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EVALUATION OF CLUSTER PERFORMANCE IN TRANSITION TO CIRCULAR ECONOMY

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Abstract

Clusters have an impact on regional development for they unite small and medium enterprises (SMEs), science and research institutions, higher education institutions, non-governmental organizations (NGOs), and other entities which aim at increasing competitiveness through cooperation, science, and business partnership, joint research and development (R&D) activities and innovation. Circular economy (CE) gains its popularity for this approach encourages focusing on resource efficiency, doing less damage to the environment, economy, and society. Hence, CE can add to the competitive advantage in clusters' development. The dissertation analyses Lithuanian clusters' performance evaluation problems and transitions to a more resource-efficient and sustainable development through CE. The object of the dissertation is clusters' performance evaluation including the transition to CE.

The literature analyses of clusters and CE were performed, which forms the basis of clusters' performance in transition to CE evaluation tool formulation, which would enable to improve clusters' performance and gain a competitive advantage in the future. The proposed tool is designed to assess a cluster's performance with integrated measures that indicate the CE transition. This tool would allow the recognition of resource-efficient and sustainable development of existing clusters.

The dissertation aims to analyze the theoretic approaches towards clusters and CE for the tool of clusters' performance evaluation in transition towards CE, which could be proposed based on the literature and empirically tested on Lithuanian clusters' case.

A sequence of tasks solution is followed in the thesis: to review the existing literature on clusters and CE by presenting the concept and available approaches; to select indicators based on literature analysis that reflect clusters' performance and make a system, suitable for evaluation; to propose a transition to CE evaluation system with reasonable indicators that are recognizable internationally; to develop an original clusters' performance evaluation tool that would include measures indicating the transition to CE; to verify the suitability of the proposed clusters' performance in transition to CE evaluation tool in Lithuanian clusters working in different sectors, to propose the conception of a database covering the clusters' performance and CE indicators.

Reziumė

Klasteriai vienija mažas ir vidutines įmones (MVĮ), mokslo ir tyrimų centrus, aukštojo mokslo institucijas, nevyriausybines organizacijas (NVO) ir kitus subjektus, kurių tikslas – padidinti konkurencingumą bendradarbiaujant mokslo ir partnerystės pagrindu, bendra mokslinių tyrimų ir eksperimentinės plėtros (MTEP) veikla ir inovacijų taikymu. Žiedinė ekonomika (toliau – ŽE) populiarėja, nes šis požiūris skatina sutelkti dėmesį į išteklių efektyvų naudojimą, naudingesnį aplinkai, ekonomikai ir visuomenei. Taigi, ŽE gali prisidėti prie konkurencinio pranašumo plėtojant klasterius. Disertacijoje analizuojamos Lietuvos klasterių veiklos vertinimo problemos ir perėjimas prie naudingesnio išteklių naudojimo ir tvaraus vystymosi per ŽE. Disertacinio tyrimo objektas yra klasterių veikla pereinant prie žiedinės ekonomikos.

Atlikus klasterių ir ŽE literatūros analizę, buvo suformuluotas klasterių veiklos vertinimo pereinant prie ŽE modelis, kuriuo remiantis galima pagerinti klasterių veiklą ir įgyti konkurencinį pranašumą. Siūlomas modelis skirtas įvertinti klasterio veiklą ir nustatyti perėjimą prie ŽE naudojant integruotas priemones. Šis modelis leis atpažinti efektyvų išteklių naudojimą ir tvarų esamų klasterių vystymąsi.

Disertacija siekiama išanalizuoti teorinius požiūrius į klasterius ir ŽE, pasiūlyti literatūros analize paremtą klasterių veiklos vertinimo pereinant prie ŽE modelį ir empiriškai jį išbandyti Lietuvos klasterių atveju.

Darbe laikomasi užduočių sprendimo sekos: atlikus mokslinės literatūros analizę, susisteminti klasterių ir ŽE koncepcijas; remiantis literatūros analize nustatyti klasterių veiklą nusakančius rodiklius ir sudaryti vertinimui tinkamą sistemą; pasiūlyti tarptautiniu mastu naudojamus rodiklius apimančią perėjimo prie ŽE vertinimo sistemą; sudaryti klasterių veiklos vertinimo pereinant prie žiedinės ekonomikos modelį; patikrinti pasiūlyto klasterių vertinimo pereinant prie žiedinės ekonomikos modelio pritaikomumą Lietuvoje skirtinguose sektoriuose veikiančiuose klasteriuose; pasiūlyti klasterių veiklą pereinant prie ŽE nusakančių rodiklių duomenų bazės koncepciją.

Notations

Abbreviations

CE – Circular Economy
HEI – higher education institution
IA – individual activity
Ltd – private company limited by shares
MITA – Agency for Science, Innovation, and Technology
MNEs– Multinational enterprise
NPO – non-profit organization
Plc – public limited company
R&D – Research and Development
SAW – Simple Additive Weighting Method
SMEs – Small and Medium Enterprises
TOPSIS – Technique for Order of Preference by Similarity to Ideal Solution

Contents

[1]The annexes are supplied in the enclosed compact disc.

Introduction

Problem Formulation

In Lithuania, the attention was drawn to the importance of clusters in promoting the competitiveness of small and medium-sized enterprises (SMEs). The Lithuanian cluster network faces challenges and is encouraged to prioritize the same areas as the European Union (EU): digitalisation, circular economy (CE) and biodiversity, value chains (Von Der Leyen, n.d.). Agency for Science, Innovation and Technology (MITA) is implementing a project meant for promotion and development of clusters. The total project budget (EUR 2,4 million) is intended for the establishment of clusters, their maturation, financing, partner search and other issues.

According to Eurostat (2019), the circularity rate of the EU (27) in 2019 was only 11,9 percent. The indicator is still low but it has grown by 0,8 percentage points from the 2014 EU average. Meanwhile, in Lithuania, circularity in 2019 reached only 4 percent and has decreased by 0.6 percentage points since 2016. The European Commission has proposed a European Green Deal ("A European Green Deal | European Commission," n.d.) to achieve a sustainable EU economy with an action plan aiming at promotion of resource efficiency and reducing pollution.

Relevance of the Thesis

Interest in clusters has grown since Marshall (1920) first described industrial districts as a socio-economic notion, where geographic location is essential for growth, competitiveness, and agglomeration patterns in regions. The necessity of cluster performance evaluation is captured to identify weaknesses and strengths for further developing and improving a cluster. Clusters may foster the transition to CE to a greater extent, for SMEs generally do not have the capacity to apply innovative solutions at their own expense. The transition to CE can be seen as a competitive advantage for the companies belonging to the cluster. Hence, the need to develop a cluster performance evaluation tool that allows assessment of clusters' contribution to the transition to CE is identified.

Object of the Research

The object of the research is cluster performance, including the transition to CE.

Aim of the Thesis

The thesis' aim is to prepare a cluster performance evaluation tool that assesses clusters' contribution to the transition to CE.

Tasks of the Thesis

In order to achieve the goal of the thesis, the following problems had to be solved:

1. To review the existing literature on clusters and CE by presenting the concept and available approaches.
2. To select indicators based on literature analysis that reflect clusters' performance and make a system suitable for cluster performance evaluation.
3. To propose a transition to a CE evaluation system with reasonable indicators that are recognizable internationally.
4. To develop a methodology that allows the assessment of cluster performance in transition to CE.
5. To verify the suitability of the proposed cluster performance in transition to CE evaluation tool by carrying out an embedded case

study in Lithuanian clusters with the application of MCDM methods (SAW, TOPSIS) and correlation – regression analysis.
6. To propose the conception of a database covering clusters' performance and CE indicators.

Research Methodology

Several research methods were used to develop the strategy for finding a solution to the set tasks of the thesis and to reveal the problems in cluster performance evaluation including the transition to CE. The initial phase of the thesis preparation involved a literature analysis to clarify the definition of a cluster, define the research object, and form a system of indicators for the evaluation of clusters' performance in transition to CE suitable for the application of MCDM methods. A systematic approach was employed to relate the literature analysis and the empirical part of the study, where qualitative and quantitative analysis methods were employed. A multiple-case study was applied to selected clusters to examine them without influencing the environment. Some of the data on restricted access were obtained through interviews and questionnaires to the clusters' coordinators; others were collected through a database search. MCDM methods (multi-criteria evaluation, experts' evaluation, SAW, TOPSIS) were used for assessment of the clusters. Correlation – regression analysis was employed to detect the degree of association between quantitative variables.

Scientific Novelty of the Thesis

The aspects of scientific novelty on cluster performance in transition to a CE evaluation are as follows:

1. The concept of a cluster is clarified. It relies on companies and associated institutions supplementing others by completing vertical (buying and selling chains) and horizontal links (complementary products and services, the use of similar specialized inputs, technologies or institutions, and other linkages) using geographical proximity to achieve competitive advantage through cooperation.
2. Two new systems of indicators are proposed, needed for cluster performance monitoring and the transition of a cluster to a CE. The indicators are selected to cover different cluster performance components: intercommunication, financial resources, human resources, marketing activities, and a set of criteria that show the transition to a CE. These two

systems can be used independently when either clusters' performance or the transition of a cluster to a CE needs to be monitored. They allow data collection, comparison over a period of time, and supervision.

3. The clusters performance in transition to CE evaluation tool is proposed and tested in selected Lithuanian clusters. The tool combines the two systems of indicators and employs MCDM methods and correlation – regression analysis that allow the evaluation of cluster performance in transition to CE. The tool employs universal indicators and can be adopted in other countries. Clusters can be identified as accelerators of the CE and the efficient use of resources, as the results suggest.

Practical Value of the Research Findings

Two new systems of indicators needed for monitoring clusters' performance and the transition of a cluster to a CE can be used by clusters' managers and coordinators for further cluster development. A systemized view may help to follow the selected data and make recommendations on further improvements.

The tool that allows evaluation of clusters' performance and clusters' contribution to the transition to CE is an essential means for the authorities at different levels of governance – city level, regional, national and European – to initiate support for further development of existing clusters through funding opportunities.

The Defended Statements

The following statements based on the present investigation results may serve as the official hypotheses to be defended.

1. A set of indicators is recommended to monitor clusters' performance (covering intercommunication, marketing activities, human resources and financial resources).
2. A set of indicators characterizing the transition of a cluster towards a CE is suggested (such as the generation of municipal and other waste, and trade in recyclable or reusable raw materials by importing, exporting, or trading between cluster members).
3. A cluster performance in transition to CE evaluation tool based on SAW and TOPSIS methods and assessing their relationship can be used by clusters in transition to CE.

Approval of the Research Findings

Ten scientific articles have been published on the topic of the dissertation. Five publications were published in scientific journals included in the Web of Science (Claritive Analytics) Emerging Sources Citation Index and five articles were published in peer-reviewed international conference materials.

The author has made seven presentations at seven international and national scientific conferences.

- 10th International Conference on applied economics *Contemporary issues in economy* June 27–28, 2019, Torun, Poland.
- 6th International Scientific Conference *Contemporary issues in business, management and economics engineering (CIBMEE-2019)* May 9–10, 2019, Vilnius.
- 10th International Scientific Conference *Business and Management 2018* May 3–4, 2018, Vilnius.
- 6th International Conference *Management, Engineering, Science & Technology 2017* and 3rd International Research Conference *Science, Technology and Management 2017* November 1–2, 2017, Dubai, UAE.
- 3rd International Conference *Lifelong Education and Leadership for All-ICLEL 2017* September 12–14, 2017, Porto, Portugal.
- 5th International Scientific Conference *Contemporary Issues in Business, Management and Education* May 11–12, 2017, Vilnius.
- *Summer School and Conference* September 5–7, 2016, Vilnius.

Two research internships were completed during the doctoral studies:

- 2017–2018: The Academy of Research and Technology (ASRT), Cairo, Egypt.
- 2017: Sidi Mohamed Ben Abdellah University (USMBA), Fez, Morocco.

Structure of the Dissertation

The dissertation is structured to include the introduction, three main chapters, general conclusions, an extensive list of references, a list of the author's publications on the topic of the dissertation, and 6 annexes. The total scope of the work is 158 pages, excluding appendices, with 10 numbered formulas, 48 figures, 21 table and 198 references.

