will react to certain therapeutic effects.

Living cells are examples of nanoorganic and metal-organic systems, which are components of our body. Colonies of bacteria that seem to be mindless at first glance demonstrate group intelligence by actively interacting with the environment, for example, on the skin. Bacteria can also be important for fermentation, the decomposition of biodegradable packaging, as well as for modern methods of synthesizing hydrocarbon resources through the adsorption of carbon dioxide in seawater, as in the Fischer-Tropsch processes.

Without modeling the behavior of biological objects at the microlevel, it is difficult to determine the most effective methods of their use and control of diseases. Viruses, for example, do not act in isolation; their impact is accompanied by specific replication processes.

The most compelling argument for creating a biotechnology cluster is the financial aspect. No branch of applied science will receive such funding as the one that will help humanity survive. Smart drug delivery systems, smart materials that interact with the environment, as well as production management systems are critically important. Without interactive technologies and influence on biological processes, modern science will remain hostage to global problems such as military conflicts, hunger and environmental crisis.

3.4 International energy clusters and their role in the restoration of energy infrastructure

3.4.1. International Energy Cluster

The Ministry of Energy and the International Energy Cluster cooperate in the restoration of energy infrastructure facilities. The International Energy Cluster is an association of seven enterprises that manufacture and supply energy equipment, metal structures, perform design, construction, installation and commissioning works, and also carry out activities in the energy and telecommunications sectors. In addition, the cluster includes five partner scientific institutions operating in the energy sector. IEC members and scientific partners implement joint projects in Ukraine, Lithuania, Germany and other EU countries.

Ukraine, as a member of the Energy Community, has undertaken to implement standards stipulated by the directives of the European Parliament and the Council of the EU aimed at reducing the energy intensity of production. Restoration, modernization and creation of new energy facilities should take into account the need to reduce the energy intensity of Ukraine's GDP, implement environmental policy and increase the competitiveness of the Ukrainian economy, which is an important condition for European integration.

Given the current state of the country's economy, it is important to develop a new vision of long-term plans for the restoration and development of the energy sector in the post-war period. This involves determining the prospects for the development of new generating capacities in Ukraine and the conditions for the development of network infrastructure, taking into account plans for economic restoration and development of regions based on modern technologies.

For the successful implementation of these tasks, it is necessary to develop coordinated positions on regulatory and project activities in the field of digital technologies in the energy sector, in particular, to prepare proposals for removing barriers and creating effective tools for forming a new model of the energy market and developing "smart" energy networks.

The project experience of the Research Institute of Energy, Automation and Energy Saving of the National University of Life Resources and Environmental Sciences of Ukraine indicates a significant interest of participants in the formation of a modern energy market model, especially in issues of energy digitalization. There is an urgent need to deepen cooperation with stakeholders in the energy sector to develop programs and projects aimed at increasing operational efficiency, flexibility of business management of energy companies, cyber security, adaptive customer-oriented energy consumption management system, etc.

Taking into account these circumstances, the National University of Life Resources and Environmental Sciences of Ukraine initiated the creation of the Educational and Scientific Cluster of Digital Energy. The purpose of the Cluster is to increase the competitiveness of energy industry enterprises, ensure their high-tech and innovative development by combining production potential and resources for the restoration of energy facilities in the post-war period, as well as the introduction of new digital technologies to support the course for further decarbonization of the economy, which is a necessary condition for Ukraine's European integration.

Cluster participants consider it necessary to cooperate with innovative businesses in the energy sector in order to have access to the market and use technologies developed as a result of innovative activities.

The document "On Amendments to the Decision of the Regional Council of December 20, 2019 No. 1242 "On the Development Strategy of the Poltava Region for 2021-2027" states that the implementation of Industry 4.0 requires support from the state through the implementation of targeted programs, which are currently under development. Therefore, an ambitious goal has been set at the regional level to promote the transition to Industry 4.0 by supporting the modernization and automation of production processes, the creation of clusters, as well as the participation of Poltava manufacturers in international value chains.

Promoting the transition to Industry 4.0 (priority in supporting the modernization and automation of production processes, the principles of energy efficiency, clustering of production, optimization of logistics, etc.):

• introduction of automation of production processes;

• optimization of production processes by introducing modern smart products;

• increasing the prestige of engineering and labor specialties;

• promoting the creation of cluster production;

• introduction of energy-efficient production technologies;

• transformation of domestic industries into competitive and efficient ones through their "digitalization";

• creation of new products and services thanks to Internet of Things technologies, virtual reality, cloud services and artificial intelligence;

• development of the sphere of export of "digital" products and services (IT outsourcing).

• creation of innovation clusters, service cooperatives (for entrepreneurs and infrastructure development) and industrial parks in rural areas to combine efforts and strengthen competitiveness.

The main research question addressed in [76], is how energy clusters can be assessed and what general conclusions can be drawn from their activities. Traditional approaches to innovation analysis of energy clusters are mostly based on surveys, interviews, open publications and patents, but do not take into account the updated activities of innovation clusters. Thus, previous cluster analysis methodologies have always lacked up-to-date information. In this sense, the analysis of energy cluster activities is important for politicians, investors, companies, etc. In addition, such an assessment helps to track the development of new technologies, the participation of different actors in the innovation ecosystem and new trends in the energy sector.

The paper presents the results of a study of leading energy innovation clusters in Germany. For this purpose, the article uses publicly available data from the websites of clusters and their members to investigate the geographical distribution, key areas of activity and activity of clusters and their members. During the project, a web data collection tool was developed that scans the websites of clusters and their participants, collecting textual information. The tool performs systematic and controlled data collection to detect the presence of keywords on certain web pages. Additionally, the data from commercially available company databases are used to supplement information not available on websites.

In total, 44 energy clusters with 4,524 members were included in the study. The proposed methodology showed that unstructured web data is a valuable source for analyzing clusters and the innovation activities of their members. The results also showed that there is a strong correlation (r = 0.85) between research and development (R&D) expenditures and the number of clusters in different federal land. The overall results showed that most energy clusters specialize in certain topics, but topics such as hydrogen, carbon and bioenergy attract the attention of different stakeholders. At the same time, various cross-sectoral topics emerge due to the interconnections between different sectors. The data obtained can help policymakers and federal innovation agencies to better understand the ongoing progress in innovation activities in the field of clean technologies. From a methodological point of view, this provides a basis for assessing the impact of cluster policies.

Fig. 19 shows the total number of clusters and their members by years of registration. In 2011, adhesion reached its maximum with the addition of 6 energy clusters. Although there is a positive correlation between the number of clusters and the number of members, they are not always closely related. This shows that the participation of members depends not only on the number of clusters, but also on factors such as the level of development of the clusters, the spreading effect of innovation clusters in the regions, the attractiveness for local participants, etc. In terms of regional distribution, the clusters are unevenly located. In fact, regional factors such as economic support, company specialization, research institutions and financial support are important elements determining the number of innovation clusters in a particular region. There are 14 clusters in Baden-Württemberg, followed by 6 clusters in Lower Saxony and 5 in Bavaria.

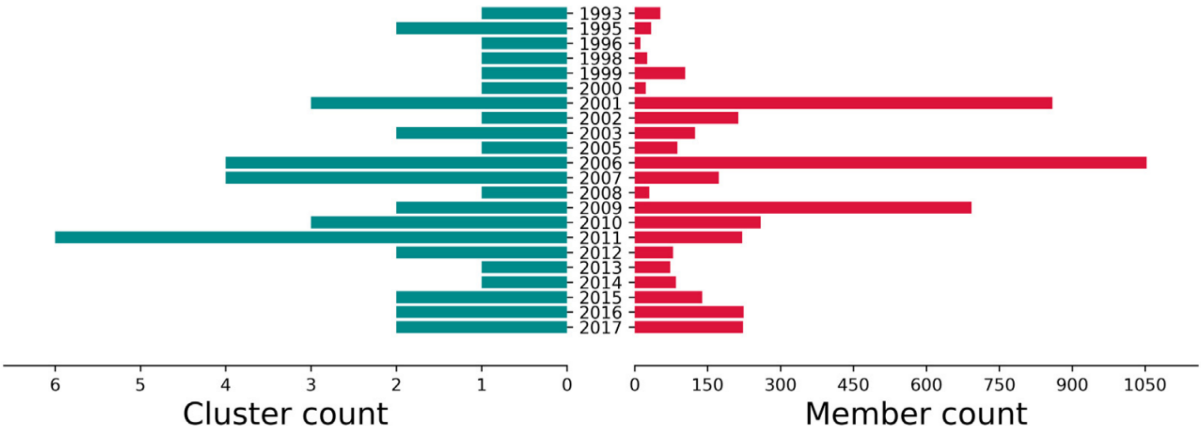

Fig. 19. Total number of clusters and members, by years of registration.

Each cluster has a thematic focus and different areas of activity are developed around it. The main thematic areas of energy clusters are listed and the number of clusters belonging to each of them is indicated. The most generalized topics are renewable energy sources, energy technologies, bioenergy, hydrogen and fuel cells, environment. In addition, a small number of clusters specialize in very narrow thematic areas, such as energy storage, energy efficiency, smart city, etc.

The main participants of clean technology innovation clusters were also analyzed. For this, the composition of the different clusters was considered. The list of participants was formed based on data from the cluster websites and the cluster platform.

Fig. 4 shows the main stages of cluster formation and the different types of participants identified from the list of members. As in other areas of innovation clusters, the key players in an energy cluster are companies (large, medium-sized, small and start-ups), research institutes, universities, non-governmental organizations and funding bodies. However, clusters in the energy sector also include several other actors (e.g. training centres, project management companies, etc.) and individuals. These actors play an important role in promoting an innovation culture and also benefit from various financial projects and measures.

After a theoretical analysis, it becomes clear that innovation clusters in Germany follow a top-down approach, in which the government takes control and the federal ministries and state energy agencies set the political guidelines and research agenda for a specific topic or sector.

In the first phase, large companies, research and educational institutions join the cluster initiative and receive access to capital and a regulatory framework to develop innovative services or solutions.

At the next stage, startups, SMEs, banks, venture capitalists and other financial actors join the cluster initiative. Startups gain access to capital, patents and talent. On the other hand, financial participants receive a reliable platform to invest their funds in innovation activities.

The third stage brings together various associations (e.g. industry associations, chambers of commerce, etc.) with members who contribute to the acceleration of innovation. The presence of these participants increases the maturity of innovation. In the final stage, other actors and individual participants enter the ecosystem and also join the cluster (see Figure 20).

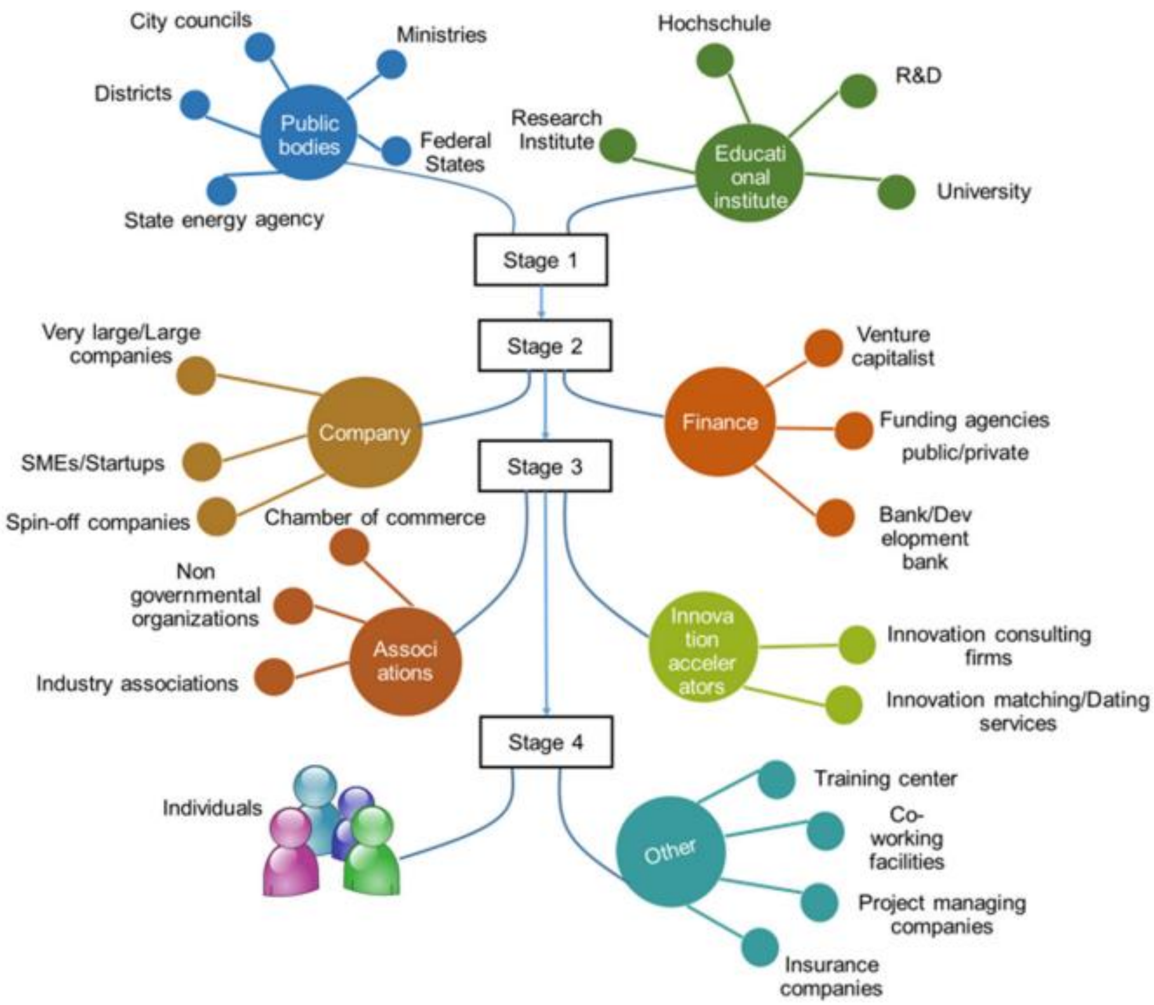

Figure 20. Energy cluster: a diverse set of stakeholders and stages.

In addition, a large number of key topics develop through the interaction of different sectors. Here are some examples of similar topics: "Biohydrogen, organic solar cells, solar heating, photobioreactor, solar cooling, fuel cell heating system, solar thermal energy, geothermal heat pump, water solution heat pump, energy-to-gas". These topics arise from the convergence of sectors and have significant potential to attract different stakeholders with very specialized activities. The presence of such topics convincingly demonstrates that energy clusters in Germany are not limited to individual topics but also cover various interdisciplinary areas.

This makes the clusters a more open and attractive platform for participants looking for opportunities to further collaborate in their field of expertise. Energy clusters are diverse in terms of member types and their number.

The percentage distribution of the number of members out of the total number of 4,524 was examined. Of these, 35.2% of the members were identified as active and profitable companies. The comparison was made using the Amadeus company database (Amadeus, 2021). Of the total number of relevant companies, 38.2% were identified as medium-sized and 30.2% as small, while the share of very large and large companies was 15.9% and 15.7%, respectively.

Most of these companies are registered in Germany, but there are also companies established in neighboring countries and other EU countries, which confirms the internationalization and cross-sectoral activities of energy innovation clusters in Germany.

On the other hand, institutes (3.9%), universities and colleges (3.6%), cities and municipalities (2.5%) are other major participants in the energy cluster identified in the participant dataset. However, energy companies are one of the key elements in the energy value chain. Nevertheless, their share of cluster-related activities is surprisingly low at only 0.5%. The category “other” includes all actors that do not match the company databases and do not belong to the specified categories.

The presence of various categories in the energy cluster indicates a broad interest in energy-related topics. Innovation clusters are leading the way in the development of new clean technologies and innovative business models. They encompass different actors in society and represent territorial cooperation between them. In addition, the states and federal governments are encouraging new policy frameworks for innovation to flourish in this sector. In this respect, the work highlighted the main cluster policies in the different federal land. In the energy sector, all lands have active cluster initiatives. However, several federal lands have very effective and influential cluster policies, which lead to an increase in the number of clusters in these specific lands. Two such examples are Baden-Württemberg (Ministerium für wirtschaft arbeit und wohnungsbau baden-württemberg, 2018) and Lower Saxony.

Unlike the cluster analysis methodology performed in Tvaronaviciene et al. (2015), the proposed methodology is data-driven and can perform a relatively simple analysis of innovation clusters using their URL data. Similar to the studies conducted by Tvaronaviciene et al. (2015), Koecker (2008), Benedikt Sedlmayr (2019), this study does not emphasize the role of unstructured data and company databases in cluster analysis. In this respect, the methodology proposed in the current work has proven to be better at using a combination of different data sources.

The analysis of energy innovation clusters is a new way to monitor recent progress and emerging interests of different stakeholders. The project was initiated to develop a cluster analysis methodology and assess its impact on the development of clean technology-related topics. The thriving Internet data can play an important role in the analysis of key activities in the energy sector. In addition, the work provides a comprehensive overview of the main cluster policies in the different federal lands of Germany. Although some federal lands have limited activities related to energy clusters, a desk review showed that the energy sector is a leadermarket for all lands. The following conclusions can be drawn from the study.

• The study aimed to obtain information on the leading energy clusters in Germany. These findings are also indicative of the success of regional energy policies and transition programs.

• The project was initiated to develop a new methodology that can analyze energy clusters by combining different sources of structured and unstructured data. It can also be extended and applied to assess clusters active in other regions.

• However, energy clusters in Germany are organized in a top-down approach. In fact, the representation of actors is quite diversified and includes civil society actors, government agencies, universities, research institutes, companies, etc. It is therefore clear that participation in an innovation cluster has become a clear interest for different actors in society.

• The paper argues that energy clusters and the website data of their members serve as an important source for measuring their activities. Based on this, a tool for guided web scraping is implemented. It uses a large set of keywords to extract data from selected web links. This reduces the amount of unstructured data, which is often a difficult task.

• Taken together, the results suggest that energy innovation clusters are quite active in conventional topics (e.g. solar, wind, renewable energy), and to some extent they are also well involved in new topics such as biohydrogen, carbon nanofibers, dye-sensitized solar energy, environment, etc. In addition, the cluster analysis also identifies various types of joint activities. A future perspective of the work is the development of an innovation indicator based on cluster and their member web data. Such an indicator could help measure the impact of cluster policies, clean technology financing and investments in new innovative technologies. Another direction of work is related to the feasibility analysis of the innovative technologies and processes identified in the proposed analysis. Methodologically speaking, the Comparison and categorization of cluster members is a major limitation of this work. Comparing names using Python scripts with company database information often results in different, inconsistent categories of participants. Therefore, future work should focus on implementing an improved method for mapping categories using website text. Regarding text content analysis, semantic similarity methods can be applied, which will significantly extend the scope of the current keyword-based method. Furthermore, adding other data sources such as social media, news articles can also provide more information about cluster activities in certain topics.

3.4.2. Zero-energy building (NZEB) clusters

Energy and environmental issues are becoming increasingly complex worldwide due to population growth and improving living standards. Buildings consume more than 40% of the final energy worldwide, and this percentage is even higher in developing countries (more than 90% of electricity). As a major energy consumer, buildings play an important role in energy conservation and environmental protection. Unlike traditional buildings, zero-energy buildings (NZEBs) use renewable energy to meet their own energy needs and are widely considered to be an effective solution to growing energy and environmental challenges. Many countries have set clear targets through legislation to promote the practical application of NZEBs. For example, the US government has set a target of achieving net-zero energy consumption for 50% of commercial buildings by 2040 and for all commercial buildings by 2050. After 2020, Europe plans to convert all its new buildings into “nearly zero-energy buildings”.

Uncertainties have a significant impact on the size of systems in clusters of zero-energy buildings (NZEBs) and need to be properly taken into account. In [77] the impact of three typical types of parameter uncertainties was investigated using Monte Carlo simulations and statistical analysis. Considering the impact of uncertainty, the study aims to compare the multi-criteria performance of two design approaches for sizing the system of an NZEB cluster. The first is a conventional stand-alone design, in which dedicated systems are designed separately in each building. The second is an integrated design, in which integrated systems are designed to provide services to all buildings. The results of the study show that the integrated design approach can significantly reduce the system size and significantly reduce the initial cost compared to the conventional stand-alone design. The initial cost of air conditioning systems, photovoltaic systems and wind turbines can be reduced by 14.4%, 13.7% and 11.8%, respectively. The integrated design also provides increased grid convenience and equivalent indoor thermal comfort compared to the conventional stand-alone design. Given such improved performance, the integrated design should replace the conventional stand-alone design for sizing the system in NZEB clusters, especially considering uncertainties.

Correct system sizing is crucial for NZEBs to achieve their expected performance and help achieve their goals. Existing methods for sizing NZEBs are based on deterministic data. Many studies have shown that such deterministic data are associated with uncertainties, the consequences of which can lead to serious problems such as oversizing systems. For example, the physical parameters of a building are difficult to determine precisely, and weather and internal load parameters used during the design phase may differ significantly from the actual conditions after commissioning. These parameter uncertainties have a direct impact on the accuracy of peak load estimation for HVAC (heating, ventilation and air conditioning) system sizing. To cope with the impact of uncertainty, two simplified methods are widely used in existing methods: the worst-case scenario method and the safety coefficient method. Although these methods have been used for a long time, oversizing is still a common problem in HVAC system sizing. Studies have shown that over 40% of rooftop units were over-sized by more than 25%. Another study proposed a method to quantify the over-sizing factor, which found that HVAC systems are typically over-sized by 100%. Since 0.2% energy savings are achieved for every 1% reduction in HVAC system size, significant energy savings are possible with proper uncertainty analysis to avoid the current problems with over-sizing HVAC systems. Given this significant energy saving potential, researchers have recently begun to investigate the impact of uncertainty on HVAC system sizing using probability distributions of uncertainties.

After achieving net zero energy consumption at the single building level, the next step is to implement this approach on a larger scale, i.e. at the cluster level. So far Cluster-wide zero net energy design can generally be implemented in two ways. First, each individual building is designed as an NZEB, without shared service systems. This is referred to in this study as a “disaggregated design approach.” Second, all buildings are considered as a single entity and integrated service systems are developed for them. This is referred to as an “integrated design approach." Integrated design can take advantage of the complementary load characteristics of buildings that arise from differences in space use, which can bring benefits across multiple criteria, such as initial costs and grid convenience.

Examples of Zero Energy Buildings

Real examples of zero energy buildings demonstrate how green building technologies and innovative design principles can lead to zero carbon emissions. These buildings serve as a source of inspiration for future architects and developers seeking to create energy-efficient buildings (see Table 11 below).

Table 11. Energy-efficient buildings

Building Name	**Location**	**Year of Completion**
Edge	Amsterdam, Netherlands	2014
Yale Health Center	New Haven, Connecticut, USA	2010
Research Support Facility	Golden, Colorado, USA	2010

One of such examples is the Bullitt Center in Seattle, Washington. Completed in 2013, the Bullitt Center is a six-storey, 50,000-square-foot commercial building that produces as much energy as it consumes. The building is equipped with solar panels, natural ventilation, and geothermal heating and cooling systems. It also incorporates sustainable building materials such as FSC-certified wood and recycled materials.

Another example is The Edge, a 430,000-square-foot office building in Amsterdam. Completed in 2014, The Edge is considered one of the most sustainable buildings in the world. It features a smart lighting system that adapts to individual needs and preferences, solar panels on the roof, and rainwater harvesting systems.

The Yale Health Center in New Haven, Connecticut, completed in 2010, is another zero-energy building. It features geothermal heating and cooling, solar panels, and energy-efficient lighting. The building also incorporates sustainable building materials such as bamboo flooring and recycled steel.

The Research Support Center in Golden, Colorado, is a zero-energy building that serves as the headquarters of the National Renewable Energy Laboratory. Completed in 2010, the facility features a large solar array, natural ventilation, and a smart lighting system. It also incorporates sustainable building materials such as bamboo and recycled carpet tiles.

These case studies demonstrate the potential of zero-energy buildings and serve as a source of inspiration for architects, builders and developers who are committed to promoting sustainable architecture and design.

The global energy crisis has prompted the European Union (EU) to focus on improving energy efficiency in the building sector. One promising approach to achieving this goal is to create clustering and energy hub concepts that enable efficient and flexible energy management in multi-carrier energy systems. In this context, the article [78] proposes to conceptualize the building cluster as an energy hub that promotes synergistic energy efficiency. The main contribution of this article is to present a state-of-the-art overview of building cluster mesoenergy hubs (BCMEEEH) energy management, focusing on an Agile framework. By analyzing the most effective BCMEEH energy management models, architectures, and methods, this review can help improve key performance indicators (KPIs) and infrastructure accuracy in real-world building energy management projects. To this end, this manuscript proposes a hierarchical energy management framework for BCMEEH in a smart city macro-energy center (SCMAEH) based on the implemented project management framework. Overall, this paper contributes to the literature by proposing a comprehensive and effective approach to BCMEEH energy management. By adopting the proposed framework, clusters can be transformed into energy hubs, contributing to sustainable energy practices and solving the global energy crisis.

3.5. Cluster Approach in Education

The article [79] describes the structure, advantages of organizing industrial educational clusters, their fundamental ideas and stages of formation, support and limitations of development. The main attention is paid to the involvement of educational institutions in clusters using examples of countries described in the works by famous economist Michael Porter. The levels of cluster analysis and classification of clusters using the examples of different countries are considered. The article describes the origin and description of educational clusters abroad, the qualitative and quantitative composition of educational clusters in individual countries, and also provides a rating analysis of national passports of educational clusters of European countries from the point of view of the designation of the European Cluster Observatory [80].

Practice has shown that the decisive role in the development of industrial and early stages of post-industrial society belongs to the level of quality of education for the population. The next generations of intellectual elite are trained in universities and colleges, and therefore the problem of ensuring the quality of higher education, which has become truly mass, rather than a select part, is currently attracting the greatest attention. To solve this problem, special government and intergovernmental programs have been created in the United States, Western and Central Europe. The development of effective systems of ensuring the quality of higher education is considered here as an integral part of legal reformations and conditions for the further development of democracy, university autonomy and academic freedom. The development of the concept of industrial clusters formation allows a more pragmatic approach to the creation of joint educational and research programs [81,82,83,84].

From the definition given by M. Porter, the founder of the theory of the modern cluster, it follows that "... a cluster is a geographically concentrated group of interconnected companies that compete ... but at the same time work together" [85,86,87].

A cluster is a set of organizations (several companies and several educational institutions: research institutes; universities, primary vocational schools, secondary vocational schools) that cooperate, complement each other and strengthen the competitive advantages of individual companies and the cluster as a whole. An example of a cluster is Silicon Valley in the USA [88,89].

The broad interaction of educational institutions, the implementation of various forms and levels of education (schools and colleges, colleges and universities, education institutions and universities, etc.) is the basis of continuing professional education. An educational cluster is a comprehensive cooperation of universities, secondary vocational education institutions, enterprises and organizations [90,91].

The main idea of industrial clusters is that cluster initiatives allow focusing the efforts of various members of the group, in a given specific cluster, on “joining” the world's leading centers of knowledge and experience in the interests of the cluster's development [73].

The literature review allowed identifying the reasons why different authors offer different names to designate this phenomenon. Thus, a number of researchers use the definition of "educational cluster" [92], emphasizing that the central role in the cluster is assigned to universities.

3.6 Knowledge cluster

It is difficult to find a description of a successful cluster on an international scale in the literature, in which neither educational nor scientific institutions would be represented. Moreover, as a rule, there are several such institutions.

Currently, the use of a cluster approach is considered one of the most effective ways to develop territories. Any cluster is based on cooperation between educational and research institutions. If an industry cluster is formed in the field of high technologies, the role of universities and scientific communities increases significantly. Often in these clusters, the university becomes a key player, which is the core of the cluster.

A classic industrial cluster includes three main interrelated elements, namely: - key companies that export their products, goods or services outside the region; - a network of suppliers that supply raw materials, components, goods, spare parts, repairs, services, etc.; - a business climate, including technology, human resources, administrative, physical infrastructure.

The use of any strategy in the development of a cluster involves both supporting and restraining factors.

Supporting factors. The first supporting factor is the participation of the state and business in the development of industrial clusters. Currently, the administration can actively develop cooperation between educational institutions, research institutes and business and ensure the solution of various cluster problems both independently and within the framework of international cooperation.

The second supporting factor is the availability of engineering and scientific personnel. The third supporting factor is the availability of opportunities for research and development work. The fourth supporting factor is the presence of certain traditions in the field of industrial cooperation in the country.

Restraining factors. First, despite the availability of suppliers, an important and serious problem is the low quality of products and services, low competitiveness and low efficiency of supply chain management.

The second factor is the inadequacy of educational and research programs in the field of professional training and compliance with the requirements for the qualification of personnel of industrial clusters.

The third factor is the presence of weak links between vocational and higher education institutions, research institutes and business.

Different levels of analysis use of different cluster concepts and orientation on certain factors. Some studies have focused on the level of companies and analyze the competitiveness of the supply chain around the main organization.

Levels of cluster analysis [93]:

Some researchers, for example, scientists from Finland and the Netherlands, focus on communications within and between industry groups (mega-groups). They reflect specific aspects of the economy of a country or region (macro-level).

Sectoral and industrial level (meso-, sub-level) exists within and between industry communications (links) at different stages of the production chain of obtaining similar products; marketing analysis of products. Such studies have been conducted by Porter in some countries, such as Finland, Sweden, the United States, Denmark and the Netherlands [94].

The company level (micro level) involves the aggregation of specialized suppliers around one or more core organizations. This type of analysis is used for strategic analysis of the company and identifies the loss of ties or strategic partners when implementing new projects [95].

The standardized quantitative method described by Porter in (Porter, 1998) identifies 16 possible clusters, which include four levels: basic consumer goods, industrial machinery, special range of goods and related services.

The four leading sectors include materials/metals, wood, oil/chemicals, semiconductors/computers. The six life support industry sectors include transportation, energy, offices, telecommunications and defense. The six sectors producing finished consumer goods and services include food/beverages, textiles/ clothes, housing, healthcare, education and entertainment/leisure.

Porter’s approach to clusters differs from the traditional division of sectors into primary, secondary and tertiary.

The following seven criteria were selected to conduct a structural and quantitative comparison of international and national cluster classifications and their comparative analysis (Porter, 1998): 1) geographic; 2) horizontal; 3) vertical; 4) lateral; 5) technological; 6) focal; 7) network quality.

Since the success of Silicon Valley, interest in the formula for success, which is expressed in the form of a three-helix cluster, such as “higher education - business - government”, has been constantly expanding, and currently it is a cluster with four helixes - “higher education”, business, government and civil society [76, 96]..

For example, in Ireland, the National Strategy for Higher Education 2030 includes engagement with all stakeholders and recommends the creation of regional clusters as a way to foster closer collaboration both between universities and between universities and other stakeholders. Collaboration at local, regional, national and international levels is considered critical for the overall development of the higher education and research ecosystem and for ensuring Ireland’s continued competitiveness [97].