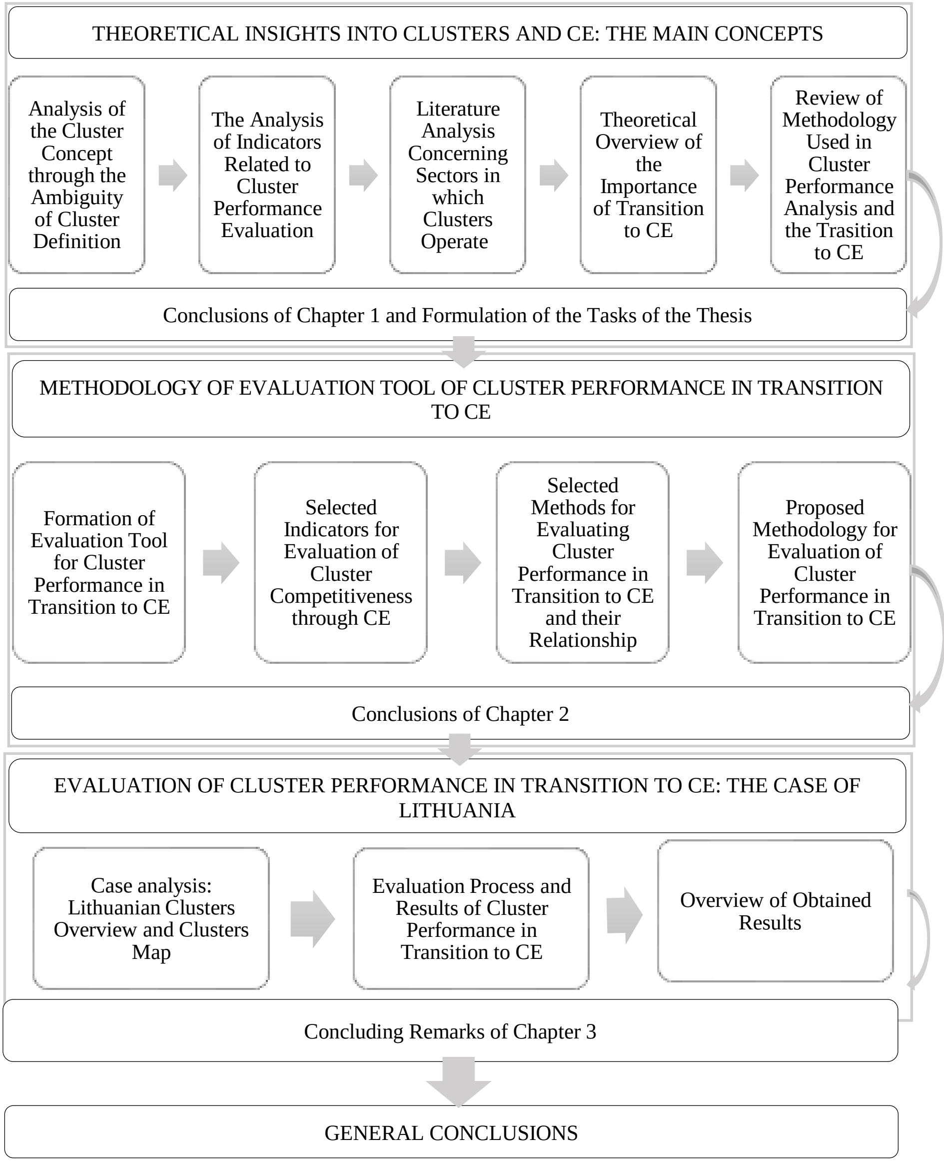


Fig. 0.1. Structure of the dissertation (Source: composed by the author)

1

Theoretical Insights into Clusters and Circular Economy: The Main Concepts

This chapter aims to identify the indicators used by scholars for cluster performance, efficiency, or competitiveness assessment; to indicate the cluster development measures suggested by governmental institutions; to specify analysed sectors; and to describe CE. It also aims to show how clusters might be affected when shifting to a CE and to select the methods.

This chapter concludes by formulating the main objective and tasks of the present investigation. The author published three articles related to this chapter (Razminienė & Tvaronavičienė, 2017a, Razminienė & Tvaronaviciene, 2017b, Razminienė & Tvaronaviciene, 2018a).

1.1. Analysis of the Cluster Concept through the Ambiguity of Cluster Definition

According to Karaev, Koh, and Szamosi (2007), clusters are an essential instrument for improving SMEs' productivity, innovativeness and overall competitiveness by overcoming their size limitations. Although many studies are conducted in different countries, a common understanding of the cluster concept has not yet been accepted. One of the most prominent authorities in this field is Porter, who claims that national clusters are formed by companies and industries linked through vertical (buyer/supplier) and horizontal (joint customers, technology, and other) relationships with the leading players located in a single nation/state (Porter, 1990). Later, Porter (1998) supplemented this definition, adding institutions (formal organizations) such as universities. A country's ability to form an industrial cluster can be related to its international competitive advantage. Reduced input costs for manufacturers, development of standard suppliers, training of professional labour, and a technical knowledge spillover effect can be achieved through the formation of clustering (Hsu, Lai, & Lin, 2014). A cluster's effectiveness is thought to be increased by facilitating the transmission of knowledge and institutions' development, which can be achieved through geographical proximity. Another essential feature that is stressed by Porter (1998) is encouraging innovation through an enhanced division of labour among companies with physical proximity among numerous competing producers.

The importance of reference to an earlier cluster concept formation is determined by Akoorie (2011). The work of the English economist Alfred Marshall should be mentioned when analysing industrial districts and industrial clusters. Marshall described a model for contemporary technological parks more than 100 years ago and called them industrial districts. Later analyses by other authors were based on Marshall's description while adapting it to develop a comparative model applicable to other industrial districts.

The term 'neo-Marshallian industry district' describes the industrial world as a community where information is shared through visible learning colleges. The cluster concept was not present in the writings of Marshall. He emphasized commercial, social and technical agreements uniting entrepreneurs even with their rivals, presenting innovations to offer both incentives and information through newly formed industrial districts of the Victorian period.

The concept of industrial districts comprises three main features (Marshall, 1920). The first is that a geographically concentrated industry supports specialized providers of inputs. The second feature addresses the concentration of workers of the same type and offers labour market pooling. The third highlights geographical proximity, which is responsible for the spread of information. Emphasis is put on knowledge and organization being the driving principles as a mutually beneficial relationship is produced between the creation of new information and organizational improvement of related companies in the industrial environment.

The cluster concept includes the ideas declared in Marshall's work (Marshall, 1920). The industrial cluster concept, as described by Porter, covers not only a relationship between companies for information sharing and organizational improvement but also the innovation-based economy, which is the result of geographically bounded concentrations of interdependent companies with specific forms of governance based on social relations, trust, and sharing of resources. Every industrial cluster is unique, having its development path and shared ideas. Non-market relations are the primary means to keep industrial districts together, while in the industrial cluster, national, regional and civil governments play an essential role in creating infrastructure and supporting companies' development. Physical structures refer to facilities such as transport, utilities, and waste disposal, while social structures are secondary and tertiary educational institutions, industry training organizations, local sources of business and technology advice, and professional and trade associations. The main characteristic feature of an industrial district and industrial cluster is the existence of cooperative and competitive forms of industrial organization in proximate geographical space.

The cluster phenomenon has gained importance mainly because of cluster benefits or externalities, as reflected in Porter's (1998) ideas. Clusters affect competition in three broad ways: first, by increasing the productivity of companies based in the area; second, by driving the direction and pace of innovation, which underpins future productivity growth; and third, by stimulating the formation of new business, which expands and strengthens the cluster itself. A cluster allows each member to benefit as if it had a grander scale or joined with others formally – without requiring it to sacrifice its flexibility (Porter, 1998).

Connell and Voola (2013) assume that the need to have an economic development policy arises from the network development of complementary and competitive companies present in every country, region or city. Clusters, usually created with a political incentive after the global economic crisis, show that economies must be diversified and include innovative jobs. A dual purpose of industry clusters can be specified: firstly, clusters enable SMEs to take advantage of the competitiveness created by business cooperation and agglomeration; secondly, they are encouraged in order to build or revitalize certain targeted regions. Stable clusters create opportunities for member companies, especially SMEs, not to compete internationally under growing pressure.

The stage along the value chain (e.g. logistics, media, or marketing) or focus on selected customer needs or market segments (e.g. health, information technology, financial services, or education) can help differentiate an industry cluster by specialization. Companies that are members of clusters may gain some additional advantages through the nature of their products or services, the resources that they use, the suppliers, or the employees and their skills. A cluster may include related collaborators and service providers such as universities, professional associations, official agencies, training companies or customers.

Interconnectedness or linkages between different actors are characteristic of a cluster, enabling the creation of value and improvement of companies' competitive advantage as they can leverage the potential strengths of the group and exploit agglomeration economies. These agglomeration economies or spatial externalities help the companies in clusters to foster a competitive advantage. Clusters' idea to move from closed to more open innovation behaviours is understood beneficial when clusters encourage more cooperative exchanges between member companies.

Initiatives supported by international organizations reflect the recognition of the role that clusters can play in regional development (Engel, Berbegal-Mirabent, & Piqué, 2018). Potential long-time success is a driving force that encourages the establishment of assistance and support in different regions. Policymakers' and other agents' aim is to build on resources inherited by regions to create differentiated and distinctive economic activity areas instead of just picking winning clusters. Individual companies get less attention as growing clusters of companies show more potential, as this is seen as less costly in terms of resources, less distorting than company-specific approaches, and more targeted than economy-wide measures. National governments' promotion of clusters has been seen in many countries over the past two decades.

Zelbst, Frazier, and Sower (2010) consider an organization's most costly strategic decision to be the location decision. This decision can also be the primary strategic advantage. There are several components which can add to competitive advantage through location decisions made by organizations in competitive economies. These components are the transfer of knowledge and innovation specialization (McCann & Folta, 2008) and complementarities (co-agglomeration). Competing companies may consider choosing the same location for their business development if they identify such a location decision as a competitive advantage.

Expósito-langa, Tomás-miquel, and Molina-morales (2015) define a cluster as a network with reference to geographical proximity and an intense feeling of belonging. These are primary elements facilitating cluster relationships based on norms and values such as trust and mutual exchange, among others, and are characteristic of inter-organizational relationships between different actors: customers, competitors, suppliers, support organizations, and local institutions. The network of relations among companies is well known for allowing knowledge to diffuse rapidly as it is typically characterized as a web of dense and overlapping ties. Knowledge resources flow quickly inside the cluster, enabling reduced search costs. The knowledge exploitation in a cluster differs from that produced in other contexts, facilitating the learning process and generating beneficial effects for all the group's companies.

Salvador, Mariotti, and Conicella (2013) question whether geographical proximity is essential for companies in respect of the innovation cluster revolution, as geographical proximity played a crucial role in network formation, company growth, and knowledge diffusion in traditional industrial districts and innovative milieu. Forward-looking public policies enable the emergence of new forms of virtual agglomeration like innovation clusters. A cluster management company identifies and manages an innovation cluster based on membership of a dedicated organization with everyday interest activities. Innovation clusters are often regarded as the most dynamic and high-tech components of larger regional communities based on sector commonalities or markets or similar technologies.

De Felice (2014) emphasizes that social capabilities are often ignored in traditional industrial districts, whereas the role of social and cultural proximity between agents for knowledge sharing is emphasized in the literature. It must be admitted that essential sources for the exchange of knowledge are local and agent relations, and workers with specific knowledge, skills, and capacity comprise human resources. The company's role must be considered too, as it may be positioned as an institution responsible for the knowledge needed to produce and spread technology. Technological knowledge is produced through a learning integration process and formal research in a company as an organization. This is the main reason why a company is considering a place of specific competences. Companies can create relationships for themselves within a district with the outside worlds. These relationships are significant sources of innovation and creation of internal ideas for business in the district. Transfers of knowledge and inputs are stimulated by easily formed social and company networks in a district, generating ideas to an extent determined by a company's abilities or social capabilities. Unique social capabilities can characterize any cluster, along with different knowledge bases, and the ideas that belong to the skilled workers of a company characterize companies in clusters. The cluster's social capabilities are comprised of the concentration of various competencies and abilities of business workers. Historical and cognitive factors explained by the economic, social, cultural and institutional relations characteristic of a population in a specific regional context can explain a cluster's birth and performance. Hence, learning and knowledge generation requires more than geographical proximity. Cluster needs to reconsider the external relations through which recognition and the spread of new ideas and knowledge are possible within the district through positive spillovers.

Markusen (1996) applied geographic and economic characteristics found after cluster examination from an economic perspective to study the formation of clusters around oligopolistic industries. Markusen (1996) identified types of cluster formed within metropolitan areas such as Marshallian industrial districts (and subdistricts), satellite platform districts, and state-anchored industrial districts. Geographic areas, public or private industrial decisions, labour availability, and trade within and outside the district determined this typology. The typologies of Markusen and Porter share similar features.