Educational and research institutions are almost always important participants in a full cluster. The first descriptions of an educational cluster can be found in Porter’s works in publications [98], as well as in Ukrainian literature [99].

The analysis of the Massachusetts education cluster, conducted by the Universities of Massachusetts and Harvard, is presented in the publications of M. Porter, which describes in detail the cluster’s role in the educational sector of the country in comparison with other states (with California) and other countries. Porter considered an educational cluster with two leaders - the Massachusetts Institute of Technology (MIT) and Harvard. He noted that the educational cluster is not traditional and therefore requires further clarification. The participants of this cluster are students, teachers, employees and financial institutions. In the center of the cluster there is a university, and nearby there are elite preparatory schools. Banks also play one of the key roles of the cluster, as they provide loans for students' education. M. Porter emphasized the uniqueness of cities such as Boston and Cambridge, which contributes to the success of the educational cluster, which is the cradle of consulting companies. The second positive factor is the presence of a large number of research institutions and teaching hospitals. The third factor is the presence of the Massachusetts Institute of Technology, which organizes and controls state institutions [86].

The Philadelphia educational cluster includes schools, colleges and universities. This cluster provides employment for 108 thousand people, which is 16% of the total employed population of Philadelphia. The following distribution of the number of employees was found: the smallest companies (1-4 people) - 30%, small companies (5-99 people) - 64% and large companies (100 and more employees) - 6%. The change in jobs in this sector is within 10%, the average age of employees is within +/- 24%, the average income of cluster members is $49 thousand per year, which is higher than in a similar cluster in Pennsylvania ($40 thousand per year) [100].

The results of the rating analysis of 80 different intellectually intensive clusters are presented in the report [101]. These are mainly IT clusters representing electronics and microelectronics, media and telecommunications, several research clusters, such as Maquarie (Sydney), Beijing (China), Espoo (Finland), Yokosuka Research Park (Japan), Cornell Research District (USA).), Oxford (England) and only one educational cluster, namely, Tsukuba Science City (Japan).

The analysis of national cluster passports from the perspective of the relevant European Cluster Observatory includes the following parameters: focus - contribution to the cluster in the employment sector in the region; rank - position of the cluster in the regional cluster ranking across all categories (sectors); (Spec =

LQ - specialty - local coefficient) for the 30 countries presented in the review [102] (a sample of educational clusters is given in Table 12).

Table 12. Localization coefficients for cluster formation in the EU[103]).

Country	**[x]**	**Number of Researchers**	**LQ**	**Number of Researchers [xx]**	**Rank/Level**	**Index**
Latvia	1	43,000	2.50	43,105	1	2.50***
Poland	5	230,000	1.63	52,758	1	2.41***
England	4	800,000	1.59	61,200 / 38,150 / 35,846	7 / 13 / 15	2.89*** / 2.07*** / 2.07***
Czech Republic	9	80,000	0.96	26,472	6	2.27**
Hungary	5	80,000	1.12	44,476	2	1.90**
Netherlands	4	210,000	1.57	112,809 / 38,782	5 / 7	1.82** / 1.41**
Finland	3	61,000	1.44	37,062	4	1.62**
Norway	3	55,000	1.36	10,060 / 20,537	6 / 12	2.87** / 1.77*
Slovakia	9	39,000	0.99	12,762	6	2.28**
Estonia	3	17,026	1.63	17,026	6	1.63*
Sweden	6	90,000	1.15	27,167	12	1.46*
Denmark	5	62,585	1.24	62,585	5	1.24*
Belgium	6	82,000	1.22	42,110	12	1.10*
Germany	9	410,000	0.85	—	—	—
Italy	8	360,000	0.86	—	—	—
Spain	6	350,000	0.92	—	—	—
France	10	210,000	0.59	—	—	—
Romania	11	90,000	0.78	—	—	—
Greece	6	70,000	0.94	—	—	—
Bulgaria	9	44,000	0.97	—	—	—
Austria	10	42,000	0.63	—	—	—
Switzerland	12	40,000	0.59	—	—	—
Ireland	7	32,000	1.05	—	—	—
Slovenia	6	16,000	1.06	—	—	—
Portugal	25	10,000	0.20	—	—	—
Turkey	35	5,000	0.02	—	—	—
Cyprus	11	4,000	0.60	—	—	—

Country	[x]	Number of Researchers	LQ	Number of Researchers [xx]	Rank/Level	Index
Iceland	6	4,000	1.36	—	—	—
Lithuania	23	3,000	0.14	—	—	—
Malta	7					

[x] - Position of the education cluster in the ranking of national clusters.

[xx] - Position of the education cluster in the ranking of regional clusters.

1) The ranking is determined according to the “three-star” methodology proposed in the publication [104].

The study presented in the publication [105] confirms that the share of the contribution of universities and research institutes to cluster structures varies across countries. The highest contributions, which amount to 24 and 11%, were found in Iceland and Germany, respectively. For the period up to 2009, financial support for cluster development was provided to 50 cluster structures, which, along with medium-sized companies (29) and small companies (515), consisted of 29 universities and 39 research institutes.

According to the Harvard project, out of 50 clusters, the Gini coefficient for the position "education and knowledge" was estimated as 0.34 for 15 EU countries (119 regions in 7 countries) - 0.20 and for 10 EU countries - 0.22. From the 50 identified large clusters, the following cluster groups were selected: the Warsaw cluster with 52,093 employees and a localization coefficient of 1.38, representing 2.74% of all employees; the Katowice cluster with 39,052 employees and a localization coefficient of 1.20, representing 2.39% of all employees; the Krakow cluster with 32,887 employees and a localization coefficient of 1.15, representing 2.29% of all employees; and the Budapest cluster with 42,703 employees and a localization coefficient of 1.73, representing 3.43% of all employees. Educational clusters of Prague and Bratislava received the highest rating, which was three stars [106].

For the classification of educational clusters in this work, the National Classification of Economic Activities, created on the basis of the International Industrial Classification of Economic Activities of the EU NACE, was used [107]. Most publications on the topic of quantitative and qualitative cluster analysis are based on the use of NACE.

The NACE structure includes the M-education section and group 80, the content of which is presented in table 13 [108,109].

Table 13. Composition of group 80 in the classifier.

Group Section	Type of Economic Activity	Reference
80	Education – educational institutions of all types	
80.1	Preschool and primary general education	[110,111]

Group Section	Type of Economic Activity	Reference
80.2	General secondary (complete), primary and secondary vocational education	[112,113]
80.22	Primary and secondary vocational education	[114,115]
80.3	Higher professional education	[116]
80.30.3	Training in institutions of additional professional education	[117]
80.4	Adult education and other education	

The calculation and comparative analysis that increase the competitiveness of educational clusters, presented in the publication [118] gave the following definition: an educational cluster is a set of interconnected vocational educational institutions, united in different sectors and connected by partnerships with each other, as well as with companies in this sector. Publications (Rating of regional educational clusters; Rating of interregional educational clusters) are presented with a list of 24 regional educational clusters and 6 interregional educational (industrial) clusters.

The main difference of an educational cluster lies not so much in the composition of participants (an educational cluster may include commercial organizations, state authorities, a cooperation organization) and in the leading role of universities (they usually serve as the core of a regular cluster), asin the specific product that is the result of such a cluster. This specific product is educational services.

Accordingly, in regular clusters, the value chain is analyzed, for example, for the subject of “input-output” in the production process, in which many companies related to sales participate. In educational clusters, instead of the production process, the educational process is analyzed, covering various stages of education - from preschool to higher education [119].

3.6. Light industry clusters

3.6.1. Clothing industry

The clothing industry is a branch of light industry. The industry is represented by enterprises of various sizes. The main output of the industry is provided by large clothing enterprises of regional significance. Since 2000, clothing industry enterprises have produced 65.3 million pieces of sewn products. By 2010, the production volume of sewn products can be increased by 1.45 times to 95 million pieces.

In recent years, the range of sewn products produced has undergone significant changes. For certain product groups, there has been a steady demand, both in the domestic and foreign markets, and in connection with this, an increase in production. These are such products as coats and short coats, raincoats, suits, dresses and trousers.

Some enterprises have been working with companies from the USA, Canada and EEC countries for a long time. At the same time, the volume of textile exports in recent years has exceeded the official import of clothing. In recent years, the European Union countries have significantly expanded operations on a toll basis, which is due to fierce price competition in their domestic markets. Western European clothing manufacturers are transferring operations for the manufacture of clothing to countries where production costs are several times lower than in Europe. Ukrainian clothing manufacturers already have a certain place in the international division of labor. However, their further participation will largely depend on the volume of investments in the clothing industry sector.

The clothing industry is in dire need of technical re-equipment with universal and special clothing equipment, which allows manufacturing competitive products.

For the purpose of technical re-equipment of clothing enterprises, it is advisable to purchase licenses from foreign manufacturers for the production of advanced equipment or create machine-building production with their participation, which will allow loading the capacities of domestic machine-building enterprises and reducing the cost of the equipment.

The main strategic goals of the development of clothing production for the period up to 2027 are the restructuring of production and the introduction of innovative technologies:

- reforming production by downsizing it for greater mobility and production of clothing in small batches,
- increasing the level of modeling and designing clothing by strengthening the role of fashion designers and stylists in creating industrial collections,
- developing and improving the technology and technological processes of clothing production,
- expanding the participation of Ukrainian enterprises in the international division of labor, increasing the production of clothing under licenses of world-famous fashion designers [120].

Garment cluster

The Khmelnytskyi Garment Cluster was the first in Ukraine to unite business structures of this type. It began to be created in 1997 with the participation of the Podillya Technological University (now Khmelnytskyi National University), the Chamber of Commerce and Industry, the Main Department of Economics of the Regional State Administration, a number of banking enterprises in the clothing industry. The student Fashion House of the university became the innovation center of the cluster. Thanks to the engineering developments, modeling and design of new products, training and internship of students and entrepreneurs in the cluster structures in Poland and Italy, the cluster participants managed to achieve production and commercial success [121].

Table 14 shows the data of the cluster analysis of clothing production based on the enterprise ZAO Kombinat PBU No. 1 "Kristi", presented in KVED codes (Ukrainian Classification of Economic Activities) and the index of the significance of the contribution to production.

Table 14. Classification of Economic Activities (KVED) of Ukraine

KVED Code	**Activity Name**	**Importance Index**
17.7	Manufacture of knitted products	2
18.3	Fur dressing and dyeing; manufacture of fur products	
17.3	Finishing of fabrics and textile products	1–2
18.2	Manufacture of clothing from textile materials and clothing accessories	3
18.22	Manufacture of outerwear	3
18.23	Manufacture of underwear	2
18.22.2	Manufacture of outerwear from woven fabrics for men and boys	
18.23.1	Manufacture of knitted underwear	2
18.24	Manufacture of other clothing and accessories	
18.22.3	Manufacture of outerwear from woven fabrics for women and girls	
17.30	Finishing of fabrics and textile products	1
18.30.2	Manufacture of garments, accessories and other articles made of fur, except headwear	3
36.63.3	Manufacture of umbrellas, walking sticks, buttons, press fasteners, zippers, etc.	
18.24.32	Manufacture of clothing made of felt, non-woven materials, impregnated or coated textiles	1
18.24.31	Manufacture of clothing accessories made of natural or composite leather	2
71–74	Business activities	0.4
74.20.4 / 74.20.41 / 74.20.42	Activities in the field of standardization and metrology	2
71–74	Activities in the field of standardization	0.3
50, 51, 52	Activities in the field of metrology	3

KVED Code	Activity Name	Importance Index
50, 51, 52	Provision of other services	0.01
60	Wholesale and retail trade; repair services	0.11
62	Wholesale and retail trade	1
65, 66, 67	Land transport and pipelines	0.02
75	Air transport	0.05
75	Financial services and insurance: financial intermediation, insurance, and auxiliary financial activities	0.02
80	Administrative and defense activities; compulsory services	0.01
90	Public administration and defense; compulsory social security	0.38
92	Education	0.10
630	Sewage disposal, waste management and related activities	2
633	Entertainment, culture and sports	1
641, 642	Auxiliary and supporting transport activities	1
701, 7022, 7031	Travel and excursion activities	1
4501, 4509	Post and telecommunications	1
7021	Other real estate indicators / real estate activities	2
7032	Construction of buildings or parts thereof	2

Fig. 20 shows the matrix of the cluster structure of a garment enterprise.

Thus, the considered examples of cluster analysis of some enterprises in Kyiv and the region provide the basis for developing a methodology for applying the cluster approach in regional development programs.

Conclusions in chapter 3

1. Four main strategies have been identified that can be used in Ukraine to increase the competitiveness of the supply system:

- increasing the efficiency of the existing supplier system;
- attracting suppliers from other countries and other regions;
- separating suppliers from the core business;
- targeted incubation of new businesses.

2. Based on the use of statistical analysis methods from various economic indicators and a system of expert surveys and expert assessments as pilot industries for testing the matrix for building industrial clusters, enterprises of the leather and textile industries have been identified.

3. It is shown that the supporting factors for the development of cluster structures in Ukraine are:

- participation of administration and business in the development of industry clusters;
- Availability of engineering and scientific personnel;
- Availability of opportunities for R&D;
- Existence of certain traditions in Ukraine in the field of production cooperation;
- Development of technological infrastructure in Ukraine.

At the same time, the restraining factors are:

- Low quality of their products and services;
- Low competitiveness;
- Low efficiency of the supply management system.

4. It has been established that the inadequacy of educational and research programs in the field of vocational training and preparation for personnel qualification requirements negatively affects the development of industrial clusters.

CHAPTER IV REGULATORY DOCUMENTS

Despite its long existence, the cluster movement in Ukraine remains insufficiently organized at the national level and develops mostly chaotically. There are already over 50 clusters and cluster initiatives in Ukraine, but there are still no complete and detailed register, agreed quality criteria, a permanent community and mechanisms for exchanging experience. State support for cluster development remains weak because no responsible bodies, national policies or programs have been created yet. As a result, the contribution of clusters to the development of the economy of regions and the country as a whole remains insignificant. This is significantly different from the situation in the EU, where industrial clusters play a key role in industrial development policy and are drivers of overall economic growth.

The Issues of clustering of the Ukrainian economy have been systematically considered at the level of the Cabinet of Ministers since 2003. In particular, the Resolution of the Cabinet of Ministers of Ukraine dated July 28, 2003 No. 1174 "On Approval of the State Program for Industrial Development for 2003–2011" provided for the creation of technological clusters, primarily in science-intensive and high-tech industries, capable of significantly strengthening the economic, scientific and technical potential of the industry, as well as optimizing regional industrial complexes and production capacities of enterprises.

The existing system of regulatory documents in Ukraine was studied, which regulates the relations of managing and manufacturing companies, service providers and the non-production sphere regarding the requirements for management systems and ensuring the level of quality of products and services by structures included in industrial clusters.

Organizational and legal structures, on the basis of which it is possible to create cluster associations, is the type and method of structural construction of an enterprise or corporation, provided for by laws and other legal norms of the country. The organizational and legal structure depends on the form of ownership, the scale of the enterprise, the formation of its capital, the nature of the connection and subordination of the constituent parts of the enterprise.

Thus, economic development is increasingly focusing on the cluster approach, as it best takes into account dynamic changes in competition and the main sources of competitive advantages. Clusters allow for the effective implementation of key relationships in technologies that are characteristic of a wide range of enterprises and industries. These relationships affect both the competitiveness of the final product and the direction and pace of innovative development. A chronological list of resolutions and orders of the Cabinet of Ministers of Ukraine aimed at clustering the economy is given in Table 15.

Table 15 Regulatory and legal field regulating the development of clusters and cluster projects in Ukraine [122].

Regulatory Legal Document	Subject of Regulation (Cluster-related Aspects)	Notes
Program for the Integration of Ukraine into the European Union. Approved by Presidential Decree No. 1072/2000 of 14.09.2000. The decree became invalid according to Presidential Decree No. 398/2015 of 07.07.2015.	Short-term (2000–2001) and medium-term (2002–2003) priorities by regions. Organization of a scientific and practical conference on applying European experience—specifically the **cluster model of business organization**—and prospects for introducing clusters in the **Ternopil region**.	https://zakon.rada.gov.ua/ 00#Text
On Approval of the Strategy for Attracting International Technical Assistance for 2005–2007. Resolution of the Cabinet of Ministers of Ukraine No. 829 of 30 August 2005.	Creation of a favorable business environment and development of small and medium-sized enterprises; promotion of new forms of production cooperation using the **cluster model of economic development**.	https://zakon.rada.gov.ua/ %D0%BF#Text
On Approval of the Main Directions for the Implementation of State Employment Policy for 2010–2011. Resolution No. 831 of 08.09.2010.	Key directions and mechanisms for implementing state employment policy, including the **introduction of the cluster model for developing traditional folk crafts**, particularly in small towns, rural areas, and mountain settlements.	
Resolution of the	Provides for the	

Regulatory Legal Document	Subject of Regulation (Cluster-related Aspects)	Notes
Cabinet of Ministers of Ukraine "On Approval of the State Regional Development Strategy until 2015" No. 1001 of 21.07.2006.	creation of **scientific and industrial clusters**.	
Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept of the National Target Program for Industrial Development until 2017" No. 947 of 09.07.2008.	Provides for the formation of **technological clusters in knowledge-intensive and high-technology industries**, capable of significantly transforming the economic and scientific-technological potential of industry.	
On the Legislative Work Plan of the Verkhovna Rada of Ukraine for 2020. Resolution adopted on 16.06.2020.	Creation of special jurisdictions with an **Anglo-Saxon legal system** within innovation development areas such as **innovation parks and clusters**, aimed at restoring foreign investors' confidence in Ukraine and attracting venture capital to stimulate the growth of startups and innovative companies.	https://zakon.rada.gov -20#Text
On Amendments to the Tax Code of Ukraine regarding the Introduction of Tax Incentives for the creation and development of technological clusters, inter-industry alliances, R&D centers, and innovative companies (startups).	Introduction of **tax incentives to support technological clusters**, digitalization projects, and the development of **Industry 4.0** initiatives.	**Помилка! Неприп гіперпосилання.**

On March 24, 2022, 16 clusters and cluster organizations of Ukraine united into the "Ukrainian Cluster Alliance" (UCA). At the beginning of May, the UCA already united 32 clusters and cluster-type associations. This is the first cluster association in Ukraine that takes on the mission of developing the entire cluster movement. The publication provides the main information about the new association, its goals and objectives, composition and terms of membership.

Granting a special status to a certain group of legal entities is not a mandatory requirement. In Ukraine, integrated cluster-type structures are formed in two ways: through the implementation of state policy on restructuring large structures or the unification of state property by contributing it to the authorized capitals of newly created or existing organizations, or at the initiative of commercial organizations in which the state does not participate. In the first case, cluster associations are created individually, taking into account the legal justification; and the contribution of state property to the authorized capitals of joint-stock companies is regulated by the legislation on privatization and separate regulatory acts of the President of Ukraine and the Government of Ukraine. In the second case, clustering is carried out on the basis of corporate legislation, which is sufficiently clear to create sustainable cluster associations.

Financing of programs for the creation of cluster structures is possible through the Small Business Support Fund, which is engaged in supporting market relations and developing competition, attracting financial resources for the implementation of targeted programs, projects and activities in the field of small business. The Fund also participates in the development and implementation of regional, sectoral and municipal programs for the development of small business, demonopolization of the economy, creation of new jobs and support for innovative activities. It also promotes the attraction of domestic and foreign investments for the development of a competitive environment and small business, and also provides consultations on taxation and legislation.

Conclusions in chapter 4

1. A cluster, as an association of organizations of various forms of ownership in order to obtain the greatest profit and competitive advantages, can be developed within the framework of the legislation in force in Ukraine.

2. Granting a certain group of legal entities that are part of a cluster, subcluster and, especially, a megacluster, a special status is objectively not necessary.

3. Cluster-type structures in Ukraine can be formed in two ways: as a result of the implementation of the state policy of restructuring large structures or on the initiative of commercial organizations in which the state does not participate.

4. The lack of need for legislative regulation of issues of identification and registration of clusters is confirmed by the practice of applying the Law "On Financial and Industrial Groups", which shows that in Ukraine there is a large number of economically successful financial and industrial groups that do not have state registration.

5. Based on world practice, the following main forms of stimulating small innovative enterprises can be distinguished, including within the framework of cluster industrial systems:

• direct financing (subsidies, loans), which reach 50% of the costs of creating new products and technologies;

• provision of loans, including the ones without interest;
• targeted subsidies for R&D;
• creation of funds for the introduction of innovations taking into account possible commercial risk;
• free loans, reaching 50% of the costs of introducing new technologies;
• use of the system of taxation of entrepreneurs without creating a legal entity duties for individual inventors;
• deferral of payment of duties or exemption from them if the invention concerns energy saving.
• free administration of records on applications of individual inventors, free services of patent attorneys, exemption from payment of duties.

The last two items of clause 5 require the development of additional by-laws within the framework of current legislation.

6. Financing of programs for the formation of cluster structures is possible within the framework of the Small Business Support Fund, state and regional projects in the field of small business in the form of organizing consultations on taxation issues and optimal application of the norms of current legislation.

5. CHAPTER V ELECTRICAL ENGINEERING AND BIOTECHNOLOGY CLUSTERS IN THE AGRO-INDUSTRIAL COMPLEX

5.1. General characteristics of agro-industrial cluster systems

In the twenty-first century, the agro-industrial complex [123] is increasingly evolving as an integrated system in which agricultural production, processing industries, logistics, innovation, energy supply, environmental management, and research infrastructure are interconnected. In such conditions, the cluster approach is regarded as one of the most effective forms of organizing regional and sectoral development, since it allows combining enterprises, research institutions, universities, engineering companies, service organizations, investors, and public authorities into a single innovation-oriented environment [124, 125, 126].

The conceptual foundations of clustering were formed in the works of classical and contemporary researchers who emphasized that territorial concentration of interconnected enterprises and institutions creates favorable conditions for productivity growth, innovation diffusion, specialization, competition, and cooperation [125, 126, 127]. According to cluster theory, the competitive advantages of regions and sectors are strengthened not merely by the presence of separate enterprises, but by the density and quality of interaction among participants, access to knowledge, supporting industries, labor markets, and institutions [125, 127, 128]. This logic is highly relevant to the agro-industrial complex, where technological chains are long, interdisciplinary, and strongly dependent on both infrastructure and local resource conditions.

For the agro-industrial sector, the cluster model is particularly important because agriculture and food production cannot be considered in isolation from energy systems, transport, storage, equipment maintenance, environmental management, biotechnology, and digital control. Agricultural enterprises operate in a space where biological processes, technological operations, climatic risks, and market fluctuations intersect. Therefore, their efficiency increasingly depends on the ability to integrate production, science, engineering, education, and innovation into coordinated territorial systems [129].

In modern practice, a cluster is not limited to the simple geographic co-location of enterprises. Rather, it functions as a network system with internal specialization, shared infrastructure, channels of knowledge transfer, coordinated investment activity, and institutional support [130]. In the agro-industrial complex, this means that producers of raw materials, processors, suppliers of machinery and electrical equipment, biotechnology laboratories, logistics operators, digital service providers, universities, and financial institutions can jointly form a development platform that strengthens the regional economy and increases value added [130, 131].

For Ukraine, clusterization of the agro-industrial complex is especially significant in the context of economic modernization, post-crisis recovery, strengthening food and energy security, and increasing the technological level of rural territories. National analytical and strategic documents emphasize that clusters are capable of becoming a mechanism for structural transformation of the economy, stimulating cooperation, industrial renewal, technological entrepreneurship, and regional competitiveness. For the agro-industrial complex, this also opens the way to combine traditional agricultural specialization with advanced engineering solutions, renewable energy systems, biotechnological production, and modern educational platforms [132].

At the same time, the development of contemporary agro-industrial clusters cannot rely only on conventional agricultural cooperation. The new stage of cluster evolution requires a transition toward interdisciplinary models in which biotechnology and electrical engineering become core technological pillars. Biotechnology is responsible for improving the biological efficiency of production, the quality and safety of raw materials and products, waste processing, and bioenergy conversion, whereas electrical engineering provides the energy, automation, control, and infrastructural basis without which innovative agro-industrial systems cannot function steadily [132].

Thus, the agro-industrial cluster should be understood as a complex territorial and sectoral system that unites biological, technological, engineering, organizational, and educational components. Its effectiveness depends on how successfully these components are integrated into a coherent innovation ecosystem. The interaction of biotechnology and electrical engineering in such systems becomes not an optional enhancement but a strategic prerequisite for sustainable development, competitiveness, and resilience of the agro-industrial complex.

5.2. Biotechnology as a Strategic Component of Agro-Industrial Cluster Systems

Biotechnology occupies an increasingly important place in the structure of the agro-industrial complex because it ensures a transition from extensive production models to knowledge-intensive, resource-efficient, and environmentally oriented systems. In the broadest sense, agricultural biotechnology encompasses biological methods and technologies used in crop production, livestock farming, feed manufacturing, food processing, environmental protection, and the utilization of agricultural waste [133, 134, 135].

One of the key advantages of biotechnology is its ability to increase the productivity and quality of agricultural production while reducing the ecological burden on agroecosystems. In crop production, biotechnological approaches contribute to the development of more adaptive and productive varieties, improved soil fertility management, biologized protection systems, and optimization of plant nutrition [135, 136]. In this respect, biotechnology becomes a tool not only of scientific progress but also of increasing resilience to climate variability, resource constraints, and market uncertainty .

In livestock farming, biotechnology influences the quality of feed, animal productivity, veterinary safety, reproductive technologies, and the processing of animal-origin products. Feed optimization, microbial and enzymatic additives, biologically active components, and the management of metabolic processes play a major role in improving the economic and technological performance of livestock enterprises [137]. These processes are particularly important in cluster structures, where livestock production is connected with feed manufacturing, veterinary services, breeding support, slaughtering, processing, logistics, and marketing [132].

Biotechnology also has a decisive role in food and processing industries. Fermentation technologies, enzymatic processing, stabilization of product quality, production of functional ingredients, microbiological control, and valorization of by-products are among the areas where biotechnology substantially increases the value added of agro-industrial raw materials [133]. In cluster systems, this means that raw agricultural materials are no longer treated as simple commodities; instead, they become the basis for diversified chains of processing and innovation-driven product development.

A separate and strategically important dimension of biotechnology in the agro-industrial complex is its contribution to circular economy and sustainable resource use. Modern biotechnology allows the conversion of agricultural residues, manure, wastewater, and food-processing by-products into valuable secondary resources, including organic fertilizers, feed components, biomaterials, and bioenergy substrates. This expands the environmental and economic potential of agro-industrial clusters and helps reduce losses along the production chain.

The European experience also demonstrates that biotechnology clusters can become significant engines of regional development when they unite universities, laboratories, startup companies, industrial partners, and public institutions. Studies on the formation of biotechnological clusters in the EU and analytical reflections on the need for biotechnological ecosystems in academic and regional environments show that such clusters are especially effective where knowledge generation is closely linked with commercialization and industrial application. This experience is relevant for Ukrainian regions, where the development of biotechnological clusters in the agro-industrial sphere can strengthen cooperation among agricultural universities, research institutions, food enterprises, pharmaceutical and veterinary sectors, and environmental initiatives [129, 130].

For the agro-industrial complex, biotechnology is not merely a scientific discipline but a factor of structural modernization. It changes the nature of production by increasing biological controllability, precision, safety, and ecological compatibility. Within cluster systems, it becomes a source of innovation, new business models, higher-quality products, and deeper processing. Therefore, biotechnology should be considered one of the fundamental pillars of contemporary agro-industrial clusters [133, 135].

5.2. Biotechnology as a Strategic Component of Agro-Industrial Cluster Systems

If biotechnology forms the biological and processing logic of innovation in the agro-industrial complex, electrical engineering provides the infrastructural and technological basis that makes such innovation operationally possible. Electrical engineering in modern agro-industrial systems includes power supply, energy conversion, electric drives, automation, control systems, digital monitoring, power electronics, renewable generation interfaces, and energy storage solutions [138, 139, 140].

Electrical engineering is one of the key technological foundations for the development of modern agro-industrial clusters. Its role is not limited to the supply of electricity to agricultural enterprises, but extends to the implementation of automated control systems, intelligent power distribution, energy-efficient electric drives, renewable energy sources, storage systems, and digital monitoring of technological processes.

In the agro-industrial complex, electrical engineering forms the infrastructural basis for the stable operation of farms, processing enterprises, storage facilities, irrigation systems, livestock complexes, and biotechnology production units. Without reliable electrical infrastructure, it is impossible to ensure the continuity of technological processes, maintain the required temperature and humidity conditions, automate production lines, or operate modern diagnostic and control equipment [138, 139].

In practical terms, no technologically advanced agro-industrial enterprise can function effectively without reliable electrical infrastructure. Irrigation systems depend on pumps and control devices; grain storage facilities rely on ventilation, drying, and monitoring systems; livestock complexes require lighting, feeding drives, climate-control systems, and sanitary equipment; food-processing enterprises use electric heating, cooling, pumping, mixing, dosing, and packaging systems. In all these areas, electrical engineering ensures continuity of production, compliance with technological regimes, reduction of losses, and the possibility of automation [138].

The integration of electrical engineering into cluster systems significantly increases the competitiveness of agro-industrial production. Such integration ensures a reduction in energy costs, improvement in process controllability, increase in equipment reliability, enhancement of environmental safety, and adaptation of production systems to modern requirements of sustainable development [129, 130]. In cluster environments, electrical engineering also facilitates the standardization of technological solutions, service cooperation, maintenance infrastructure, and digital interoperability among participants.

A particularly important direction is the use of energy-efficient electric drives and intelligent control systems. In agriculture and processing, many operations are performed by motors and electromechanical systems whose efficiency directly affects production costs. The transition to modern drives, power converters, automated regulation, and sensor-based control allows enterprises to optimize load schedules, reduce unnecessary energy consumption, minimize mechanical wear, and improve technological accuracy. When such solutions are disseminated within cluster systems, the cumulative effect for the region becomes much greater than at the level of individual firms.

The role of electrical engineering is further strengthened by the growth of decentralized energy systems. Agro-industrial enterprises are increasingly interested in local generation, hybrid systems, and flexible energy management because centralized power supply may be insufficiently stable or economically burdensome. Solar generation, wind energy, bioenergy installations, battery storage, and local microgrids create new opportunities for agricultural and processing enterprises, particularly in rural areas. The development of energy clusters and flexible energy hubs in Europe confirms the importance of such integrated solutions in enhancing resilience, decarbonization, and economic efficiency [138, 139].

Another important function of electrical engineering in the agro-industrial complex is digitalization. Modern electrical and automation systems serve not only as power infrastructure but also as channels of information collection and control. Intelligent sensors, SCADA elements, programmable logic controllers, metering devices, and digital communication systems create the basis for real-time management of technological processes, energy consumption, environmental parameters, and equipment condition. This makes electrical engineering an essential component of precision agriculture, precision processing, and data-driven management in cluster systems.