Three types of cluster are presented by Porter (2003): local industry clusters, resource-dependent clusters, and trading industry clusters. For example, supporting the similarities between Markusen and Porter's typologies, characteristics of local industry clusters are compared with those of the Marshallian industrial district (Porter, 2003):

- Employment evenly distributed across the cluster.
- Goods and services provided mainly to local markets.
- Competition with other regions is limited.
- Most companies provide services.
- Industries produce few goods.

Locally consumed services such as health services, utilities, and retail goods comprise clusters. Products that are used locally, including newspapers, soft drinks, and goods-producing industries, are provided within clusters.

Another cluster that has similarities with Markusen's hub and spoke industrial district is Porter's resource-dependent cluster. According to Porter's classification, employment is located near the needed resources, and competition is domestic and international. Therefore, any manufacturing associated with this cluster type is directly related to resources. Knowingly, resource-dependent clusters are tied to the immobile assets.

Porter's traded industry cluster has features similar to Markusen's satellite platform district. Resources are not immobile in this type of cluster, so the products and services are sold across regions and other countries. Furthermore, the cluster is located in an area considering the competition, such as available labour concentrations.

The typologies of Markusen (1996) and Porter (2003) categorize cluster formation in isolation, although they both conclude that clusters do not form in isolation. Markusen (1996) also conclude that governmental action or a large company's action can form a cluster in isolation.

Porter (1990) made many observations in his work on industry clusters, and it is essential to mention the difference between two critical types (Martin, Mayneris, Martin, Mayer, & Mayneris, 2008). The first, 'traded clusters', are crucial for economic development. They are found clustered in a limited number of regions within a country and only in a few countries globally, for they are composed of industries that sell to markets beyond their local region. They are complimented for providing higher wages for their workers and adding to the local economy through innovation and productivity, as well as generating all-important spillovers. Meanwhile, 'local industries' are distributed evenly across jurisdictions serving their local markets; however, they present lower wages, lower productivity, and a lack of spillovers.

Porter's (1990) focus is on the dynamics of industry clustering, and workers are one of the concerns in his work. Employers seek skilled workers, and clusters serve that perfectly, as traded clusters attract specialized human resources to their region.

Niu (2010) explains that the knowledge within a cluster can be shared unwittingly through competitive interactions or the industrial atmosphere. Joint action such as horizontal cooperation (between competitors) or vertical cooperation (supply chain relationships) enables companies in a cluster to achieve sustainable competitive advantage. Cooperative and collaborative relations among companies in different institutional forms, such as strategic alliances and producer consortia, create joint action gains, sharing and exchanging knowledge and information quickly. Two types of competitive characteristics can be distinguished and further developed into a competitive advantage for a cluster:

1. Those based on traded interdependencies.
2. Those based on non-traded interdependencies.

Traded interdependencies, such as alliances, acquisitions or technological know-how in which formal exchanges occur, exist in the economic sphere and involve formal exchanges of value. When industries mature, traded interdependences are readily dispersed. The processes surrounding economic transactions in a cluster can be understood better if this approach is adopted.

Non-traded interdependencies share knowledge without or with limited market mechanisms. They include customs, cultures and beliefs, and exist outside the economic sphere. The industrial atmosphere, as Marshall calls it, is associated with knowledge in the air, as reflected in non-traded interdependencies. The same competitive characteristics can be applied to the economic system in a cluster, reducing transaction costs related to traded interdependencies.

Time has changed the importance of traded and non-traded interdependencies. Advantages related to traded interdependencies, such as lower production costs, specialized labour pools, and spillovers of technological knowhow, are identified by traditional agglomeration economics. The main factors that were considered to reduce the importance of proximity in attaining advantages were the emergence of globalization and information technology. Clusters have developed learned patterns of adaptation advantages that have been attributed to interaction and trust for competitive. Therefore, individual company and mutual competitive advantage can be explained through the importance of the industrial atmosphere, or knowledge in the air.

Karaev et al. (2007) emphasize that competitiveness is a significant characteristic of a cluster concept. Therefore, a distinction should be made between a nation's competitiveness and that of a region, an industry, or a single company. The business environment in which companies or industries emerge determines the competitiveness of a particular region. Different agents define competitiveness as the ability of a country to achieve sustained high rates of growth in terms of gross domestic product per capita; as a measure of levers that a country has to promote sustained improvements in its wellbeing, given the global competition; and as the ability of an economy to provide its population with high and rising standards of living and a high level of employment for all those willing to work on a sustainable basis. Primary macro competitiveness indicators can be listed as lower country risk rating and higher computer usage; higher gross domestic investment, savings and private consumption; more imports of goods and services than exports; increased purchase power parity and gross domestic product (GDP); larger and more productive, but not less expensive, labour force; and higher research and development (R&D) expenditures.

There are two ways that a company can gain a competitive advantage over its rivals at the micro level (Jin, Guo, & Li, 2019). These are cost advantage and differentiation. In the first case, a company can produce and sell comparable products more efficiently than its competitors by lowering costs. The second case suggests that the expectations of customers can be fulfilled by providing unique products or services. Nonetheless, the main element in these definitions is productivity.

The competitiveness assessment also includes intellectual capital and its relationship with innovation capacity (Gloet & Terziovski, 2004; Solleiro & Castañón, 2005). Karaev et al. (2007) claim that competitive advantage is a core competence, showing it as an advantage that one company has relative to competing companies. Barnett and Pontikes (2004) focus more on survival as a primary determinant of competitiveness as a contrast to identifying factors that determine an organization.

An essential element of cluster dynamics is the interaction between competitive and cooperative attitudes in a cluster. As already discussed, a cluster combines not only competing companies in the same industry, but also business partners with consistent competencies. Cluster members cooperate with cluster links (e.g. in a supply chain or an export promotion programme), creating competitive pressure, an essential driver for innovation. Companies' roles can be changed according to market requirements, as cluster members can interact as partners or as competitors (Lee, Martin, Hsieh, & Yu, 2020).

Broekel, Fornahl, and Morrison (2015) present the hypothesis that companies in clusters gain an additional advantage because of their location and can expect support from public R&D subsidization programmes and better embeddedness in knowledge networks of subsidized R&D collaboration. The Sixth EU Framework Programme (Leather, 2008) focuses on research excellence, and companies in clusters that are keen on international collaboration with state-of-the-art knowledge sources are likely to get support. More globally, central positions are maintained by companies in clusters instead of being involved in public support of collaborative R&D networks. Companies in clusters engage in public research organizations (not universities) through national subsidization schemes. These are additional advantages of belonging to a cluster.

The scholars present different cluster notions characterized as being of different significance in various fields (R. Martin & Sunley, 2003; Novikov, 2019; Novotná & Novotný, 2019). Scientific literature on clusters can be beneficial in terms of contemporary economic development, but at the same time, banal and misleading pieces of writing exist. The cluster concept's importance is comprehensible and highly supported by promoters, but there is a feeling that there is something behind it that must be critically reviewed. The cluster concept provokes uncertainty as it is very elastic, and clusters cannot determine or present a universal model on how agglomeration is related to regional and local growth. The cluster notion has such a universal description that it can be added to any other notion of a similar nature, which makes it overly stretched, thin, and fractured. Another circumstance that encourages awareness of the ambiguity of the cluster term is that the existence of an association between some high-growth industries and various forms of geographical concentration in a region or geographic location does not prove that their relative success and economic growth is the consequence of being concentrated in that location.

The cluster notion was invented to describe geographically localized or clustered companies that also have a competitive advantage (Cavallo, Ghezzi, & Balocco, 2019; Gallego-Bono & Chaves-Avila, 2020). Naturally, there were attempts by economic geographers studying local industrial specialization, particularly economic agglomeration, and regional development that could represent the spatial form and nature of local business concentrations. However, they did not have any significant impact on policymakers. The previously mentioned competitiveness might be the keyword in cluster description as the emphasis was on companies' competitiveness, industries, nations, and locations. Politicians and policymakers have stressed that competitiveness is important for succeeding in today's global economy, and this position conforms to the cluster notion. The purpose of this definition is to inform companies, cities, regions and nations on how to be competitive globally. The cluster notion seems tempting, for it refers to the current preoccupation with micro-economic supply-side intervention and the policy imperatives of raising productivity and innovation. The cluster concept has attracted considerable interest in promoting geographical clusters' competitive advantage, referring to its aims, performance, productivity and competitiveness.

The cluster concept is very generic: given its vague and sufficiently indeterminate meaning, it can be applied to an extensive range of industrial groupings and specializations, demand-supply linkages, factor conditions, institutional set-ups, and others (Gallego-Bono & Chaves-Avila, 2020). At the same time, it claims to be based on fundamental processes of business strategy, industrial organization and economic interaction. The cluster idea has mainly been accepted as valid in terms of the national economy, decomposing the economy into distinct industrial-geographical groupings seeking to understand and promote competitiveness and innovation, instead of being tested and evaluated actively. The cluster concept has attained popularity for the incompleteness of the definition, which can be seen as an advantage and a disadvantage. It might be claimed that the definition of the term allows a wide range of interpretations, enabling the term to be used for conflating and equating quite different types, processes and spatial scales of economic localization.

The definition of the cluster concept has two core elements. The first is that the companies in a cluster must be linked in some way. It turns out that clusters consist of companies and associated institutions which can supplement or complete others by completing vertical (buying and selling chains) (Alexander, 2018; Humphrey, Todeva, Armando, & Giglio, 2019) and horizontal links (complementary products and services, the use of similar specialized inputs, technologies or institutions, and other linkages) (Novotná & Novotný, 2019). Clusters produce benefits for the companies through relationships or networks. The second core element is that clusters must be composed of geographically proximate groups of interlinked companies. Sitting in the same location allows the companies to avail themselves of the value-creating benefits that evolve from networks of interaction between companies.

The two elements reveal the cluster definition's primary problem, as it lacks clear industrial and geographical boundaries. The definition does not give the level of industrial aggregation at which a cluster should be defined, or the range of related or associated industries and activities which should be included. It also omits the strength of linkages between the companies or the level of economic specialization sufficient for a local concentration of companies to constitute a cluster. The spatial scale and geographical range needed for clustering processes (inter-company linkages, knowledge spillovers, rivalry, business, social networks and others) to operate and the spatial density of such companies and their interactions are not defined. The boundaries of clusters are continuously evolving as new companies and industries emerge and established ones shrink or decline, and this adds to the main problem of the definition, which seems intentionally opaque and fuzzy.

Authors offering cluster definitions are given unlimited scope, as the definition of the concept may differ in different locations depending on the segment in which the member companies compete and the strategies they employ (Novikov, 2019). Such geographical licence sets the term at two extremes: it can be defined as national groups of industries and companies that are strongly linked, although dispersed over several different locations within a country without obvious major geographical concentrations or a local grouping of similar companies in related industries within a highly circumscribed area (R. Martin & Sunley, 2003).

Geographic terminology is used by policymakers who are engaged in the analysis of the definition. The main problem is that the cluster concept does not contain fixed boundaries in terms of spatial range or limits, and different clustering processes are used on different geographical scales. The possibility of using the term for a non-pre-specified geographical size or scale connections enables misuse, which inevitably weakens the cluster concept's empirical and analytical significance.

Companies in clusters are considered to have superior performance to those who do not benefit from a cluster (Table 1.1). Clusters raise the productivity, innovativeness, competitiveness, profitability, and job creation of their constituent companies, the geographical areas in which the clusters are located, and the broader national economy (R. Martin & Sunley, 2003). Despite some attempts to prove that economic advantages are analysed and evident or claims that belonging to clusters may add, on average, two to four percent to companies' profitability, the evidence is not complete and needs far more detailed research. Success stories are used to support the argument of superior performance. However, the situation seems not to reflect the real situation, as only a few extensive studies have been carried out, comparing similar companies inside and outside clusters or gathering information about clustering in particular industries.

Some studies have sought to present evidence that clustering and innovation have a positive association. Companies in local concentrations and their more geographically dispersed partners have been taken into account, but no clear evidence has been provided that new technologies are adapted faster in clustered companies. The same is true of company growth: clustered companies that are strong in their industry show better results, faster growth, and better perspectives on innovation processes, while clustered companies that are strong in other industries show the opposite, as growth and innovation rates are not fast. Nonetheless, a high economic growth rate and innovation are not necessarily achieved in regions based on specialized clusters. There is also no valuable evidence to support the view that clusters boost business performance and local economic development.