Thus, electrical engineering should be regarded not as an auxiliary service sector but as a system-forming factor in the development of innovative agro-industrial clusters. It connects energy supply, automation, infrastructure, and digital intelligence into a common technological framework that supports both agricultural production and biotechnological processing .

5.3. Electrical Engineering as the Infrastructural and Technological Basis of Agro-Industrial Clusters

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5.4. Synergy of Biotechnology and Electrical Engineering in the Agro-Industrial Complex

The most promising trajectory of agro-industrial modernization lies in the convergence of biotechnology and electrical engineering. Separately, each of these directions creates important technological advantages. Together, they form an integrated innovation platform capable of transforming raw materials, energy, biological processes, infrastructure, and information into a coherent production system [138,141].

The synergy between biotechnology and electrical engineering is especially visible in bioenergy systems. Organic waste from agriculture, livestock production, and food processing can be converted into biogas, biomethane, thermal energy, electricity, and biofertilizers. In such systems, biotechnology ensures the biological conversion of substrates through fermentation and decomposition processes, while electrical engineering provides mixing, pumping, temperature control, instrumentation, process automation, power conversion, protection, synchronization, and distribution of generated energy [139].

This interaction is equally important in livestock and poultry production. Animal productivity, sanitary safety, feed efficiency, and product quality increasingly depend on automated microclimate systems, controlled feeding, monitoring of environmental and physiological parameters, and reliable operation of electromechanical equipment. Here biotechnology is related to feed conversion, microbiological quality, metabolic processes, and veterinary-biological requirements, while electrical engineering ensures the technical execution of these processes through ventilation, heating, lighting, pumping, refrigeration, sensor systems, and intelligent control [142].

In aquaculture and related biological production systems, biotechnology and electrical engineering are also inseparable. Water quality control, aeration, circulation, lighting, feeding automation, temperature regulation, and monitoring of biological productivity depend on integrated electrotechnical solutions. At the same time, the biological efficiency of such systems is determined by species characteristics, feed technologies, microbiological conditions, and ecological management. Consequently, cluster-based development in aquaculture and fish processing requires both biotechnological knowledge and advanced electrical-engineering support.

Food processing provides another important field of convergence. Fermentation, enzymatic treatment, drying, cooling, pumping, sterilization, dosing, and packaging are typical operations where the technological objective is biological or biochemical transformation, but the operational implementation relies on electrical energy and electromechanical systems. The quality and repeatability of such processes increasingly depend on automated regulation of temperature, humidity, pressure, flow rates, residence times, and hygienic conditions. Thus, electrical engineering ensures controllability and reproducibility, while biotechnology ensures the intended transformation of raw materials into higher-value products [135].

In scientific and innovation terms, the convergence of biotechnology and electrical engineering creates new opportunities for interdisciplinary product development. Advanced materials and functional polymers for biological and medical applications, biosensors, monitoring devices, and smart bioprocessing equipment are examples of technological domains where the boundaries between biological, chemical, and electrical-engineering knowledge are increasingly blurred [141]. This is especially relevant for university-based innovation ecosystems and cluster environments, where interdisciplinary cooperation can accelerate the transfer of research results into industrial application [143].

From the perspective of cluster theory, the synergy of biotechnology and electrical engineering increases the density of internal linkages, expands the spectrum of specialization, and strengthens the innovative capacity of the region. Agricultural producers, processing plants, electrical-equipment suppliers, automation companies, biotechnology laboratories, design bureaus, startup teams, and educational institutions can create joint value chains that are more stable and diversified than isolated sectoral structures [125, 126, 129, 138]. Such diversification is particularly important under conditions of market volatility and technological change.

Therefore, the development of agro-industrial clusters should be based not on narrow sectoral specialization alone but on the integration of complementary technological domains. Biotechnology and electrical engineering together provide the biological efficiency, technical controllability, environmental sustainability, and innovation potential required for the long-term competitiveness of the agro-industrial complex.

5.5. Organizational, Educational, and Institutional Mechanisms for the Development of Biotechnology and Electrical Engineering Clusters

The effective development of clusters in the agro-industrial complex depends not only on technologies but also on institutional design, organizational coordination, and human capital. Cluster structures require mechanisms of communication, strategic planning, internal cooperation, competence distribution, and trust-building among participants. This is especially important for interdisciplinary clusters, where enterprises and institutions may operate in very different professional logics—agricultural, engineering, biotechnological, educational, financial, and regulatory [126, 128, 129].

An important condition for successful cluster development is the presence of coordinating structures capable of integrating the interests of participants and ensuring continuity of joint activity. These structures may take the form of associations, development agencies, cluster offices, competence centers, technology parks, or self-regulatory bodies. Their functions include strategic coordination, identification of common projects, support for innovation transfer, access to financing, organization of training, dissemination of best practices, and representation of the cluster in interaction with public authorities and international partners [130].

The Ukrainian discourse on cluster development also emphasizes that clusters should be seen as an instrument for strengthening regional competitiveness, improving business cooperation, and forming new production systems [131]. For agro-industrial clusters, this requires systematic policy support, including facilitation of cooperation among small and medium enterprises, support for innovation infrastructure, improved access to investment, and targeted stimulation of technological modernization. The formation of biotechnology and electrical-engineering clusters in the agro-industrial complex therefore must be embedded in broader regional development strategies [129].

Education and research institutions play a special role in cluster systems. They are not only suppliers of human resources but also producers of knowledge, initiators of innovation, partners in applied research, and platforms for interdisciplinary communication. Studies on educational and knowledge clusters show that universities can become core institutions of cluster development when they actively interact with industry, participate in technology transfer, support entrepreneurial activity, and adapt curricula to the needs of regional specialization [143,144]. This logic is highly relevant for agro-industrial clusters where electrical engineering, biotechnology, automation, ecology, and agrarian sciences intersect.

For regions with agrarian specialization, the participation of universities and scientific centers is essential for training engineers, biotechnologists, energy specialists, technologists, and managers capable of operating in integrated production environments. The cluster approach in education supports the alignment of competencies with the needs of industry, the creation of interdisciplinary training modules, and the development of practice-oriented innovation ecosystems [143, 144]. In this sense, educational clusters and production clusters should not be treated as separate phenomena; rather, they are interconnected layers of the same regional innovation system [128].

Human capital is a particularly important issue because the integration of biotechnology and electrical engineering requires specialists with broader systemic thinking. Traditional narrow training is often insufficient for contemporary agro-industrial challenges. Engineers must understand biological and environmental constraints; biotechnologists must understand process automation and infrastructure; managers must understand value chains, innovation economics, and sustainability standards. Therefore, cluster development should involve not only industrial cooperation but also the modernization of educational content, research agendas, and lifelong learning systems [143, 144].

Institutional sustainability also depends on the quality of legal and policy frameworks. International and European documents on cluster policy show that successful clusters typically emerge where policy support is smart rather than purely administrative: it stimulates cooperation, competence accumulation, export orientation, digital transformation, and innovation networking instead of imposing rigid centralized models. For Ukraine, this means that cluster policy in the agro-industrial sector should create favorable conditions for local initiative, institutional trust, cross-sectoral partnerships, and access to modern technologies.

Thus, organizational, educational, and institutional mechanisms are not secondary supplements to technological development. They are the very environment within which biotechnology and electrical engineering can be transformed from isolated competences into a functioning agro-industrial cluster ecosystem [128].

5.6. Ukrainian Experience and Prospects for the Formation of Biotechnology and Electrical Engineering Clusters in the Agro-Industrial Complex

Ukraine already has important preconditions for the development of interdisciplinary agro-industrial clusters. These include strong agricultural specialization of many regions, a network of agrarian and technical universities, significant scientific potential, developed food-processing sectors, and increasing interest in renewable energy, technological modernization, and regional innovation ecosystems [130, 131, 143, 144]. At the same time, the practical implementation of cluster models remains uneven and requires stronger institutional consolidation.

The available Ukrainian experience of cluster development confirms both the potential and the challenges of this approach. Analytical works on Ukrainian cluster structures, regional initiatives, and national cluster-development concepts indicate that clusterization can support economic renewal, cooperation, and regional competitiveness, but it requires better coordination, more active policy instruments, and higher readiness of enterprises for partnership-based development. For the agro-industrial complex, this is particularly important because the sector is often dominated by fragmented value chains and uneven technological levels [132].

Agricultural clustering in Ukraine has already been discussed in relation to agro-processing, meat production, feed systems, and regional specialization. Such studies show that the cluster approach can improve the interaction of raw-material producers, processors, service structures, and supporting institutions. At the same time, the next stage of cluster evolution should move beyond traditional product specialization and include innovation-oriented integration of biotechnology and electrical engineering [142].

This is especially relevant for livestock, meat-processing, and feed-production systems. Contemporary studies in animal production and feed technologies show the importance of biological quality, feed composition, product characteristics, and technological control. When these sectors are connected with modern electrical infrastructure, refrigeration, automated feeding, ventilation, processing equipment, and energy-efficient systems, they can become the basis of high-value regional clusters combining biological and engineering specialization [132, 135].

The same logic applies to crop production and raw-material processing. Agronomic research on productivity and cultivation technologies demonstrates the importance of scientifically grounded management of biological factors. However, the competitiveness of crop-based systems today also depends on drying technologies, storage, ventilation, sorting, irrigation, precision input application, and data-based monitoring—all of which require modern electrical-engineering solutions. Therefore, future crop-oriented clusters should be designed as integrated biotechnological and electrotechnical systems rather than as simple commodity chains.

Aquaculture and related biological sectors also provide opportunities for cluster formation. The development of fish production and processing is closely linked with water-quality monitoring, feeding systems, aeration, pumping, temperature management, and quality control. In this case, cluster formation can integrate biological production, technical infrastructure, feed supply, scientific support, environmental control, and processing.

The European and international experience of cluster development further supports the idea that modern clusters grow stronger when they unite advanced technologies, research capacities, and sustainability goals. Energy clusters in Germany, for example, show the role of innovation networks in tracking cleantech development and enabling technological transformation. Methodological works on cluster-based energy systems and flexible meso-energy hubs suggest that distributed, intelligent, and adaptive infrastructures are increasingly important for future production systems. These lessons are relevant for Ukrainian agro-industrial regions, especially where local generation, energy resilience, and decentralized solutions are strategically important [128, 129].

In practical terms, promising directions for the formation of biotechnology and electrical engineering clusters in the agro-industrial complex of Ukraine include several interrelated lines.

First, there is strong potential for bioenergy-oriented agro-industrial clusters**,** where crop residues, livestock waste, and food-processing by-products are used as feedstock for biogas and related energy systems. Such clusters can combine farms, livestock enterprises, engineering companies, energy operators, universities, and environmental services [138, 139].

Second, there is a basis for processing clusters with integrated biotechnology and automation**,** especially in dairy, meat, feed, fermentation, and food-preservation industries. In such systems, product quality and safety depend equally on biological technologies and precise electrical-engineering control.

Third, there is room for smart agricultural infrastructure clusters built around irrigation, storage, climate control, controlled-environment systems, precision farming, and distributed power supply. These models are especially important for regions facing resource constraints and the need for higher productivity per unit of resource input.

Fourth, Ukrainian regions can develop educational and innovation clusters in which agrarian universities, technical universities, laboratories, startups, and enterprises jointly form competence centers focused on biotechnology, electrical engineering, automation, energy efficiency, and agro-processing. Such structures would support both staffing and commercialization of applied research.

Fifth, there is a strategic need for regional platforms of cluster coordination**,** capable of integrating local authorities, business associations, scientific institutions, and investors around common agro-industrial modernization goals. Without such coordination, many promising projects remain fragmented and do not scale to the regional level.

Despite these opportunities, several barriers must also be acknowledged. Among them are insufficient institutional trust among potential participants, limited access to long-term financing, weak technology-transfer mechanisms, fragmentation of small producers, uneven innovation capacity of enterprises, and the lack of systemic interdisciplinary training. Overcoming these barriers requires targeted public policy, stronger regional leadership, and practical demonstration projects capable of proving the economic viability of cluster cooperation.

In strategic terms, the formation of biotechnology and electrical engineering clusters in the agro-industrial complex can become one of the most effective pathways for Ukraine's rural modernization. Such clusters are capable of increasing value added, strengthening food and energy security, reducing technological and energy losses, stimulating local innovation, and creating new jobs in rural and semi-rural regions. They also correspond to the broader goals of sustainable development, because they combine economic productivity with environmental rationality and knowledge-based growth.

Conclusions to Chapter V

The conducted analysis allows concluding that the modern agro-industrial complex should be understood as a multidisciplinary production and innovation system in which biological, engineering, organizational, and energy-related components are increasingly interconnected. Under such conditions, the cluster approach serves as an effective framework for uniting enterprises, research institutions, educational organizations, and infrastructure actors into territorially embedded systems of sustainable development.

Biotechnology performs a strategic role in the agro-industrial complex by increasing biological efficiency, improving product quality and safety, supporting waste utilization, enabling bioenergy conversion, and expanding opportunities for deeper processing of agricultural raw materials. Its value in cluster systems lies in its ability to generate new value chains and innovation trajectories.

Electrical engineering provides the infrastructural and technological basis for agro-industrial modernization. Through power supply, automation, energy-efficient drives, digital monitoring, renewable generation interfaces, and intelligent control systems, it ensures the stable and efficient functioning of agricultural, processing, and biotechnological processes. In contemporary conditions, electrical engineering should be considered a system-forming component of regional agro-industrial development.

The interaction of biotechnology and electrical engineering creates a powerful synergistic effect. Together they enable controlled biological processes, reliable energy and automation infrastructure, improved environmental performance, and higher value added of production. Their integration is especially important for bioenergy systems, food processing, livestock technologies, aquaculture, precision agriculture, and circular resource-use models.

The successful development of such clusters requires not only technology but also institutional support, educational integration, research participation, and effective coordination mechanisms. Universities, laboratories, engineering firms, agricultural enterprises, and public institutions must be viewed as co-creators of cluster ecosystems rather than isolated actors.

For Ukraine, the formation of biotechnology and electrical engineering clusters in the agro-industrial complex represents a strategically promising direction of modernization. It can strengthen the competitiveness of regions, expand innovation potential, improve energy resilience, and support sustainable economic development of rural territories. Therefore, the cluster integration of biotechnology and electrical engineering should be treated as one of the key priorities of long-term agro-industrial policy and regional innovation strategy.

CONCLUSIONS

The analysis of methodological approaches to the development of national clustering systems in a number of foreign countries and the development of the industrial cluster system in Ukraine, carried out during the implementation of this work, allows us to draw the following general conclusions:

1. All existing approaches to clustering reflect the attempts of countries over the past decades to find a single approach to effective economic development on an international scale. Mechanical transfer of Western experience to Ukrainian conditions is impossible for many reasons.

(For example, business incubation programs offer unsustainable or unworkable models; attempts to blindly copy networks and develop business clusters based on the Northern Italian model have led to more than modest results in many developing countries; the UK Local Enterprise Agency model, which was transferred to a number of countries with economies in transition, has not yet gained stability on its "native environment").

2. From the analysis of methodological approaches to the development of national cluster systems, it follows that there is no simgle solution to the problem of the cluster approach.

3. The corresponding directions of state policy in implementing a particular aspect of clustering can be formulated as follows:

It is shown that a cluster, as an association of organizations of different forms of ownership in order to obtain the greatest profit and competitive advantages, can develop within the framework of the legislation in force in Ukraine.

5. Granting a certain group of legal entities that are part of a cluster, subcluster, and especially a megacluster, is not objectively necessary.

6. Cluster-type structures in Ukraine can be formed in two ways: as a result of the implementation of state policy on the restructuring of large structures or on the initiative of commercial organizations in which the state does not participate.

7. The absence of need for legislative regulation of issues of identification and registration of clusters is also confirmed by the practice of applying the Law “On Financial and Industrial Groups”, which shows that in Ukraine there are a large number of economically successful financial and industrial groups that do not have state registration.

8. Based on world practice, the following main forms of stimulating small innovative enterprises can be distinguished, including the ones existing within the framework of cluster industrial systems:

• direct financing (subsidies, loans), which reach 50% of the costs of creating new products and technologies;

• provision of loans, including without interest payments;

• targeted subsidies for R&D;

• creation of funds for the introduction of innovations, taking into account possible commercial risk;

• free loans, reaching 50% of the costs of introducing new technologies;

• use of the system of taxation of entrepreneurs without creating a legal entity; • deferral of payment of duties or exemption from them, if the invention concerns energy saving.

• free administration of records upon applications of individual inventors, free services of patent attorneys, exemption from payment of duties.

The last two items of clause 8 require the development of additional by-laws within the framework of current legislation.

9. Financing of programs for the formation of cluster structures is possible within the framework of the Small Business Support Fund, state and regional projects in the field of small business in the form of organizing consultations on taxation issues and optimal application of the norms of current legislation.

10. The competitiveness of a cluster that develops in a specific business environment, taking into account the economic, geographical and social components of this environment, forms the model and criteria of the cluster structure.

11. The following 7 aspects were selected to conduct a structural and quantitative comparison of the international and national classification of clusters and their comparative analysis:

1) geographic: building geographical clusters of economic activity, ranging from purely local to truly global (geographical clustering of economic activity);

2) horizontal: the classic division of sectors located at certain levels of the conglomerate (for example, as in the classification of industries). Several industries/sectors can be part of one larger cluster;

3) vertical: clusters can have adjacent stages of the production process (similar to the concepts of value systems, supplier networks). In this vertical aspect, it is important who among the network participants is the initiator of innovative activity;

4) lateral: different sectors that may have common capabilities and are capable of generating savings through scale effect, which leads to new combinations (for example, the multimedia cluster that is currently being formed);

5) technological: a set of industries that use the same basic technology (such as a biotechnology cluster);

6) focal: a cluster of companies centered around a single center i.e. a company, a multi-generational family, a research institute, or an educational institution;

7) network quality: here the question is not whether companies actually cooperate, but how well they do it. A network is not always an idyllic gathering of companies where all kinds of innovation are automatically stimulated. It happens that networks suppress innovation processes and encourage defensive behavior. Relationships with suppliers can stimulate innovation processes, but they can be used to shift costs to partners and limit them financially. In this case networks are neither stable nor stimulating.

The above criteria allow for a full or partial (depending on the amount of information) analysis of similarities and differences in the construction of the considered national clusters.

12. A classification and coding system for cluster structures has been developed based on a 3-criteria analysis, which includes territorial, process and economic criteria.

13. It has been established that the quality of management activities in the cluster must meet uniform standardized requirements.

14. Four main strategies have been identified that can be used in Ukraine to increase the competitiveness of the supply system:

- increasing the efficiency of the existing supplier system;
- attracting suppliers from other countries and other regions;
- separating suppliers from the core business;
- targeted incubation of new businesses.

15. Based on the use of statistical analysis methods from various economic indicators and a system of expert surveys and expert assessments, enterprises of the leather and textile industries were identified as pilot industries for testing the matrix for building industrial clusters.

16. It is shown that the supporting factors for the development of cluster structures in Ukraine are:

- Participation of administration and business in the development of industry clusters;
- Availability of engineering and scientific personnel;
- Availability of opportunities for R&D;.
- The existence of certain traditions in Ukraine in the field of production cooperation;
- The development of technological infrastructure in Ukraine.

At the same time, the restraining factors are:

- Low quality of their products and services;
- Low competitiveness;
- Low efficiency of the supply management system.

17. It has been established that the inadequacy of educational and research programs in the field of vocational training and preparation for personnel qualification requirements negatively affects the development of industrial clusters.

APPENDIX 1. LIST OF CLUSTER ORGANIZATIONS REGISTERED IN UKRAINE

No.	Name	Region	Areas of Activity	Website / Contacts
1	Kherson Agro-Cluster "EA.F.Tech"	Kherson	Agro-industrial sector	http://ea-f-tech.com/
2	Ukrainian Aerospace Cluster	Dnipro	Aerospace engineering and production of defense and heavy equipment technologies	www.uac.in.ua
3	Dnipro Space Cluster	Dnipro	Production of rocket and space technology and defense technologies	https://www.dniprospacecluster.com/
4	Kharkiv IT Cluster	Kharkiv	IT technologies	https://it-kharkiv.com/
5	Agro Food Cluster	Kharkiv	Production and processing of agricultural products	http://agrofoodcluster-kh.com/
6	Sumy IT Cluster	Sumy	IT technologies	In the process of creation
7	Konotop IT Cluster	Konotop	IT technologies	https://itcluster.konotop.info/
8	Chernihiv IT Cluster	Chernihiv	IT technologies	https://chernihiv.it/
9	Innovation Cluster "RInnoHU	Mykolaiv	Development of startup ecosystems	http://rinnohub.org/

No.	Name	Region	Areas of Activity	Website / Contacts
	B”		and innovative entrepreneurship	
10	Prykarpattia Eco-Energy Efficient Cluster	Ivano-Frankivsk	Alternative energy and environmental protection	https://peec.org.ua/
11	Publishing and Printing Cluster	Lviv	Printing and publishing	https://ppcluster.com.ua/
12	Ternopil IT Cluster	Ternopil	IT technologies	https://itcluster.te.ua/
No.	Name	Region	Areas of Activity	Website / Contacts
13	Energy Cluster “Innovative Energy”	Lutsk	Energy technologies	http://inenergy.org.ua/
14	Kyiv IT Cluster	Kyiv	IT technologies	https://itcluster.kiev.ua/en/
15	Association of Industrial Automation Enterprises of Ukraine	Kyiv	Engineering, Automation, Mechanical Engineering	https://appau.org.ua/
16	Zaporizhzhia IT Cluster	Zaporizhzhia	Information and communication technologies	
17	Vinnytsia IT Cluster	Vinnytsia	IT technologies	https://www.it-vn.org.ua/
18	Mariupol IT Cluster	Mariupol	IT technologies	http://mariupol.space/
19	Mykolaiv IT Cluster	Mykolaiv	IT technologies	http://www.itcluster.mk.ua/
20	Cherkasy IT Cluster	Cherkasy	IT technologies	https://www.itcluster.ck.ua/

No.	Name	Region	Areas of Activity	Website / Contacts
21	Creative Industries Cluster	Kherson	Creative industries	https://www.facebook.com/creativeindustriescluster/
22	Ukrainian Fashion Cluster	Lviv	Fashion industry	http://ufcluster.com/
23	Kharkiv Light Industry and Design Cluster	Kharkiv	Light industry and design	http://kharkivfashioncluster.com.ua/
24	Khmelnytskyi Energy Cluster	Khmelnytskyi	Renewable energy sources (RES) and energy efficiency	https://www.energycluster.net/
25	Light Industry Cluster	Chernihiv	Light industry	------
26	Podillya Women Apparel Cluster	Khmelnytskyi	Light industry	http://pwgroup.info/en.html
27	Cluster Podillya Wedding Group	Khmelnytskyi	Wedding industry	http://pwgroup.info/en.html
28	Lviv Medical Cluster	Lviv	Medical tourism	https://medicaltourismlviv.com
29	Ukrainian Furniture Association	Kyiv	Furniture industry	http://uafm.com.ua

No.	Name	Region	Areas of Activity	Website / Contacts
30	Ukrainian Organic Cluster	Kyiv – Kherson	Agro sector – agriculture	https://organiccluster.com.ua/

LIST OF SOURCES USED

1 EUROPEAN COMMISSION Financial programming 2026-2027 Figures by MFF heading, cluster, programme, section, budget line and nomenclature changes Chapter 01 01 — support administrative expenditure of the ‘research and innovation’ cluster Luxembourg: Publications Office of the European Union, 2024. 557 p.

2 Юрчак Олександр, Крікунов Михайло, Демчук Олег та інш. Національна програма кластерного розвитку до 2027 Концепція, Орієнтири розвитку, Рекомендації. 2023. 74с.

3 Roelandt Theo, Pim den Hertog, Jacobs Dany, "Nederlandse clusters in beeld"// ESB, 1997.-V.12,N2.-P. 124-128.

4 Marshall, Alfred. Industry and Trade. 3ded. London: Macmillan, 1920

5 Czamanski S., and L. A. Ablas. Identification of industrial clusters and complexes: a comparison of methods and findings //Urban Studies.-1979.-V.16.-P.61-80

6 Porter, M. (1990). The competitive advantage of nations. Free Press.

7 Porter, M. (2003). The economic performance of regions. RegionalStudies, 37(6–7), 549–578. https://doi.org/10.1080/0034340032000108688

8 Jacobs, D., A-P De Man Clusters. Industrial Policy and Firm Strategy: A Menu Approach // Technology Analysis & Strategic Management.-1996.-V.-8, N 4.- P.425-437.

9 van der Linde, Claas. "The Demography of Clusters - Findings from the Cluster Meta-Study." In: Brocker, J., D., Dohse and R. Soltwedel (eds.) Innovation Clusters and Interregional Competition. Berlin, Heidelberg, New York: I 3pringer,-Verlag, Berlin, Heidelberg, New York 2003, p. 130-149.

10 Ketels, C. & Protsiv, S. (2021): Cluster presence and economic performance: a new look based on European data, Regional Studies, 55:2, 208-220, DOI: 10.1080/00343404.2020.1792435. Available at: https://www.tandfonline.com/doi/full/10.1080/00343404.2020.1792435 (last accessed 15.11.2022)

11 Roelandt, T.J.A., P. den Hertog 'Cluster Analysis and Cluster-based Policy in OECD Countries: a synthesis', in: Boosting innovation; the cluster approach, -1999.-P. 413-427.

12 Rosenfeld, S. Industrial-Strength Strategies, Regional Business Clusters, and Public Policy. Washington D.C.: The Aspen Institute Rural Economic Policy Program, 1995.

13 Roelandt Th.J.A., Gilsing V.A. J. van Sinderen New Policies for the New Economy Cluster-based Innovation Policy: International Experiences Dutch Ministry of Economic Affairs/OCFEB Paper presented at the 4th Annual EUNIP Conference Tilburg, The Netherlands 7-9 December 2000.-P.1-25

14 Rosenfeld, S. A.. Overachievers: Business Clusters that Work. Chapel Hill, NC: Regional Technology Strategies, Inc. 1995.

15 Harrison, B. "Industrial Districts: Old Wine in New Bottles?" // Regional Studies .-1992.-V.26.-P.469-483.

16 Roelandt, T.J.A., P. den Hertog 'Cluster Analysis and Cluster-based Policy in OECD Countries: a synthesis', in: Boosting innovation; the cluster approach, -1999.-P. 413-427.

17 Christian Ketelsa and Sergiy Protsiv Cluster presence and economic performance: a new look basedon European data Regional studies 2021, VOL. 55, NO. 2, 208–220https://doi.org/10.1080/00343404.2020.1792435

18 ECCP (2021): European Cluster Panorama Report 2021. Available under: https://clustercollaboration.eu/sites/default/files/2021-12/European_Cluster_Panorama_Report_0.pdf (last accessed 16.11.2022)

European Cluster Panorama 2021 Leveraging clusters for resilient, green and digital regional economies An initiative of the European Union Authors: Susana Franco, Orkestra Asier Murciego, Orkestra Juan Pablo Salado, Orkestra Eduardo Sisti, Orkestra James Wilson, Orkestra

19 Rubel Th., Palladino S. Nurturing Entrepreneurial Growth in States Economies. Wash.

20 A Governor’s Guide to Building State Science and Technology Capacity ISBN: 1-55877-357-6 Copyright 2002 by the National Governors Association, 444 North Capitol Street, Washington, D.C. 20001-1512. at: www.nga.org.

21 Емельянов С.В. Стратегия развития науки и технологии в США в XXI веке// Проблемы теории и практики управления.-2002.-№1.-С.3

22 Porter M., Opstal D. U.S. Competitiveness 2001: Strength, Vulnerabilities and Long-Term Priorities. Council of Competitiveness. 2001, p.ii.

23 3 International Wine Business Research Conference, Montpellier, 6-7-8 July 2006 CLUSTERS OF GRAPES AND WINE by Rolf A.E. Mueller Department of Agricultural Economics, University at Kiel, Germany and Daniel A. Sumner University of California Agricultural Issues Center and Department of Agricultural and Resource Economics, University of California, Davis

24 Roger R. Stough, Peter Arena, Raj Kulkarni, Jim Riggle Mark Trice Industrial Cluster Analysis of the Virginia Economy // The Mason Enterprise Center, MS 2C9 The Institute of Public Policy George Mason University, December 16, 1999. 82.P.

25 Rosenfeld, Stuart A. Bringing Business Clusters into the Mainstream of Economic Development // *European Planning Studies* 1997.-V.5,N1.-P. 3-23.

26 Glasmeier, Amy K., and Bennett Harrison. Response: Why Business Alone Won’t Redevelop the Inner City: A Friendly Critique of Michael Porter’s Approach to Urban Revitalization // *Economic Development Quarterly*.- 1997.-V.11,N1.-P.28-38.

27 Bergman, E., E.Feser, and S.Sweeny. *Targeting North Carolina Manufacturing: Understanding the State’s Economy through Industrial Cluster Analysis*.Chapel Hill, NC: UNC Institute for Economic Development. 1996.

28 Bosworth, Brian and Daniel Broun. Connect the Dots: Using Cluster-Based Strategies to Create Urban Employment//*Firm Connections*.- 1996.-V4,N2.-P.1-6.

29 Held, J.R. Clusters as an Economic Development Tool: Beyond the Pitfalls//*Economic Development Quarterly*.- 1996.-V.10.-P. 249-261.

30 Stough, Roger R., Robert J. Stimson and Brian Roberts, forthcoming. "Merging Quantitative and Expert Response Data in Setting Regional Economic Development Policy: Methodology and Application." *Applied Geographic Studies*, New York, Wiley.

31 Feser Edward, Goldstein Harvey, Renski Henry, Renault Catherine Regional Technology Assets and Opportunities:The Geographic Clustering of High-Tech Industry, Science and Innovation in Appalachia//Office of Economic Development University of North Carolina at Chapel Hill August 2002.-141 P.

32 Becker Karen, Feser Edward Applying Cluster Analysis to North Carolina's Regions ,Carolinas Economic Development Partnership Region // Institute for Economic Development University of North Carolina at Chapel Hill February 1997.-72 P.

33 Becker Karen, Feser Edward Applying Cluster Analysis to North Carolina's Regions □□□Northeastern Economic Development Partnership Region// Institute for Economic Development University of North Carolina at Chapel Hill January 1997.-60 p.

34 Feser Edward J. Koo Kyojun Renski Henry C. Sweeney Stewart H. Incorporating Spatial Analysis in Applied Industry Cluster Studies // Economic Development Quarterly.-2001.- March.-44 p.

35 The emerging optics cluster of Arizona Prepared for Arizona Department of Commerce Governor's Strategic Partnership for Economic Development and Pima& Santa Cruz Counties School to Work Partnership, Inc. 2000. 41 P.