Table 1.1. Advantages and disadvantages of clustering (Source: Composed by the author based on Martin and Sunley (2003), Novikov (2019) and Novotná and Novotný (2019))

Claimed advantages	Potential disadvantages
Higher innovation	Technological isomorphism
Higher growth	Labour cost inflation
Higher productivity	Inflation of land and housing costs
Increased profitability	Widening of income disparities
Increased competitiveness	Over-specialization
Higher new company formation	Institutional and industrial lock-in
High job growth	Local congestion and environment pressure

The main intention of cluster policies is to promote the supply of absent local and regional public goods. Four suggestions are identified. Firstly, the benefits of creating cooperative networks and encouraging dialogue between companies and agencies are emphasized, as companies can exchange information, pool resources, design collective solutions to shared problems, and develop a stronger collective identity. Secondly, collective marketing of an industrial specialism is involved, raising awareness of the region's industrial strengths. Thirdly, some local services, such as financial advice, marketing and design services, should be provided for clusters. Lastly, the weaknesses in existing cluster value chains should be identified, and investors and businesses should be invited to fill these gaps and strengthen demand and supply links.

These measures can be beneficial to local and regional economies. Whether the implementation of such policies within a cluster framework improves the economies' effectiveness and outcomes is debatable, however: some cases show that such a framework is unnecessary or even constraining. Other existing network policy types promoting information sharing between companies can be applied instead of the cluster framework.

Taking all the disadvantages into account, it seems that authorities should encourage local and regional businesses to investigate other forms of cooperation which would enhance their potential results and boost innovations. The cluster concept has achieved enormous popularity among policymakers and the academic community, as it has been accepted as being closely tied to positive images and associations. The cluster concept is associated with a high-productivity, knowledge-rich, decentralized, entrepreneurial, and socially progressive economy within local policymakers' reach.

The concept of a cluster that is reflected in this dissertation relies on companies and associated institutions which can supplement or complete others by completing vertical (buying and selling chains) and horizontal links (complementary products and services, the use of similar specialized inputs, technologies or institutions, and other linkages) using geographical proximity to achieve competitive advantage through cooperation.

1.2. Analysis of Indicators Related to Cluster Performance Evaluation

The traditional bibliometric technique was chosen to identify trends in the cluster literature. Fifty articles were selected, which allowed the research aspects to be systemized and valuable observations to be made. The findings indicate that cluster performance evaluation should be sector sensitive to get the best results and suggest how the cluster execution could be improved. On the national level, clusters usually cannot compare their performance, for there is no system to serve this purpose. A detailed analysis of cluster performance indicators is needed when clusters' performance in transition to CE evaluation tool is composed.

The literature analysis allowed identification of the indicators discussed in research papers when clusters are perceived from the scientific point of view. Nine groups of indicators were identified as being frequently used by scholars, authors having perceived their importance. Some general observations are marked for a more in-depth understanding of the matter.

The first group of indicators was proximity indicators. Scholars view proximity as having an impact on clusters' performance (Table 1.2).

According to Ben Letaifa and Rabeau (2013), geographical proximity is worth the attention that it gets, enabling collaboration and innovation. However, some clusters fail to collaborate despite their geographical proximity. Ben Letaifa and Rabeau's study is based on examining a cluster that fails to collaborate, and the emphasis is on the interaction among geographic, institutional, organizational, cognitive and social proximities. The findings suggest that the most crucial proximity in collaboration achievements is social proximity, while geographical proximity can be harmful for social proximity. What is more, geographic distance may have a positive effect on entrepreneurship and innovation. Naturally formed clusters with private entrepreneurial initiatives are more progressive in innovations than those created by economic policies.

A garment cluster in South India was highlighted by Carswell (2013) through empirical and analytical studies to prove that labour should get more attention in global production networks. A horizontal approach with gender, age, caste, and regional connections taken into account is employed to reveal how social relations and livelihood strategies are relevant in comparison to vertically-linked production networks. Here, effects on workers' livelihoods and social relations are discussed to shape local development of global capitalism.

Table 1.2. Proximity-related indicators commonly used in the scientific literature (Source: Composed by the author)

Authors	Indicator – proximity
Alcácer and Chung (2014)	Supply and demand must be examined in agglomeration economies when localization and concentration take place
Basile, Benfratello, and Castellani (2013)	Location determinants of inward greenfield investments in regions
Bathelt and Zhao (2020)	Geographical proximity impacts interaction and learning in economic contexts
Ben Letaifa and Rabeau (2013)	The emphasis is on the interaction among geographic, institutional, organizational, cognitive, and social proximities
Bindroo, Mariadoss, and Pillai (2012)	Customer cluster proximity's importance to company innovation
Boschma, Minondo, and Navarro (2013)	Regional capabilities may show the tendency for new industries to be developed in regions
Carswell (2013)	A horizontal approach with social networks and vertically linked production networks
Casanueva, Castro, and Galán (2013)	How social networks impact the transition of tacit and explicit knowledge
Castellani, Jimenez, and Zanfei (2013)	The importance of geographical proximity
Crespo, Suire, and Vicente (2014)	Regional resilience through local knowledge sharing.
Pablo D'Este, Guy, and Iammarino (2013)	Geographical proximity
Fallah, Partridge, and Rickman (2014)	Proximity to a research university and proximity in the urban hierarchy
Funk (2014)	Local environments
Helsley and Strange (2014)	Agglomeration efficiencies
Schmitt and Van Biesebroeck (2013)	The relative importance of three dimensions: geographical, cultural and relational proximity
Xiang and Huang (2019)	Geographical proximity facilitates knowledge flows and learning processes
Zhu, He, and Liu (2014)	Geographical relocation, outsourcing, and plant closure

Pablo D'Este, Guy, and Iammarino (2013) are interested in the collaboration between universities and industry, considered an essential channel of potential localized spillovers. According to the authors, the factors that go along with university-industry collaboration, especially geographical proximity, do not get enough attention from researchers and interested parties. For this reason, the authors share their ideas on how clustering and technological complementarity among the companies in a partnership contribute to the formation of university and industry research collaborations.

Fallah, Partridge, and Rickman (2014) pay attention to geography in high-tech employment growth and examine geographic dimensions such as industry cluster effects, urbanization effects, and proximity to a research university. Their study suggests slightly negative evidence of localization or within-industry cluster growth effects rather than positive growth effects. Universities create human capital rather than knowledge spillovers for nearby companies. Three broad geographic factors are suggested for the research: the size of the high-tech sector, the influence of urban agglomeration, and human capital with universities.

The European automotive industry was used as a case to investigate the trends affecting the manufacturing of sophisticated goods (Schmitt & Van Biesebroeck, 2013). It is noted that the importance of proximity in the supply chain has recently grown, and the relative importance of three dimensions is evaluated: geographical, cultural, and relational proximity. The results show that some aspects of proximity are valued in companies' sourcing strategy.

The study by Funk (2014) develops and tests a theory of how a company's local environment influences the ability to generate innovations. The case study shows that networks are beneficial as they create and sustain diversity internally, even when proximity to industry peers decreases.

Bindroo et al. (2012) study's primary concern is the effect of customer clusters on a company's innovation. Multi-country data are used to test the theoretical model of customer cluster proximity's importance for company innovation. Variation in the different innovation outcomes was tested.

Bouncken and Kraus (2013) present a novel notion that describes the simultaneous pursuit of cooperation and competition, termed co-opetition (Table 1.3). This phenomenon can have a dual effect on SMEs' innovations. While co-opetition can trigger radical innovation, it can be also harmful because it results in too novel revolutionary innovation. The damaging or encouraging effects depend on three types of innovation performance: sharing knowledge with the partner, learning from the partner, and technological uncertainty. The study resolves that positive results of co-opetition are achieved in revolutionary innovation when SMEs integrate their partners' knowledge. Hence, a negative influence on revolutionary innovation is discovered when SMEs are sharing knowledge with their partners. Seven different profiles of SMEs are displayed following a latent profile analysis.

Table 1.3. Innovation-related indicators commonly used in the scientific literature (Source: Composed by the author)

Authors	Indicator – innovation
D'Angelo et al. (2013), Funk (2014), Zhu, Geng, Sarkis, and Lai (2015)	Innovation
Bathelt and Zhao (2020)	Industry innovation
Bouncken and Kraus (2013)	Radical innovation or too novel revolutionary innovation
Casanueva et al. (2013)	Product innovation
He and Wong (2012), Tan, Shao, and Li (2013)	Innovation performance
Morrison, Rabellotti, and Zirulia (2013)	Innovativeness
Schot and Steinmueller (2018)	R&D, systems of innovation and transformative change
Tavassoli and Carbonara (2014)	Region's innovation
Wang and Lin (2013)	Technological innovation
Zardini, Ricciardi, Bullini Orlandi, and Rossignoli (2020)	Collaborative, adaptive innovation

The article by Casanueva et al. (2013) is designed to analyse the relationship between social networks and innovation in mature geographical clusters. A wide range of ties are analysed to understand how they impact the transition of tacit and explicit knowledge. The results show that a central position is significant in product innovation, while structural holes are weak. Correlation – regression analysis were applied to compare the variables in a single cluster of 52 SMEs. The authors suggest that longitudinal studies would be useful to examine how different relationships evolve and to see the causality between the variables. More detailed research could be undertaken, taking interactions between the variables as the independent variables.

Correlation – regression analysis is applied to investigate the relationships between corporate knowledge management and innovation performance Lai et al., (2014) suggest that industry clustering has a positive effect on corporate innovation performance and corporate knowledge.

A comprehensive framework is applied by Maskell (2014) to allow discussion of the approaches available to companies engaged in globally extended learning (Table 1.4). The article explores knowledge and solutions from geographically and relationally remote sources that can be acquired through pipelines, listening posts, crowdsourcing, and trade fairs.

Table 1.4. Knowledge-related indicators commonly used in scientific literature (Source: Composed by the author)

Authors	Indicator – knowledge
Bouncken and Kraus (2013)	Sharing knowledge with the partner, learning from the partner, and technological uncertainty; cooperation
Feldman (2014)	Mechanisms and institutions promote the creation of useful knowledge
Heindl (2020)	Explored and exploited knowledge differ strongly between actors
Lai, Hsu, Lin, Chen, and Lin (2014)	Corporate knowledge management
Maskell (2014)	Knowledge can be acquired through pipelines, listening posts, crowdsourcing, and trade fairs
Morrison et al. (2013)	Global pipelines, knowledge endowment, and internal knowledge transfer
Stanko and Olleros (2013)	Three dimensions are studied: the outsourcing of innovation activities, geographic clustering of companies, and mobility of labour
Tavassoli and Carbonara (2014)	The variety and intensity of internal and external knowledge

Correlation – regression analysis is used to ascertain the association between two variables. Tavassoli & Carbonara (2014) identify that both the variety and intensity of internal and external knowledge matter for innovation.

Feldman (2014) provides a literature analysis that observes the mechanisms and institutions that promote useful knowledge.

Two wine clusters in Chile are analysed in terms of networking and the performance of companies within clusters (Giuliani, 2013)(Giuliani, 2013)(Giuliani, 2013). Product success is considered, together with the degree of closure, structural holes, and external openness.

He and Wong (2012) attempt to examine whether local networking is beneficial to companies, what kinds of collaboration contribute more to innovation, and how different collaborations impact innovation performance (Table 1.5).

Li et al.'s (2013) primary concern is the impact of spatial relationships on company performance. An industry cluster in China was the focus of a case analysis, and additional cluster links were determined by companies’ performance. Network relational characteristics, such as tie strength, tie stability, and tie quality, were considered for companies' performance. The results show that distant linkages should be developed to avoid lock-in and entropic deterioration.

Table 1.5. Networking-related indicators commonly used in the scientific literature (Source: Composed by the author)

Authors	Indicator – networking
D'Angelo, Majocchi, Zucchella, and Buck (2013)	One of the critical resources
Pablo D'Este et al. (2013)	Collaboration between universities and industry
Giuliani (2013)	Different kinds of networking
He and Wong (2012)	Local networking
Li, Veliyath, and Tan (2013)	Network relational characteristics, such as tie strength, tie stability, and tie quality, are considered for companies' performance
Lorenzen and Mudambi (2013)	Personal relationships, social network
Tan et al. (2013)	Ties between companies and colleges, ties between companies and industrial associations, and ties between companies
Wang and Lin (2013)	Inter-company relations

Lorenzen and Mudambi (2013) supplement the cluster definition by including links to personal relationships. This theory of the social network allows testable propositions to be formed. Local spillovers have the best potential in global linkages with decentralized network structures. There are two different points in this theory: clusters may have the potential for in-depth (when clusters are linked to the global economy by decentralized pipelines) or in-breadth (when clusters are linked through decentralized personal relationships) catch-up in industries and technologies. The theoretical propositions are illustrated in case studies in two emerging economies in India.