36 The Changing Face of the Software cluster in Arizona Prepared for Arizona Department of Commerce Governor's Strategic Partnership for Economic Development in conjunction with Morrison Institute for Public Policy, August 1999. 44.P

37 Nations J.D., Phillips K. The Mining and Minerals Cluster in Arizone: An analysis for the Strategic Economic Development Vision for the Arizona-Sonora Region.- November 24, 1997.-117 P.

38 Письмак В. НОВЫЕ ФОРМЫ ОРГАНИЗАЦИИ ИННОВАЦИОННОГО ПРОЦЕССА // Экономист». 2003.-№ 9.-С.53-65.

39 Internet Cluster Analysis, 1999; A.T.Kearney analysis. www.jointventure.org. cluster/pdf, cluster00.pdf

40 Joint ventures internet cluster (analysis 2000) A publication of Joint ventures: Silicon Valley Network. 2000. P. 28

41 OECD Economic Surveys: Mexico 2019

OECD'**s** periodic surveys of the **Mexican** economy. Each edition surveys the major challenges faced by the country, evaluates the short-term outlook, and

makes specific policy recommendations. Special chapters take a more detailed look at specific challenges.

42 Ramos-Vaca Chifiuahua Siglo XXI Presentation Slides for World Bank Competitiveness Seminar. Washington (DC , September 30 1996

43 Nadvi Khalid Industrial Clusters and Networks: Case Studies of SME Growth and Innovation UNIDO Paper commissioned by the Small and Medium Industries Branch, October 1995

44 Rabellotti Roberta Recovery of a Mexican Cluster[1] Devaluation Bonanza or Collective Efficiency" World Development, volume 27. no 9. p 1571-1585 1999

45 Rabellotti, Roberta Is There an "Industrial District Model"' Footwear Districts in Italy and Mexico Compared. World Development volume 23 no 1 p 29-41 1995

46 Rabellotti. Roberta and Hubert Schmitz. The Internal Heterogeneity of Industrial Districts in Italy. Brazil and Mexico Regional Studies volume 33, no 2, p. 97-108,1999

47 Flowcs- Williams, I. "Stimulating Local Clusters. " Paper prepared for the World Bank Workshop for Practitioners in Cluster Formation, Chihuahua, Mexico, 17-20 November 1997.

48 Gregory M Spencer, M.Sc.Pl., Ph.D. Cluster Atlas of Canada Prepared by: Gregory M Spencer, M.Sc.Pl., Ph.D. Manager of Local IDEAs Munk School of Global Affairs University of Toronto greg.spencer@utoronto.ca A data profile of resource, manufacturing, and service clusters in Canadian provinces using data from the 2011 Census and National Household Survey Manager of Local IDEAs Munk School of Global Affairs University of Toronto

49 Home - The Cluster Centre

50 Hernandéz, J.M., Pezzi, A.,Soy, A. (2010): Cluster and Competitiveness: the case of Catalonia (1993-2010), Papers d'Economia Industrial, n. 31 Barcelona, Available under: (https://empresa.gencat.cat/web/.content/001-departament/04-serveis/01-publicacions/Empresa_Industria/papers_d_economia_industrial/documents/arxius/31_angles.p df (last accessed 01.12.2022)

51 Strong cluster policy in Catalonia

52 Ahedo, M. (2006): Business Systems and Cluster Policies in the Basque Country and Catalonia (1990–2004), European Urban and Regional Studies, 13:1, 25-39. Available at: https://www.researchgate.net/publication/249668868_Business_Systems_and_Cluster_Policie s_in_the_Basque_Country_and_Catalonia_1990-2004 (last accessed 08.11.2022).

53 Jan-Philipp Kramer (Prognos) Marie-Kristin Komendzinski (Prognos) Lennart Galdiga (Prognos) Maximilian Welford (Prognos) Fabian Schmidt (Prognos) Clusters meet Regions' event "Boosting talent as a key driver for a

future sustainable competitiveness" – the case of Catalonia The ECCP series of events "Clusters meet Regions Brussels, December 2022

54 Twenty years after the Porter Report for Portugal Vítor da Conceição Gonçalves ISEG, Lisbon School of Economics and Management, Universidade de Lisboa, Lisboa, Portugal Fernando Ribeiro Mendes ISEG – School of Economics and Management, Universidade de Lisboa, Lisboa, Portugal Idalina Dias Sardinha SOCIUS, Research Centre in Economic and Organizational Sociology, ISEG, Lisbon School of Economics and Management, Universidade de Lisboa, Lisboa, Portugal, and Ricardo Rodrigues CEGE, Centre for Management Studies, ISEG, Lisbon School of Economics and Management, Universidade de Lisboa, Lisboa, Portugal.

55 Vítor João Pereira Domingues Martinho Socioeconomic Impacts of Forest Fires upon Portugal: An Analysis for the Agricultural and Forestry Sectors *Sustainability* 2019, *11*(2), 374; https://doi.org/10.3390/su11020374

56 Martinho, Vítor João Pereira Domingues. (2016). *Forestry activity in Portugal within the context of the European Union: a cluster in agricultural economics for sustainable development. Environment, Development and Sustainability, 18(5), 1339–1397.* doi:10.1007/s10668-016-9775-x

57 Поліщук А. А., Шостя А. М., Мерзлов С. В., Усенко С. О., Леуський М. В., Кузьменко Л. М., Ільченко М. О. Сучасний стан рибництва в Україні та розвиток галузі на Полтавщині. Scientific Progress & Innovations. 2024. № 27 (1). С. 101–106. doi: 10.31210/spi2024.27.01.17

58 Концепція кластеризації економіки України (проект) // Міністерство економіки України. [Електронний ресурс]. – Режим доступу: http://www.kmu.gov.ua

59 Войнаренко М. П. Концепція «кластерів» як альтернатива командно-адміністративній системі управління /М. П. Войнаренко, Л. П. Радецька, В. Р. Філінюк// В кн. «Проблеми реформування економіки України». – К. : Логос, 1999. – С.74 – 75.

60 Підвищення конкурентоздатності економіки областей Заходу та Півдня України на основі формування нових виробничих систем (кластерів). Підсумки соціально-економічних досліджень / За ред. С. І. Соколенко. – К. : Логос, 2005. – С. 13.

61 Для чого Україні кластери: список українських кластерів, які активно ведуть свою діяльність – Ucluster

62 Industry4Ukraine. National Cluster Development Program until 2027: Concept, Development Guidelines, Recommendations, 2020.

63 Кизим Микола Олександрович, Хаустова Вікторія Євгенівна Український досвід формування кластерних структур. Проблеми економіки 2012, № 1, С.3-11.

64 Гангур, В. В., Маренич, М. М., Єремко, Л. С., Шостя, А. М., Пузир, Д. О., & Кирлиця, А. О. (2023). Вплив способів основного обробітку ґрунту на урожайність гібридів кукурудзи в умовах Лівобережного Лісостепу.

Scientific Progress & Innovations, 26(4), 19–23. https://doi.org/10.31210/spi2023.26.04.04.

65 Investigating the Uppsala Biotech Cluster Robin Teigland Göran Lindqvist Anders Malmberg Anders Waxell Investigating the Uppsala Biotech Cluster Baseline Results from the 2004 Uppsala Biotech Cluster Survey Robin Teigland Göran Lindqvist Anders Malmberg Anders Waxell CIND Research Paper 2004:1

66 ШИПОША ВАЛЕРІЙ АНАТОЛІЙОВИЧ ДИСЕРТАЦІЯ МЕХАНІЗМ УПРАВЛІННЯ РОЗВИТКОМ БІЗНЕС-ІНТЕГРОВАНИХ СТРУКТУР ПРОМИСЛОВИХ РЕГІОНІВ Спеціальність 08.00.03 – економіка та управління національним господарством Подається на здобуття наукового ступеня кандидата економічних наук

67 Пути кластеризации экономики с целью повышения конкурентоспособности Запорожской области [Электронный ресурс]. – Режим доступа: http:// http://ucluster.org

68 Кайшева Л.И., Кулик Р.А., Волкова Н.Н., Левкивский М.И., Козаченко Е.М., Сахно Т.В. Кластерный механизм управления региональным развитием и налогообложение кластерных структур. Вторая Международная периодическая научно-практической конференция «Спецпроект: анализ научных исследований» Сборник докладов. Днепропетровск. 7-11 декабря, 2005. С. 26-30.

69 Шипоша В.А. Механізм управління розвитком бізнес-інтегрованих структур промислових регіонів. – Кваліфікаційна наукова праця на правах рукопису. Дисертація на здобуття наукового ступеня кандидата економічних наук за спеціальністю 08.00.03 – економіка та управління національним господарством. – Донецький національний університет імені Василя Стуса, Вінниця; Інститут економіки промисловості НАН України, Київ, 2021.

70 Національна програма кластерного розвитку до 2027 року. Концепція. Орієнтири розвитку. Рекомендації / О. Юрчак та ін. Київ: АППАУ, Платформа Industry4Ukraine, 2020. 76 с.

71 Комісаренко Сергій Васильович — академік НАН України, в.о. академіка-секретаря Відділення біохімії, фізіології і молекулярної біології НАН України, директор Інституту біохімії ім. О.В. Палладіна НАН України Вісн. НАН України, 2023, № 5 с.41-43.

72 Ляшенко В. І., Квілінський О. С., Трушкіна Н. В. Особливості розвитку транспортно-логістичної системи Німеччини в контексті збалансованого сталого розвитку. Stages of Formation and Development of the Economy of Independent Ukraine: Collective monograph / Ed. by Doctor of Economics Sciences, Prof. Yu. Pasichnyk; Academy of Economic Science of Ukraine. Germany, Nuremberg: Verlag SWG imex GmbH, 2021. P. 183-192.

73 Ткаленко С. І., Любачівська Р. З. Особливості формування біотехнологічних кластерів ЄС: досвід для України. Проблеми економіки 2015. № 1, С.37-41.

74 Іван Демидов, проректор львівської політехніки Чому біотехнологічний кластер необхідний Львівській політехніці 14 ЧЕРВ. 2021, https://lpnu.ua/news/chomu-biotekhnolohichnyi-klaster-neobkhidnyi-lvivskii-politekhnitsi

75 Tamara Sakhno, Dmytro Ivashchenko, Anatolii Semenov, Olena Ivashchenko, and Yuriy Sakhno Clusteroluminogenic polymers: applications in biology and medicine (Review Article) Fizyka Nyzkykh Temperatur/Low Temperature Physics, 2024, Vol. 50, No. 3, pp. 276–287

76 Mahendra Singh, Denilton Luiz Darold, Marian Klobasa, Andrea Zielinski, Rainer Frietsch Keeping track of cleantech development using innovation clusters and member's website data: Evidence from leading energy clusters in Germany Energy Reports 10 (2023) 756–767

77 Limei Shen [a], Yongjun Sun [b] Performance comparisons of two system sizing approaches for net zero energy building clusters under uncertainties Energy and Buildings Volume 127, 1 September 2016, Pages 10-21 https://doi.org/10.1016/j.enbuild.2016.05.072

78 Mahdi Nozarian [a b], Amin Hajizadeh [a], Alireza Fereidunian [b] A methodological review on management of building cluster meso energy hubs in accordance with the agile framework: Exploring flexibility upward the building-cluster-city hierarchy Sustainable Energy Technologies and Assessments Volume 67, July 2024, 103834 https://doi.org/10.1016/j.seta.2024.103834

79 Семенова К.А., Сахно Т.В. Семенов А.О. Кластерний підхід в системі освіти Кластерний підхід в системі освіти // International periodic scientific journal «Modern scientific researches» Issue 12, Part 3. 2020. P.21-30. ISSN 2523-4692. DOI 10.30889/2523-4692.2020-12-03-052.

80 Волкова Н.Н., Сахно Т.В. Модернизация высшего образования: кластеры. Материалы международной научно-практической конференции «Украина –субъект европейского образовательного пространства. 24-25 мая 2005 .Киев. С.8.

81 Волкова Н.Н., Иргибаев А.К., Делия О.В., Сахно Т.В. Образовательные учреждения в кластерных структурах: теоретический анализ. Вестник Евразийского национального университета им.Л.Н.Гумилева. – 2017. - №3(118). – С.590-597.

82 Волкова Н.Н., Сахно Т.В. Промышленные кластеры (монография). Изд-во АСМИ, Полтава, 2005. – 272 с..

83 Волкова Н.Н., Сахно Т.В. Промышленные кластеры России (монография). Изд-во «Техсервис», Полтава 2008. – 532 с.

84 Culatta R. Education Innovation clusters: accelerating innovation through regional partnerships // Educause review. 2012. Vol. 47. № 6. P. 25–34.

85 Porter M. On Competition — Boston: Harvard Business School, 1998. Портер, Майкл, Э.. Конкуренция.: Пер. с англ. - М.: Издательский дом «Вильяме», 2005, стр. 256.

86 Оксенюк С. Г. Економічний кластер: поняття, сутність, структура, типи / С. Г. Оксенюк // Вісник Хмельницького національного університету. Економічні науки. - 2016. - № 2(1). - С. 182-188. - Режим доступу: http://nbuv.gov.ua/UJRN/Vchnu_ekon_2016_2(1)__36.

87 Завадська Д.В. Економічна кластеризація: сутність, проблеми та перспективи розвитку в Україні / Д.В. Завадська // Вісник соціально-економічних досліджень : зб. наук. пр. / голов. ред. М. І. Звєряков ; Одеський держ. екон. ун-т. – Одеса, 2012. – № 1 (44). – С. 187–196.

88 Волкова Н.Н., Сахно Т.В. Индустриальные кластеры США // «США # Канада».-2007.-№ 1.- С.51-68.

89 П'ятницька, Г.Т. Науково-освітні кластери: відмітні характеристики та передумови розвитку [Текст] / Г.Т. П'ятницька // Маркетинг і менеджмент інновацій. - 2016. - № 3. - С. 191-207. - Available: http://mmi.fem.sumdu.edu.ua/sites/default/files/mmi2016_3_191_207.pdf

90 Culatta R. Accelerating innovation in educational technology // Educause review. 2012. Vol. 47. № 6. P. 14–20.

91 Лисенко І. Аналіз світового досвіду взаємодії регіональних інноваційних кластерів та вищої освіти. Проблеми і перспективи економіки та управління. 2019. № 3 (19). С. 229-239.

92 Tieman R. Education clusters: universities use reforms to remove barriers // Financial Times. 2009. 16 Dec. URL: www.ft.com/cms/s/0/93558644-e90f-11de-a756-00144feab49a.

93 Bergman, Edward M., Feser Edward J. Industrial and Regional Clusters: Concepts and Comparative Applications. Web Book in Regional Science. Morganton, WV: Regional Research Institute, West Virginia University, 1999.

94 Ministry of Higher Education and Science, 2013: Strategy for Denmark's Cluster Policy, p. 11. Available at http://ufm.dk/en/publications/2013/files-2013/cluster-policy.pdf

95 Porter M.E. The Economic Performance of Regions / Michael E. Porter // Regional Studies. – August / October, 2003. – Vol. 37(6&7). – P. 549-578.

96 Lupak, N. M., Kopotun, I. M., Hamza, A. V., Albul, S. V., & Panova, S. O. (2020). Creation of clusters and tools for improving the professional competence of future educators. European Journal of Educational Research, 9(2), 709-716. https://doi.org/10.12973/eu-jer.9.2.709

97 Towards a Future Higher Education Landscape, including Process and Criteria for Designation as a Technological University and Guidelines on Regional Clusters. Dublin: Higher Education Authority. HEA 2012. 25 p. Available at: http://www.hea.ie/sites/default/files/towards_a_future_higher_education_landscape_incl_regional_clusters_and_tu- _13th_february_2012.docx. Accessed 10 March 2014..

98 Porter M., Ketelhohn N., Artiganave A., Kelly J., Krasniqi M., Gi M. T. P., Zhang L. The Massachusetts Higher Education and Knowledge Cluster: The Microeconomics of Competitiveness, USA, Massachusetts Press, 2010. 33 p. Available at: http://www.isc.hbs.edu/resources/courses/moc-course-at-

harvard/Documents/pdf/student-projects/USA_(MA)_Higher_Education_and_Knowledge_2010.pdf

99 Волкова Н.Н., Сахно Т.В. Кластерный подход в системе образования. Экономика: проблемы теории и практики. Сб.научных трудов.- 2005. Вып.206:В 4т. Том II.-Днепропетровск, ДГУ.-С.507-514.

100 Industry Cluster Profiles – Education, Philadelphia Updated on June 30, 2014 – 13 p.

http://www.philaworks.org/sites/philaworks.org/files/pdf/IndustryProfiles_Education_final.pdf

101 Temouri Y. The Cluster Scoreboard: Measuring the Performance of Local Business Clusters in the Knowledge Economy, OECD Local Economic and Employment Development (LEED) Working Papers, 2012/13, OECD Publishing. 2012, 45 p. http://dx.doi.org/10.1787/5k94ghq8p5kd-en

102 Innovation Clusters in Europe: A statistical analysis and overview of current policy support. (PRO INNO Europe initiative a) European Commission Enterprise and Industry Directorate-General, DG Enterprise and Industry report, 2013. - 63 p. Available at: http://www.central2013.eu/fileadmin/user_upload/Downloads/Tools_Resources/Cluster.pdf

103 European Commission. (2016). Smart Guide to Cluster Policy. Guidebook Series: How to support SME Policy from Structural Funds. European Commission. http://shorturl.at/ovyAR

104 Innovation Clusters in Europe: A statistical analysis and overview of current policy support. (PRO INNO Europe initiative a) European Commission Enterprise and Industry Directorate-General, DG Enterprise and Industry report, 2013. - 63 p. Available at: http://www.central2013.eu/fileadmin/user_upload/Downloads/Tools_Resources/Cluster.pdf

105Muller L., Lammer-Gamp T., Kocker G.M., Christensen T.A., Clusters are Individuals. Published by: The Danish Ministry of Science Innovation and Higher Education 2012. October. – 260 p. Available at: http://www.cluster-analysis.org/downloads/ClustersareIndividualsVolumeIIAnnex.pdf

106 Sölvell Örjan, Ketels Christian, Lindqvist Göran. Industrial specialization and regional clusters in the ten new EU member states. Paper to be presented at the Druid Summer Conference 2006 on Knowledge, innovation and competitiveness: dynamics of firms, networks, regions and institutions Copenhagen, Denmark, June 18-20, 2006 Track E: Innovative Regions and Growth. 2006. – 20 p. Available at:http://www2.druid.dk/conferences/viewpaper.php?id=572&cf=8

107 Національний класифікатор України -Класифікація видів економічної діяльності (КВЕД) ДК 009:2010- Чинний від 01.01.2012 р.

108 Ketels C., Protsiv S. Methodology and Findings Report for a Cluster Mapping of Related Sectors. European Cluster Observatory Report Center for Strategy and Competitiveness Stockholm School of Economics October 2014. – 38

p. http://ec.europa.eu/growth/smes/cluster/observatory/d1.2-cluster-mapping-report.pdf

109 Степанова М.Е., Кузнецова Е.В. Кластерный подход в образовании как форма социального партнерства при реализации ФГОС. Научные исследования в образовании 2012 № 4 - с.50-53.

110 Balalieva O.V. Technology of cluster formation in the modern system of preschool education. Science and world. International scientific journal, 2014. N9 (13), pp.107-109. http://scienceph.ru/d/413259/d/science-and-world--9-(13)-september.pdf.

111 Попова Л. В., Яковлева Т. А Организационно-педагогические условия вхождения школы в сетевой проект образовательной кластерной платформы «Мега-Класс» // Вестник Красноярского государственного педагогического университета им. В.П. Астафьева Номер: 1 (51) Год: 2020 Страницы: 15-28

112 Топор А.В. Особенности экологической подготовки будущих учителей в системе образовательного кластера «профессиональный колледж – вуз». Вестник Московского Государственного гуманитарного университета им. М.А.Шолохова Серия «Социально-экологические технологии» 2013. №2. с. 96-102 http://mggu-sh.ru/sites/default/files/topor_1.pdf

113 Мазур Т. М. Формування кластерів освіти і профорієнтації шкільної молоді в умовах реконструкції великого міста (на прикладі Львова) / Т. М. Мазур // Сучасні проблеми архітектури та містобудування. - 2018. - Вип. 51. - С. 286-293. - Режим доступу: http://nbuv.gov.ua/UJRN/Spam_2018_51_39.

114 Михайлова, Н. Н. Капустина Г. Ю. Повышение качества профессионального образования и инвестиционной привлекательности педагогических колледжей города Москвы в условиях кластерного взаимодействия. Научные исследования в образовании: прил. к журналу "Профессиональное образование. Столица". - 2012. - № 9. - С. . 46-53. http://cyberleninka.ru/article/n/povyshenie-kachestva-professionalno-obrazovaniya-i-investitsionnoy-privlekatelnosti-pedagogicheskih-kolledzhey-goroda-moskvy

115 Шапошнікова Н. П. Освітньо-виробничі кластери як засіб забезпечення ринку праці кваліфікованими робітниками / Н. П. Шапошнікова // Науковий вісник Південноукраїнського національного педагогічного університету ім. К. Д. Ушинського. Педагогічні науки. - 2017. - № 2. - С. 115-118. - Режим доступу: http://nbuv.gov.ua/UJRN/Nvpupupp_2017_2_23.

116 Осечкина, Л. И. Кластерный подход как условие повышения эффективности деятельности вуза. Высшее образование в России. – 2012. – № 08-09. – С. 73-76. http://vovr.ru/upload/8-9-12.pdf

117 Грушникова Е.В., Кластерный подход как одно из условий повышения качества дополнительного профессионального образования педагогов ISSN 1991-5497. Мир науки, культуры, образования. 2011. № 6 (31) с.112-113. http://cyberleninka.ru/article/n/klasternyy-podhod-kak-odno-iz-usloviy-

povysheniya-kachestva-dopolnitelnogo-professionalnogo-obrazovaniya-pedagogov.

118 Войнаренко, М. П. Кластерные модели объединения предприятий в Украине [Текст] / М. П. Войнаренко // Экономическое возрождение России. - 2007. - № 4(14). - С. 68-82.

119 Semenova K.A., Sakhno T.V., Semenov A.O Cluster approach in education system // International periodic scientific journal «Modern scientific researches» Issue 12, Part 3. 2020. P.21-30. ISSN 2523-4692. DOI 10.30889/2523-4692.2020-12-03-052.

120 Свірський Р. Впровадження нових виробничих систем – кластерів: досвід Рівненської області. – Рівне: Рівненська торгово-промислова палата, 2004. – 44 с.

121 Кизим Микола? Хаустова Вікторія Український досвід формування кластерних структур The Ukrainian experience of formation and development of cluster's structures. Available from: https://www.researchgate.net/publication/336040106_Ukrainskij_dosvid_formuvanna_klasternih_struktur_The_Ukrainian_experience_of_formation_and_development_of_cluster%27s_structures [accessed Aug 22 2024].

122 Підготовлено С.О.Кропельницькою в рамках експертної роботи з розробки Національної програми розвитку кластерів в Україні. Детальніше: https://www.industry4ukraine.net/publications/konczepcziya-rozvytku-klasteriv-naczionalnogo-rivnya/

123 Кузьменко Л.М., Шостя А.М., Усенко С.О., Поліщук А.А., Ільченко М.О., Шаферівський Б.С. Вплив шроту соняшника в комбікормах на забійні та м'ясні якості свиней Науковий вісник ЛНУВМБ імені С. З. Ґжицького. Серія: Харчові технології, 2024, т. 26, № 101. С. 48-55. https://doi.org/10.32718/nvlvet-f10108 Published: 2024-05-30

[129] European Cluster Panorama 2021. Leveraging clusters for resilient, green and digital regional economies.

[130] European Commission. (2016). *Smart Guide to Cluster Policy*.

[131] Національна програма кластерного розвитку до 2027 року. Концепція. Орієнтири розвитку. Рекомендації / О. Юрчак та ін. Київ: АППАУ, Платформа Industry4Ukraine, 2020.

[132] Кизим М. О., Хаустова В. Є. Український досвід формування кластерних структур. *Проблеми економіки*. 2012. № 1. С. 3–11.

[133] Бакум В. В. Методологія розробки агропромислових кластерних утворень регіону. *Економіка АПК*. 2009. № 4. С. 38–45.

[134] Шпак И. А. Кластеры как форма повышения конкурентоспособности перерабатывающих предприятий АПК Украины. 2004.

[135] Ткаленко С. І., Любачівська Р. З. Особливості формування біотехнологічних кластерів ЄС: досвід для України. *Проблеми економіки*. 2015. № 1. С. 37–41.

[136] Іван Демидов. Чому біотехнологічний кластер необхідний Львівській

політехніці. 2021.
[137] Singh, M., Darold, D. L., Klobasa, M., Zielinski, A., Frietsch, R. Keeping track of cleantech development using innovation clusters and member's website data: Evidence from leading energy clusters in Germany. *Energy Reports*. 2023. Vol. 10. P. 756–767.
[138] Nozarian, M., Hajizadeh, A., Fereidunian, A. A methodological review on management of building cluster meso energy hubs in accordance with the agile framework. *Sustainable Energy Technologies and Assessments*. 2024. Vol. 67. 103834.
[139] Shen, L., Sun, Y. Performance comparisons of two system sizing approaches for net zero energy building clusters under uncertainties. *Energy and Buildings*. 2016. Vol. 127. P. 10–21.
[140] Комісаренко С. В. Вісн. НАН України. 2023. № 5. С. 41–43.
[141] Sakhno, T., Ivashchenko, D., Semenov, A., Ivashchenko, O., Sakhno, Y. Clusteroluminogenic polymers: applications in biology and medicine. *Low Temperature Physics*. 2024. Vol. 50(3). P. 276–287.
[142] Поліщук А. А., Шостя А. М., Мерзлов С. В. та ін. Сучасний стан рибництва в Україні та розвиток галузі на Полтавщині. *Scientific Progress & Innovations*. 2024. № 27(1). С. 101–106.
[143] Кузьменко Л. М., Шостя А. М., Усенко С. О. та ін. Вплив шроту соняшника в комбікормах на забійні та м'ясні якості свиней. *Науковий вісник ЛНУВМБ*. 2024. Т. 26. № 101. С. 48–55.
[144] Волошинов В., Гутий Б., Шостя А. та ін. Морфологічний склад туш свиней данського і канадського походження та вплив статі й передзабійної маси на їх якість. *Науковий вісник ЛНУВМБ*. 2024. Т. 26. № 101. С. 182–193.
[145] Гангур В. В., Маренич М. М., Єремко Л. С. та ін. Вплив способів основного обробітку ґрунту на урожайність гібридів кукурудзи в умовах Лівобережного Лісостепу. *Scientific Progress & Innovations*. 2023. 26(4), 19–23.
[146] Semenova K. A., Sakhno T. V., Semenov A. O. Cluster approach in education system. *Modern Scientific Researches*. 2020. Issue 12, Part 3. P. 21–30.
[147] Волкова Н. Н., Иргибаев А. К., Делия О. В., Сахно Т. В. Образовательные учреждения в кластерных структурах: теоретический анализ. *Вестник Евразийского национального университета им. Л.Н. Гумилева*. 2017. № 3(118). С. 590–597.
123 Бакум В.В. Методологія розробки агропромислових кластерних утворень регіону / В.В. Бакум // Економіка АПК. – 2009. – № 4. – С. 38–45.
124 Porter, M. (1990). *The Competitive Advantage of Nations*. Free Press.
125 Porter, M. E. (2003). The Economic Performance of Regions. *Regional Studies*, 37(6–7), 549–578
126 Rosenfeld, Stuart A. (1997). Bringing Business Clusters into the Mainstream of Economic Development. *European Planning Studies*, 5(1), 3–23.

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

128 European Cluster Panorama 2021. *Leveraging clusters for resilient, green and digital regional economies*.

129 European Commission. (2016). *Smart Guide to Cluster Policy*.

130 Національна програма кластерного розвитку до 2027 року. Концепція. Орієнтири розвитку. Рекомендації / О. Юрчак та ін. Київ: АППАУ, Платформа Industry4Ukraine, 2020.

131 Кизим М. О., Хаустова В. Є. Український досвід формування кластерних структур // *Проблеми економіки*. 2012. № 1. С. 3–11.

132 Шпак И. А. Кластеры как форма повышения конкурентоспособности перерабатывающих предприятий АПК Украины. 2004.

133 Ткаленко С. І., Любачівська Р. З. Особливості формування біотехнологічних кластерів ЄС: досвід для України // *Проблеми економіки*. 2015. № 1. С. 37–41.

134 Іван Демидов. Чому біотехнологічний кластер необхідний Львівській політехніці. 2021.

135 Комісаренко С. В. // *Вісник НАН України*. 2023. № 5. С. 41–43.

136 Гангур В. В., Маренич М. М., Єремко Л. С. та ін. Вплив способів основного обробітку ґрунту на урожайність гібридів кукурудзи в умовах Лівобережного Лісостепу // *Scientific Progress & Innovations*. 2023. 26(4), 19–23.

137 Волошинов В., Гутий Б., Шостя А. та ін. Морфологічний склад туш свиней данського і канадського походження та вплив статі й передзабійної маси на їх якість // *Науковий вісник ЛНУВМБ*. 2024. Т. 26. № 101. С. 182–193.

138 Singh, M., Darold, D. L., Klobasa, M., Zielinski, A., Frietsch, R. Keeping track of cleantech development using innovation clusters and member's website data: Evidence from leading energy clusters in Germany // *Energy Reports*. 2023. Vol. 10. P. 756–767.

139 Nozarian, M., Hajizadeh, A., Fereidunian, A. A methodological review on management of building cluster meso energy hubs in accordance with the agile framework // *Sustainable Energy Technologies and Assessments*. 2024. Vol. 67. 103834.

140 Shen, L., Sun, Y. Performance comparisons of two system sizing approaches for net zero energy building clusters under uncertainties // *Energy and Buildings*. 2016. Vol. 127. P. 10–21.

141 Sakhno, T., Ivashchenko, D., Semenov, A., Ivashchenko, O., Sakhno, Y. Clusteroluminogenic polymers: applications in biology and medicine // *Low Temperature Physics*. 2024. Vol. 50(3). P. 276–287.

142 Поліщук А. А., Шостя А. М., Мерзлов С. В. та ін. Сучасний стан рибництва в Україні та розвиток галузі на Полтавщині // *Scientific Progress & Innovations*. 2024. № 27(1). С. 101–106.

143 Semenova K. A., Sakhno T. V., Semenov A. O. Cluster approach in education system // *Modern Scientific Researches*. 2020. Issue 12, Part 3. P. 21–30.

144 Волкова Н. Н., Иргибаев А. К., Делия О. В., Сахно Т. В. Образовательные учреждения в кластерных структурах: теоретический анализ // *Вестник Евразийского национального университета им. Л.Н. Гумилева*. 2017. № 3(118). С. 590–597.

Наукове видання

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