The study's primary interest is the competitive advantage required for companies given the competitive pressures for differentiation and the institutional pressures of conformity (Tan et al., 2013). Measures, such as innovative performance, ties between companies and colleges, ties between companies and industrial associations, and ties between companies are tested. Here, outside companies tend to be isomorphic institutionally and competitively, while significant companies avoid institutional conformity and competitive differentiation.

Table 1.6. Economic indicators commonly used in the scientific literature (Source: Composed by the author)

Financial indicator	Authors	Main points
Export	Blancheton and Hlady-Rispal (2020; D'Angelo et al. (2013); Daddi, Tessitore, and Frey (2012)	Capability distance between new and existing export products; the influence of crucial resources on export performance
External investments	Heindl (2020); Isaksen (2015); Zardini et al. (2020)	External investments are often needed in regions
Foreign direct investment (FDI)	Bathelt and Li (2014)	FDI activities are taken into account in the examination of multinational enterprises
Market efficiency	Alcácer and Chung (2014)	Supply and demand sides of agglomeration economies must be examined
Production	Daddi et al. (2012)	The amount of production
Returns/profit	Dobusch and Schüßler, (2013); Stanko and Olleros (2013); Tokatli (2013)	Increasing returns; profita-bility; profit-making or cap-ital accumulation
Trade quotas	Adrian Smith, Pickles, Buček, Pástor, and Begg, (2014)	Struggling with the removal of trade quotas

Boschma et al. (2013) analyse the emergence of new industries in 50 Spanish regions at Nomenclature of Territorial Units for Statistics (NUTS) level 3 over 30 years to see how regions diversify over time. NUTS 3 is a system for dividing up the economic territory (Eurostat, n.d.). Econometric evidence is provided after Spanish regions are analysed in terms of capability distance between new and existing export products. The results show that regions tend to follow the industrial structure trends rather than the national industrial structure. This assumption suggests that regional capabilities may show that proximity encourages development of new industries in regions.

Alcácer and Chung (2014) question whether companies' location creates a competitive advantage because of agglomeration economies and provide a combination of fundamental economic and strategy concepts. Both supply and demand sides of agglomeration economies are examined, and three fundamental concepts are employed – localization, concentration, and market efficiency – to address several conceptual gaps. The results show that companies tend to choose a location by taking into account all three concepts: companies need more localized factor supply, less concentrated factor pools, and lower risk of appropriation by proximate competitors.

Table 1.7. Research indicators commonly used in the scientific literature (Source: Composed by the author)

Investment indicator	Authors	Main points
R&D	Bathelt and Zhao,(2020; Castellani et al. (2013); D'Agostino, Laursen, and Santangelo (2013)	International R&D investments; high-tech R&D and medium or low R&D
Upgrading	Tokatli (2013); Zhu et al. (2014)	Capital accumulation can differ depending on company upgrades and product upgrades

Stanko and Olleros (2013) study the effects of knowledge spillover mechanisms on industry innovativeness and profit and industry growth changes. Three dimensions are studied: the outsourcing of innovation activities, geographic clustering of companies, and mobility of labour. The findings suggest that outsourcing negatively affects innovativeness but benefits profitability.

Foreign direct investment (FDI) activities are taken into account in examining multinational enterprises (MNEs) and their behaviour regarding global cluster networks and global city-region networks (Bathelt & Li, 2014). It is suggested that multinational cluster enterprises are more likely to set up new foreign affiliates in other, similarly specialized clusters to keep up with global industry dynamics. Conversely, non-clustered companies avoid investing in clusters. Another hypothesis that was generally supported by the investigation of 299 FDI cases from Canada to China is that cluster networks generate horizontal and vertical connections and shape global city-region networks (Table 1.6).

The study by Smith et al. (2014) is designed to show the development of Eastern Europe's clothing industry in recent years; it has been struggling with the removal of trade quotas, increasing competitive pressures, and the global economic crisis.

The importance of geographical proximity for MNEs regarding international R&D investments is discussed by Castellani et al. (2013). The gravity model of trade was used to see how geographical distance impacts R&D investments. The results show that geographic distance has a negative impact on the probability of setting up R&D on manufacturing plants. Meanwhile, once measures of institutional proximity are accounted for, MNEs are equally likely to set up R&D labs in nearby or more remote locations (Table 1.7).

D'Agostino et al. (2013) study the relationship between a region's home and foreign investments in R&D that affects home regional knowledge production. The findings suggest that regions of high income have an advantage in high-tech R&D, while emerging economies have an advantage in medium or low R&D.

A literature study, data collection, and analysis allow Tokatli (2013) to conclude that upgrading has some limitations, and profit-making or capital accumulation can differ depending on company upgrades.

The research by Zhu et al. (2014) investigates environmental problems caused by the intensive industrialization model. The authors suggest that pollution-intensive enterprises could restructure their products through innovation, upgrading, geographical relocation, outsourcing, and plant closure, especially in China's coastal regions.

Table 1.8. Government indicators commonly used in the scientific literature (Source: Composed by the author)

Government indicator	Authors	Main points
Policies	Crespo et al. (2014)	Policy-oriented analysis
	Ketels (2013)	Policies are mostly focused on strengthening existing agglomerations
	Nathan and Overman (2013)	Spatial economy and industrial policy interventions
	Chen (2020)	Short-term development policies should focus on growth
Subsidiaries	Bathelt and Zhao (2020); Corredoira & McDermott, (2014); Xiang and Huang (2019)	How do MNE subsidiaries and local institutions help or hinder emerging market suppliers from upgrading their capabilities?

Corredoira and McDermott's (2014) primary concern is how MNE subsidiaries and local institutions help or hinder emerging market suppliers from upgrading their capabilities. Fieldwork and unique survey data on Argentinian auto parts suppliers were combined to reveal that process upgrading improves when suppliers have ties to institutions that improve access to a range of experiential knowledge. The study shows that suppliers benefit from MNE subsidiaries in cases where suppliers collaborate with non-market institutions and can recombine experiential knowledge with standards gained from the subsidiaries.

Crespo et al. (2014) claim to present an evolutionary framework of regional resilience by emphasizing local knowledge sharing (Table 1.8). Simple statistical measures of cluster structuring are proposed so that the properties of degree distribution (the level of hierarchy) and degree correlation (the level of structural homophily) of regional knowledge networks can be studied. The successful combination of technological lock-in and regional lock-out is analysed. The policy-oriented analysis results show that policies must focus on regional diagnosis and targeted interventions on missing links rather than applying policies based on a definite increase of relational network density.

Ketels' (2013) study is designed to review recent studies on competitiveness and clusters in regions and regional policy. The findings show that policies are mostly focused on strengthening existing agglomerations rather than establishing new ones.

Nathan and Overman (2013) review the development of cluster policies and the evolution of the cluster notion. The authors suggest that governments should pay careful attention to the spatial economy and industrial policy interventions.

D'Angelo et al. (2013) study regional and global pathways to internationalization for SMEs to examine the influence of innovation, human resource management, and networking. The correlation – regression model is applied to compare the variables; the results show that SMEs' export performance varies depending on the geographic scope of internationalization.

Jiang and Miao (2015) present new insights into the structure and dynamics of natural cities. One of their findings is that natural cities evolve in a nonlinear manner in spatial and temporal dimensions as spatially clustered geographic units.

A formal model is developed to examine when global pipelines, which are often said to foster the growth of clusters and innovativeness, contribute to increased local knowledge (Morrison et al., 2013). Various characteristics are taken as dependants, such as size, knowledge endowment and internal knowledge transfer. The results suggest that global pipelines benefit clusters that have high-quality local connections or knowledge endowment.

Daddi et al. (2012) investigate the correlation between eco-innovation and competitiveness within districts (Table 1.9). Fifty-four clusters were examined for the case study, compiling the most eco-efficient districts at the national level. Four indicators were chosen: number of enterprises, employment, production, and exports. The last three years' data were assessed from two districts working in the same product field. The study shows that there is a connection between eco-innovation and competitiveness in some cases.

Through a case analysis, Dobusch and Schüßler (2013) show the relationship between positive feedback on path dependence and increasing returns. Regional path-dependent industrial development is often characterized by lock-in effects when dealing with changes such as path renewal and path creation Isaksen (2015) suggests that regions often need external investments to achieve path renewal and path creation.

Table 1.9. Resource indicators commonly used in the scientific literature
(Source: Composed by the author)

Resource indicator	Authors	Main points
Cluster formation	Ben Letaifa and Rabeau (2013)	Naturally formed clusters with private entrepreneurial initiatives or created by economic policies
Cluster size	De Vaan, Boschma, and Frenken (2013)	Clustering becomes positive after a cluster reaches a critical size
	Daddi et al. (2012)	Number of enterprises
Company's experience	D'Angelo et al. (2013)	One of the critical resources
Growth	Jiang and Miao (2015)	Natural cities evolve in a nonlinear manner in spatial and temporal dimensions
Dimensions	Morrison et al. (2013)	Fostering the growth of clusters
	Wang and Lin (2013)	Company attributes, company size and technological intensity
Employment	Daddi et al. (2012)	Human resources
Human resource management	D'Angelo et al. (2013)	One of the critical resources
Labour	Carswell and De Neve (2013)	Information on occupations, incomes, migration patterns, caste, education, and asset ownership.
Path dependence	Dobusch and Schüßler (2013)	Positive feedback of path dependence
	Isaksen (2015)	Lock-in effects often characterize regional path-dependent industrial development

Carswell and De Neve (2013) emphasize the importance of labour and highlight that it receives less attention from scholars than it deserves. Labour's multiple and everyday forms of agency are seen as helping to shape local developments of global capitalism and producing transformative effects on workers' livelihoods and social relations. The research was carried out in one Indian city and its rural hinterland and took over a year. Quantitative and qualitative information was used for the study and different methods, including case studies, focus group discussions, and in-depth interviews with many garment workers, labour contractors, supervisors and company owners. Participation observation research was carried out in a small garment unit. Overall, the study collected information from 300 garment workers on occupations, incomes, migration patterns, caste, education, and asset ownership.

Longoni and Cagliano (2015) examine how the environment and social sustainability are integrated into operations strategies, as these two issues are becoming critical competitive priorities for companies (Table 1.10). The findings suggest that traditional operations strategies are slightly modified for market-oriented strategies, and capability-oriented strategies need to be supplemented by environmental and social sustainability issues.

Table 1.10. Sustainability indicators commonly used in the scientific literature (Source: Composed by the author)

Sustainability indicator	Authors	Main points
Environment	Blancheton and Hlady-Rispal (2020); Longoni and Cagliano (2015); Prieto-Sandoval, Ormazabal, Jaca, and Viles (2018); Wang and Lin (2013); Wang, Qiu, and Swallow (2014); Zhang and Huang (2012)	Environment integration in operations strategies; regional environment; fresh food accessibility; primary business environment changes in manufacturing outsourcing
Social sustainability	Longoni and Cagliano (2015)	Social sustainability is becoming a critical competitive priority for companies

A large scale questionnaire survey was employed by Wang and Lin (2013) to research technological innovation. Dimensions such as innovation, regional environment, inter-company relations, company attributes, company size and technological intensity were considered. The findings suggest that company-level attributes are essential to innovation, and specific factors are modified by types of innovation and companies' strategies and motivation.

The study by Wang et al. (2014) is designed to research how community gardens and farmers' gardens improve fresh food accessibility. The results show that community gardens tend to cluster with supermarkets.

Zhang and Huang (2012), in their study of supply chain strategy, consider manufacturing outsourcing in China, aiming to investigate the impacts of the significant business environment changes. The findings show that China's coastal part is attractive for clusters formed there and has an efficient logistics service.

1.3. Literature Analysis Concerning Sectors in which Clusters Operate

Economic interests connect cluster members through participation in product or service value creation chains in which sense clusters differ from other cooperation forms. Clusters are more than simple horizontal networks, which are typical of companies working in the same market or depend on the same industry group, cooperating in such areas as R&D, innovations, product creation or purchase policy. More generally, clusters are cross-sectoral (vertical and horizontal) networks composed of different companies that supplement each other, science and education institutions, and other members that can provide reasonable solutions in the cluster value creation chain. Cluster members can efficiently create products or services following participating cluster facilitators, who help find shared cross-sectorial cooperation contacts and develop them.

The literature analysis reveals that clusters and cluster organizations are sector sensitive. Previous studies (Razminienė, & Piccinetti, 2015) showed that every cluster differs depending on its sector. Therefore, involvement in the CE should be measured according to the industry or type of activity, as it is impossible to apply a universal model. The characteristics of companies within an industry may differ, and engagement in the CE may be defined with varying degrees of importance by different companies. Authors interested in the clusters analyse them from different perspectives in their scientific papers, as shown in Table 1.11, according to the sector that clusters belong to. These articles are selected from the Web of Science (Claritive Analytics) database.

De Vaan, Boschma, and Frenken (2013) identify that recent empirical evidence shows that companies in clusters do not outperform companies outside clusters, and spatial clustering based on localization externalities is being questioned. Their study finds that in the global video game industry, the net effect of clustering becomes positive after a cluster reaches a critical size. Two hazard models are used to test the hypothesis concerning failure and acquisition. The study suggests that studies in economic geography should be more sensitive to industry specificities, reflecting the exact nature of localization externalities and different modes of performance.

Tanner (2014) presents a study that considers the emergence of new industries. Literature analysis, patent data and qualitative interviews reveal that some regional diversification processes occur in regions where pre-existing economic activities are not technologically related to the emerging industry.

Table 1.11. Sectors commonly analysed in the scientific literature
(Source: Composed by the author)

Type	Authors
MNEs, global cluster networks and global city-region networks	Bathelt and Li (2014)
Garment clusters, the clothing industry	Carswell (2013); Carswell and De Neve (2013); Smith, Pickles, Bu Ek, Pastor, and Begg (2014)
Footwear cluster	Casanueva et al. (2013)
Auto parts, the automotive industry	Corredoira and McDermott (2014); Schmitt and Van Biesebroeck (2013)
Manufacturing companies	Kuivalainen et al. (2013); Tessitore, Daddi, and Frey (2012)
High-tech sector	Fallah, Partridge, and Rickman (2014); Melnyk, Korcelli-Olejniczak, Chorna, and Popadynets (2018)
Agriculture – community gardens and farmers' gardens	Wang et al. (2014)
Food and beverage – wine clusters	Giuliani (2013)
Universities and industry	D'Este et al. (2013)
Global video game industry	De Vaan et al. (2013)
Creative clusters	Zheng (2011)
New industries	Tanner (2014)
Customer clusters	Bindroo et al. (2012)
Business clusters	Helsley and Strange (2014)

Zheng (2011) shows the impact of creative clusters on urban entrepreneurialism in China. The main concern is that even though these clusters play an essential role in attracting business, they are not productive in terms of fostering talent or boosting entrepreneurship in the creative industry itself.

Different authors agree that geographical proximity is worth the attention that it gets as it enables collaboration, innovation (Ben Letaifa & Rabeau, 2013; Boschma et al., 2013; Castellani et al., 2013; D'Este et al., 2013; Maskell, 2014) and knowledge sharing (Crespo et al., 2014; D'Angelo et al., 2013). Furthermore, social networks are analysed to understand their relationship with innovations (Ben Letaifa & Rabeau, 2013; Casanueva et al., 2013), production (Carswell, 2013) and knowledge sharing (Lorenzen & Mudambi, 2013). The scholars suggest that industry clustering has a positive effect on innovation performance and knowledge (Bouncken & Kraus, 2013; Feldman, 2014; Lai et al., 2014; Morrison et al., 2013; Tavassoli & Carbonara, 2014). Literature study, data collection, and analysis allow the conclusion that profit-making or capital accumulation can differ depending on companies' upgrades (Tokatli, 2013) or path dependence (Dobusch & Schüßler, 2013). D'Agostino et al. (2013) study the relationship between a region's home and foreign investments in R&D that affect a home's regional knowledge production. Recent research on competitiveness and clusters for regions and regional policy shows that policies are mostly focused on strengthening existing agglomerations rather than establishing new ones (Ketels, 2013). The concept of creating shared value which is emphasized by scholars in cluster studies also receives criticism for several reasons, such as not being original, ignoring tension between social and economic goals, being naïve about the challenges of business compliance, and having as its basis a shallow conception of the corporation's role in society. On the other hand, this concept has strengths in successfully appealing to practitioners and scholars, elevating social goals to the strategic level, articulating a clear role for governments in responsible behaviour, adding rigour to ideas of conscious capitalism, and providing loosely connected concept (Crane, Palazzo, Spence, & Matten, 2014).

1.4. Theoretical Overview of the Importance of Transition to Circular Economy

The use of natural resources has increased unprecedentedly in the last hundred years, in line with human development. Due to increased global resource extraction, which has mostly affected economic development in Europe, North America and other parts of the world, transition to the CE becomes a complex task that needs to be maintained by the government and implemented long term (Winans, Kendall, & Deng, 2017). A new ambitious CE package has been adopted by the European Commission (European Commission, 2018) that encourages shifting from a linear economy to a more circular economy that is stronger due to the sustainable use of resources. Benefits will be brought to the environment and the economy through the proposed actions, contributing to closing the loop of product lifecycles through promoting recycling and reuse (Niero & Olsen, 2016).

By definition, CE is viewed as an industrial system designed or intended to be restorative or regenerative (Haas, Krausmann, Wiedenhofer, & Heinz, 2015; Hobson, 2016; Jiao & Boons, 2017; Murray, Skene, & Haynes, 2017) and promoted by scholars, policymakers, NGOs and corporations. Global corporations such as Google, Cisco and Philips took advantage of this idea even before the European Commission presented 'Closing the loop: An EU action plan for the circular economy' (European Commission, 2015; Hobson et al., 2016). However, CE is not that easy for SMEs to implement due to a lack of resources, R&D personnel, information systems, and other limitations that require financing

(Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Ghisellini, Cialani, & Ulgiati, 2016; Lewandowski, Lewandowski, & Mateusz, 2016; Park, Sarkis, & Wu, 2010).

The degree of pollution in the natural environment is recognized as a consequence of stagnant production formation, resource over-consumption, and population growth. The living conditions of people, especially in Western countries, have improved because of industrial development. Although there is another side to this phenomenon, poverty has increased rather than decreased due to economic growth (Mogos, Davis, & Baptista, 2020). Ultimately, poverty has grown faster than the world's gross economic product, demonstrating that living standards depend not only on material wellbeing but also on human relationships with the environment.

This literature analysis aims to offer an overview of the CE and to review the possibilities to connect business and science so that innovative technologies and products are developed to increase SMEs' resource efficiency through clusters and cluster organizations. Generally, SMEs cannot become involved in the CE on their own. They lack knowledge, resources, financing, and other components. These limitations can be eliminated by clusters or cluster organizations. Companies in clusters gain a competitive advantage by being able to integrate into a larger unit and use common properties. Indicators that may help determine the possibility of companies belonging to a cluster being involved in the CE are identified in this chapter. Later in this sudy author suggests the indicators and test how close cooperation and other advantages that companies obtain from belonging to a cluster can affect their engagement in the CE and resource efficiency. These benefits can be used in the further development of circular value chains within a cluster.

Bibliometric analysis was applied to identify the trends in CE and how it is viewed through clusters. The material was selected from the Web of Science (Claritive Analytics) platform, which provides world-class research literature. This platform allows access to the Web of Science Core Collection, the main advantages of which are the fully indexed and searchable publications, with searches across all authors and all author affiliations. Citation alerts allow citation tracking, Citation reports enable the graphical representation of citation activity and trends, and publication patterns can be identified.

The primary search was initiated with the keywords 'circular economy' for a search by topic. The search yielded 4,809 results, with publications from 1991 onwards (Figure 1.1). During the last six years, the number of publications has doubled almost every year, reaching 1,617 in 2019. The growth of interest in the CE is evident, as the total number of publications has reached 4,010 since the number started growing exponentially in 2014. Almost one-third were published during the last year.

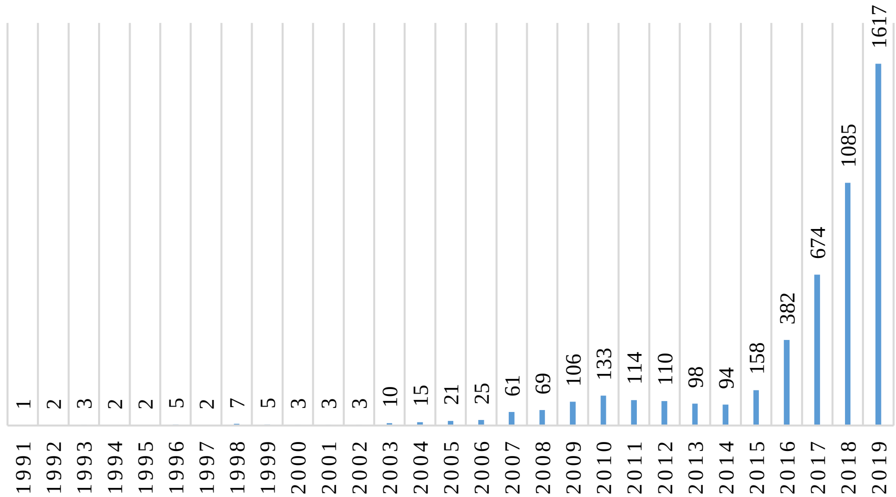


Fig. 1.1. The dynamics of interest in the topic 'circular economy' in Web of Science (Caritive Analytics) database, 1991–2019
(Source: Composed by the author based on Web of Science (Claritive Analytics), 2018)

Further steps included refining the search results according to Web of Science (Claritive Analytics) categories: environmental sciences, green sustainable science technology, engineering environmental, environmental studies, engineering industrial, engineering manufacturing, engineering mechanical, economics, agricultural economics policy, and business. This research includes 50 articles published in the last five years selected using the criteria of search by keywords, Web of Science (Claritive Analytics) categories, and publication years.

The traditional bibliographic analysis was chosen because it allows the researcher to track the latest trends in the scientific literature regarding the CE. In this case, a limited number of articles were selected, disregarding those articles which were highly cited but did not fall into one of the Web of Science (Claritive Analytics) categories selected in this research. From this perspective, the research method can be applied in further analysis taking into account different Web of Science (Claritive Analytics) categories or varying the number of selected articles.

There are numerous articles about the CE that emphasize the growing interest in the field. The concept is studied in various contexts and from different angles. Some trends are noted, and several articles are selected for closer review. Examples of literature analysis, case analysis, or more complex assessment are taken into consideration to present a general image of how CE is studied in the literature. Figure 1.1 notes authors interested in the field and offers significant suggestions for further analysis. The articles are selected according to the usage count in the Web of Science (Claritive Analytics) database.

The CE literature concentrates on different approaches, and consumers and producers must move towards a more circular way of applying materials. Several authors mention a linear take-make-consume-dispose economy (Mendoza, Sharmina, Gallego-Schmid, Heyes, & Azapagic, 2017; Muranko et al., 2017; Rivera, 2018; Zwirner et al., 2017), which seems to be wrong as resources are limited and this may endanger future generations. Waste is considered as a resource or product by Iacovidou, Velenturf, and Purnell (2019), Iuga (2016), Van Ewijk, Stegemann, and Ekins (2018), Velenturf, Purnell, Tregent, Ferguson, and Holmes (2018), Wilts, von Gries, and Bahn-Walkowiak (2016), and Zwirner et al. (2017). The reduce-reuse-recycle is viewed as a component of the CE by Cooper et al. (2017), Ghenţa and Matei (2018), Heyes, Sharmina, Mendoza, Gallego-Schmid, and Azapagic (2018), Moreau, Sahakian, van Griethuysen, and Vuille (2017), Nakamura and Kondo (2018), Vanegas et al. (2018), and Wuttke et al. (2017). Closing the loop as a way towards CE is considered by Braun, Kleine-Moellhoff, Reichenberger, and Seiter (2018), Bressanelli, Adrodegari, Perona, and Saccani (2018), Cerdas et al. (2015), Cole, Gnanapragasam, Singh, and Cooper (2018), Haupt, Vadenbo, and Hellweg (2017), Hobson et al. (2017), Niero, Hauschild, Hoffmeyer, and Olsen (2017), Niero and Olsen (2016), Stewart, Niero, Murdock, and Olsen (2018), and Witjes and Lozano (2016). Lifecycle assessment is highlighted by Boutkhoum et al. (2016), Junnila et al. (2018), Niero and Kalbar (2019), and Van der Voet, Van Oers, Verboon, and Kuipers (2018). Resource efficiency (Huang et al., 2017; Iuga, 2016; Lozano et al., 2018; Michelini, Moraes, Cunha, Costa, & Ometto, 2017; Milios, 2017; Muranko et al., 2017; Nußholz, 2017; Pan & Li, 2016; Popa & Popa, 2016; Reuter, 2016; Smol, Kulczycka, & Avdiushchenko, 2017; Walker, Coleman, Hodgson, Collins, & Brimacombe, 2018; Wilts et al., 2016) or eco-efficiency (Blomsma & Brennan, 2017; D'Amato et al., 2017; Gregorio, Pié, & Terceño, 2018; Guo, Lo, & Tong, 2016; Kalmykova, Rosado, & Patrício, 2016; Liu et al., 2018) is considered to be an essential component of the CE. Greener solutions are costly but crucial when environmental protection is approached.

One of the indicators included by the European Commission (EC) in the CE indicator set in the thematic area 'production and consumption' is the EU's self-sufficiency for raw materials, measured as a percentage. This indicator needs to be mentioned because raw materials are important for the EU's economy. Different industrial sectors are dependent on the raw materials, and they are supplied in a mix of ways, by extraction, recycling and imports. Critical raw materials are sensitive to supply disruption and are of high importance to the economy of the EU. Some countries may have significant environmental impacts that are affected by the extraction of these materials, which might affect environmental policies. The EU sufficiency for raw materials shows how much of the EU's demand is met (Eurostat, n.d.). The indicator is expressed as a percentage and is defined as import reliance. Import reliance is defined in Eurostat and includes measures such as net import, apparent consumption, exports and domestic production.

Some of the raw materials meet the needs of the EU or exceed it, as can be seen in Figure 1.2. These are indium (115%) and limestone (97.1%). Cobalt (68.2%), gallium (65.8%) and tungsten (56.4%) fulfil more than half of the EU's need. Others, like aluminium (36.4%), silicon (36.3%), germanium (35.9%), fluorine (30.3%), iron (25.7), copper (17,5%), vanadium (15.6%), lithium (14.5%), platinum (2.3%) and natural graphite (0.6%) do not reach half of the need. Elements like dysprosium, europium, magnesium, molybdenum, neodymium, phosphorus, tantalum and yttrium are fully imported into the EU. Only a few critical raw materials exceed the needs of the EU; others would be insufficient even if all were recycled or reused.

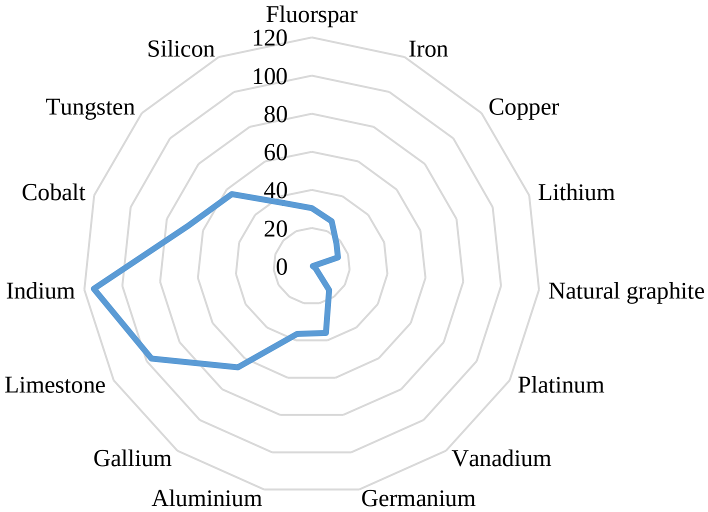


Fig. 1.2. The EU's self-sufficiency for raw materials in 2016, percentages, calculated as import reliance
(Source: Composed by the author, according to Eurostat).

Although EU countries have a variety of raw materials, the amount of them is not sufficient. The resources are limited and not easy to access in some cases. Hence, involvement in the CE might add to the self-sufficiency of critical and other raw material supply by reducing the need to extract them.

During the last forty years the extraction of global materials has grown by 300 percent, Zwirner et al. (2017) state, which threatens the stock of finite materials and causes damage to the planet by filling it with waste, endangering the global economy and ecosystems. Relying on the evolution of resource recovery from waste and some sustainability principles, Zwirner et al. (2017) developed an approach to help develop a dynamic, flexible, transparent valuation. This approach can help move closer to sustainability and set the foundation for future CE assessment methodologies.

The amount of recycled waste materials reaches four gigatons per year (Gt/y), compared with 62 Gt/y of processed materials and 41 Gt/y of outputs in 2005 (Haas, Krausmann, Wiedenhofer, & Heinz, 2015a). The same authors discuss the degree of circularity of the global economy regarding he qualification of different material flows through suggested schemes. The materials discussed in the research – fossil energy carriers, biomass, metals, non-metallic minerals – are far from closing the material loop. The conclusions suggest that a CE cannot rely on recycling alone and other factors of material consumption must be considered, such as materials accumulated as in-use stock and many materials used for energy generation.

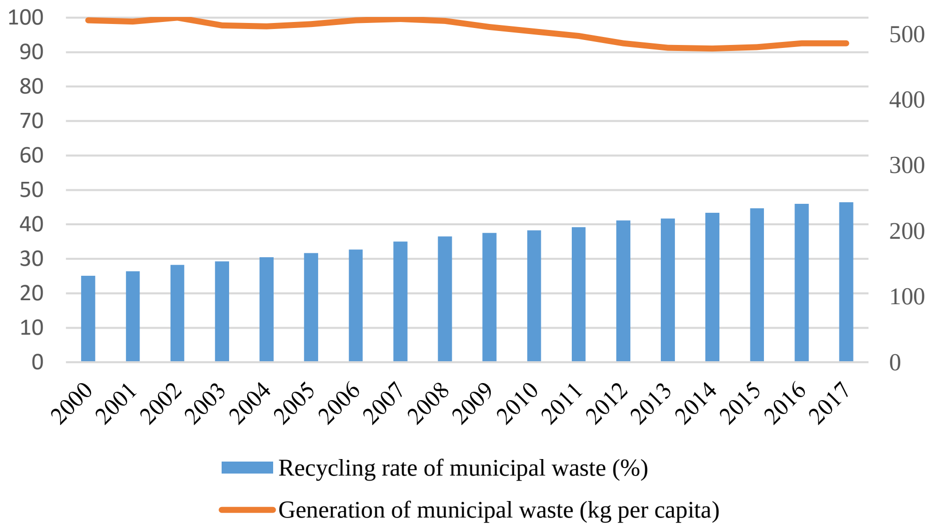


Fig. 1.3. Generation of municipal waste (kg per capita) in comparison to recycling rate of municipal waste (%) in the EU28, 2000–2017
(Source: Composed by the author, according to Eurostat)

From the overall view that is unfolding in Figure 1.3, it might be claimed that the EU28 is moving towards being a recycling society. According to the statistics, 521 kg per capita of municipal waste was produced in 2000, reaching a peak of 525 kg per capita in 2002 and later decreasing to its lowest point of 478 kg per capita in 2014. Over the next three years, the amount of municipal waste per capita grew to 486 in 2017, although, according to the statistics, the peak of 2002 should not be reached soon.

The situation with the recycling rate of municipal waste (Figure 1.4), which measures the share of recycled municipal waste in the total municipal generation, is different. The indicator includes material recycling, composting and anaerobic digestion. The ratio is expressed in a percentage as both measures are expressed in tonnes in primary data. The percentage of recycled municipal waste has grown gradually since 2000 when it was 25.1 percent, reaching 46.4 percent in 2017. The growing amount of generated municipal waste (Figure 1.5) since the lowest in 2014 might have affected recycling, which has slowed down in the same period. Despite that, the recycling rate of municipal waste has grown by 21.3 percent in the given period.

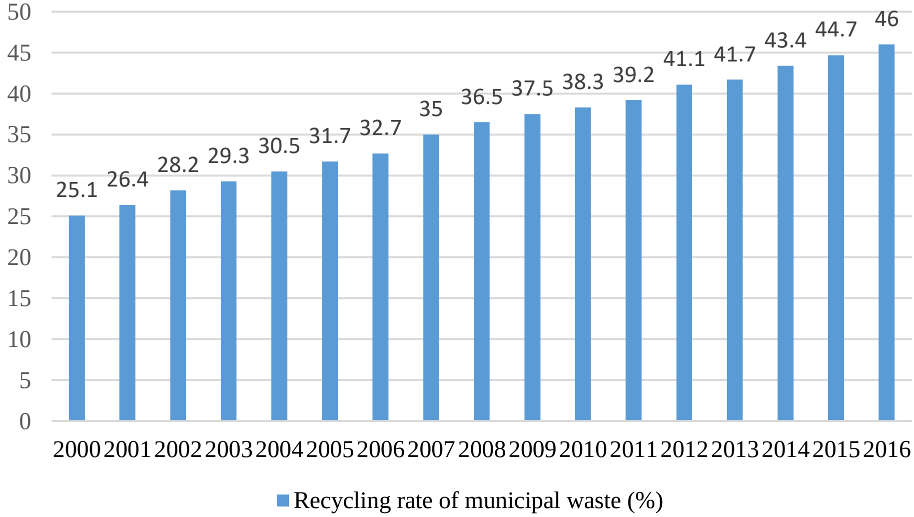


Fig. 1.4. The recycling rate of municipal waste (%) in the EU28, 2000–2016
(Source: Composed by the author, according to Eurostat)

Other authors still claim that such statistics are not satisfactory when transition to the CE is discussed. Wilts et al. (2016) assume that resource-efficient CE must come in action. Only 40 percent of municipal waste generated in the EU was recycled in 2011, while another 37 percent was landfilled and 23 percent incinerated, even though around 500 million tonnes could have been reused or recycled. Ten countries were selected for a case study targeting current national framework conditions. The approach addresses two pillars: the policy and institutional factors versus waste programmes. The study results highlight that the transition from waste management to integrated resource management depends on several components. These components are the context sensitivity of incentive structures, policy mixes, and coordination of policy instruments for transnational chains that often lead to a generation of waste.

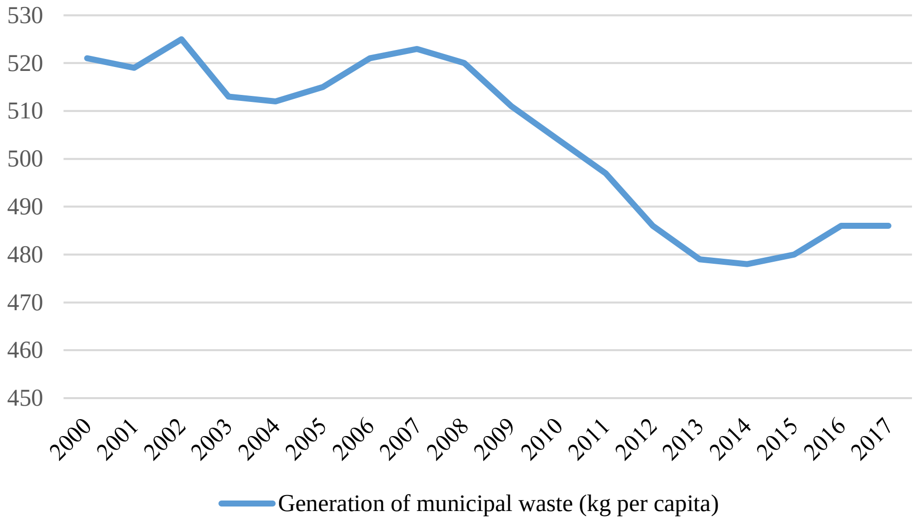


Fig. 1.5. Generation of municipal waste (kg per capita) in the EU28, 2000–2017 (Source: Composed by the author, according to Eurostat)

Li and Su (2012) emphasize the importance of the Chinese chemical industry, shifting to a CE for this industry to counter severe resource shortage. Other eco-environmental problems are present, such as pollution, damaging the ecosystem and lack of resources. Examples are given of companies that have applied the CE in practice through reusing solid waste, waste heat, and effluents. The shortage of resources and infinite demands have encouraged companies to turn to a CE. The method suggested in Li and Su's research helps to diagnose dynamic circular economic development trends and make a comparison between different companies to indicate the stage of CE development. Four features of a CE are indicated: minimum investment, minimum effluents, maximum exploitation of resources, and renewable energies, or least influencing the environment.

Waste is introduced as a product by Iuga (2016). The differences in waste generation in urban and rural areas are described with classification and objectives of solid waste management provided. The author introduces measures which can be identified as aiming at reducing waste: reduction of materials, product durability, production efficiency, substitution of products, recycling, eco-design of products, service maintenance/repair, consumer support in waste reduction, systemizing separation and collection of waste, and encouraging industrial symbiosis. A comparison of different resource efficiency indicators is provided, comparing Romania and the EU by adopting a 'turning waste into a resource' approach, where domestic material consumption in Romania was measured before and after joining the EU. Romania's dependence on imports, which may impact its vulnerability, can be reduced by transitioning to a CE.

It is often suggested that the paper sector has high recycling rates. The study by Van Ewijk et al. (2018) suggests that the previous recycling metrics do not provide enough information, and final products and reused waste as outputs of a process should be considered as material efficiency.

The results of implementing the Resource Recovery from Waste (RRfW) programme in the United Kingdom (UK) are presented by Velenturf et al. (2018). It is identified that the UK's economy is overly reliant on unsustainable production and consumption. Iacovidou, Velenturf, and Purnell (2019) in the study state that materials, components and products (MCPs) reproduced from waste are of a low quality, which makes them uncompetitive with their virgin counterparts. The quality of MCPs and inefficiency encouraged the resource reprocessing industry and the manufacturing sector to look for resource efficiency solutions. A quality assessment typology is suggested in the study, presented in the single-use plastic bottle manufacturing process, although it can apply to any MCP as a screening tool for the identification of sustainable interventions.

The principles of the CE are discussed by Moreau et al. (2017), starting with three main components: reduce, reuse, and recycle. It is highlighted that following these principles may lead to lower energy intensity and higher labour intensity, but the proportions highly depend on institutions. National and economic policies can impact the profitability of CE through waste management and resource efficiency. The core of the economy is presented as labour, which has a renewable nature, and should be involved in remanufacturing and recycling.

Cooper et al. (2017) conduct a study aiming to analyse the energy demand reduction that might be achieved through CE opportunities, and identify the priority areas that should be changed to achieve better results. The findings suggest that CE approaches may be able to reduce energy demand.

The research paper by Witjes and Lozano (2016) is designed to bridge the gap between sustainable public procurement and sustainable business models. The proposed model suggests moving towards a CE by closing the loops through recycling, changing the scheme from price per unit to value provided per service to ensure that technical, non-technical and socio-cultural specifications are included and the responsibility of the product/service is shared. Collaboration between procurers and suppliers is considered, enabling raw material utilization and waste generation to be reduced.

The generation of e-waste, which contains highly toxic materials requiring specialist treatment and other materials such as carbon and valuable metals like aluminium, gold and copper, has grown during the last decade. Cole et al. (2018) present the results of interviews with stakeholders covering end-of-life treatment of e-waste, extending product lifetimes, repair, and reuse. Reuse should be encouraged to reduce carbon emissions, extending product lifetime in this way and closing the loop.

Digital technologies are viewed not only as introducers to serviced business models but also as supporters of CE models in the research by Bressanelli et al. (2018). A framework developed in this study investigates how eight identified functionalities enabled by the Internet of Things (IoT), Big Data, and analytics affect CE drivers (resource efficiency, extending lifespan, closing the loop).

A closed loop production (CLP) system is introduced in the article by Cerdas et al. (2015), referring to a potential reduction of carbon emissions, water consumption, waste avoidance, and embodied energy throughout the lifecycle. A CLP manufacturing system differs from a cradle-to-cradle (C2C) system, ensuring that the producer realizes the amount of material recovered and prevents valuable resources from being disposed to landfill. At the same time, the CLP includes both forward production activities and backflows to the manufacturers. There are three reverse flows: consumer returns, which are lightly used and returned by the customers within the first month, usually not because of defects; end of use, which are intensively used products with outdated technology; and end of life, which are non-functioning ancient products with very high recovery and energy costs. Reverse logistics (RL) is suggested in CLP chains, meaning systematic planning, implementation and management of the returned product flow to recapture the value. Industrial symbiosis is described by Cerdas et al. (2015) as serving to create links between companies to exchange materials, energy, water and by-products. A hybrid manufacturing/remanufacturing system satisfies product demand through manufacturing new products or remanufacturing recovered products. The authors conclude by stating the need to create a production model that merges some elements of the CLP system into operational elements of a company, using the term ‘circulation factories’.

Several studies have been conducted by different scholars (Niero et al., 2017; Niero & Olsen, 2016; Stewart et al., 2018), and aluminium products are usually considered for one lifecycle in lifecycle assessment, although aluminium cans have a high potential for products in multiple loops. In the study by Niero and Olsen (2016), different scenarios were considered; the results show that after 30 loops of aluminium production and recycling, the lifecycle assessment (LCA) option is more environmentally friendly than other recycling scenarios.

In the article by Niero et al. (2017), eco-efficiency, defined as increasing value while reducing resource use and pollution, and eco-effectiveness – the maximization of benefits to ecological and economic systems – are combined to show what challenges occur when creating circular industrial systems. LCA and C2C models were combined to develop a continuous loop packaging system for aluminium cans. LCA adopts a tool-driven approach, which suggests that products' environmental performance should be evaluated.

C2C adopts a goal-driven approach, where the goal is to use a cyclical metabolism through upcycling materials and using waste as a material. Tools and metrics are then developed to measure progress.

Haupt et al. (2017) question in their article whether currently used scales are suitable for measuring the CE. The study shows that national statistics usually refer to data on materials in relation to goods consumed. Such numbers reflect only the input into recycling systems despite the secondary materials produced. Here, the official recycling rates are separated into closed- and open-loop collection, recycling rates, and export rates. The authors conclude that the current system of indicators showing CE rates fails to describe how much material is kept within material cycles. Waste management could be improved by adding closed- and open-loop recycling rates.

Merli et al.'s (2018) extensive literature analysis referring to articles from the Web of Science (Claritive Analytics) and Scopus databases provides an overview of how scholars deal with the topic of the CE. Studies on the CE are concentrated in China and Europe because there are suggestions of how public policies should be implemented there. Scholars view CE at a macro level of analysis (country, region, or city), at a micro level for its operationalization in single companies, and at a meso level for the implementation of industrial symbiosis. The CE concept has blurred boundaries, for there is no clear definition or universal agreement on the guiding principles for action, which allows CE to be associated with a variety of definitions for its roots. Scholars should pay more attention to new approaches to production and consumption, for there has been a lack of consideration of circular design and innovative strategies to slow material and resource loops. Value-focused innovative practices that embody the CE philosophy, such as the sharing economy, product-service systems, dematerialization and remanufacturing, should be further explored by academia. The concept of CE is growing and may open the path towards innovative and sustainable ways of production and consumption.

Liu and Bai (2014) emphasize that companies usually have a good general understanding of the CE, a positive view of it, and a relatively strong willingness to operate it. However, companies lack the enthusiasm to adopt the principles of

CE. For structural, contextual and cultural reasons, knowledge about the positive effects of CE implementation does not encourage companies to work towards it.

Policymakers focus on regulations to overcome the barriers and engage companies in operating a CE. Initiatives should encourage companies to establish eco-industrial chains. Environmental pressure from competing companies and customers does not affect companies' behaviour in shifting to a CE.

Wen and Meng (2015) offer an analysis of substance flow and resource productivity, jointly applied to evaluate the industry's CE performance in China quantitatively. Substances can exit the system at multiple stages in the production chain, and the complicated relationship between enterprises makes the substance flow analysis extremely challenging at the industrial chain level. The research shows that resource productivity is high in the chain. Resource productivity can be enhanced by applying several properties: prolonging industrial chains, connecting chains, matching projects with recycling companies, designing eco-industrial chains, and establishing industrial symbiosis systems.

Industrial symbiosis systems can improve industrial systems' resources and energy productivity by reducing material consumption and waste discharge to yield enormous economic and environmental benefits. The same economic output can be achieved with less resource consumption, as proven by improved resource productivity. Efficient utilization of resources and energy can be reflected in resource productivity, which makes it a suitable index for the promotion of CE and quantitative assessment of industrial symbioses.

Public and political attention can easily be attracted using a catchy framework, and phrases such as regenerate, share, optimize, loop, virtualize and exchange serve the purpose Hobson and Lynch (2016). The problem with these words, according to Hobson and Lynch (2016), is that they are gaining new meaning in the context of a CE but miss out the social and cultural aspects. The meaning of phrases incorporated into the definition of CE requires further exploration and expansion, as they offer non-monetary forms of sharing goods, ideas and experiences.

Social and political facets of the CE lack significant consideration. The consumer-limited and problematic means of engaging with the issues at the heart of the CE, such as responding to environmental labels or renting rather than buying goods, are not strategies that have to date brought about desired widespread adoption of sustainable lifestyles. Here, the point is made that CE debates must include questions related to the society, the citizen, and consumption, which includes broadening the ontological toolkit of CE debates, interventions, and policies to include notions of diverse economies and post-capitalism.

A comprehensive attempt to make sense of the concept of CE is made in scientific research (Korhonen, Honkasalo, & Seppälä, 2018). All three dimensions of sustainable development are highlighted: economic, environmental, and social. The CE concept contributes to the importance of high value and high quality material cycles in a new way and shows the possibilities of the sharing economy alongside sustainable production for a more sustainable production-consumption culture.

Park et al. (2010) state that the integration of business value elements can guide organizations to gain a competitive advantage while looking at the broader perspective of supply chains and eco-industrial parks. Sustainability within supply chains takes on a more critical role as supply chain competitive advantage, rather than individual, organizational competitive advantage, becomes essential. Relationships within and between organizations in a CE economy can be quantified by developing formal models and simulations.

According to the European Commission (Eurostat, n.d.), a CE is about minimizing the generation of waste and maintaining the value of products, materials and resources for as long as possible. This new economic model offers tremendous opportunities to save natural resources and combat climate change, making production, consumption and waste management more sustainable and creating local green jobs.

The Circular Economy Action Plan, which was released by the European Commission in December 2015, offered a framework for monitoring progress, aiming at the stimulation of transition towards this new model. It is essential to track progress, although the process is not easy as the transition involves different areas. Such a monitoring tool should help citizens and policymakers to identify success factors and help to identify the areas where more action is needed. A more circular economy is a long-term aim that needs new priorities to be set to achieve better results.

Ten indicators in four areas are included in the CE monitoring framework, generally covering the Circular Economy Action Plan: production and consumption, waste management, secondary raw materials and competitiveness, and innovation. The structure of indicators is suggested by the European Commission to cover the four areas and reflect the concept of closing the loop (Figure 1.6).

Information on these indicators is available from Eurostat, the Joint Research Centre (JRC), the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), and the European Patent Office. The indicators which need development are further elaborated, especially for methodology and data collection. Data are regularly updated to ensure that reporting is consistent. The four thematic areas cover these indicators: EU self-sufficiency for raw materials; generation of municipal waste per capita; generation of waste excluding major mineral wastes per GDP unit; generation of waste excluding major mineral wastes per domestic material consumption; the recycling rate of municipal waste; the recycling rate of all waste excluding major mineral waste; the recycling rate of packaging waste by type of packaging; the recycling rate of e-waste; recycling of biowaste; the recovery rate of construction and demolition waste; the contribution of recycled materials to raw materials demand; the circular material use rate; trade-in of recyclable raw materials; private investments, jobs, and gross value added related to CE sectors; and patents related to recycling and secondary raw materials.

Fig. 1.6. Circular economy monitoring framework
(Source: Circular economy. Closing the loop, 2018)

Part of the information in this set of indicators is covered by statistics from each country collected by national statistics departments. Another part is provided generally for the EU as a unit.

Scholars see the CE as a priority for better performance. It is viewed from different perspectives: resource efficiency or eco-efficiency, where waste is considered as a resource, closing the loop; and reduce-reuse-recycle approaches and lifecycle assessment.

The CE occurs at several levels: within the company, between businesses, between businesses and consumers, and between consumers. It also needs to involve the public sector. Clusters involve different actors that can encourage engagement in the CE.

1.5. Review of Methodology Used in Cluster Performance Analysis and Transition to Circular Economy

Scholars are analysing clusters, cluster literature and the CE from different aspects and employ various techniques for the multidisciplinary nature of the subject, making it hard to trace the changing themes in the literature (Li et al., 2013; Tanner, 2014; Zheng, 2011). Literature analysis usually depends on traditional direct citation counts and co-citation analysis (Lazzeretti et al., 2014), which in general are past-oriented but can help to trace emerging themes or identify the shortage of attention to some aspects worthy of further examination (Figure 1.7).

A case study is the most frequently used method in cluster analysis. Different authors, including Alcácer and Chung (2014), Ben Letaifa and Rabeau (2013), Boschma et al. (2013), Bouncken and Kraus (2013), Carswell (2013), Daddi et al. (2012), Dobusch and Schüßler (2013), Funk (2014), Giuliani (2013), He and Wong (2012), Isaksen (2015), Li et al. (2013), Lorenzen and Mudambi (2013), Morrison et al. (2013), Schmitt and Van Biesebroeck (2013), Tokatli (2013), and Zhang and Huang (2012), rely on this method as it enables close or in-depth research of a single or small number of cases in their natural conditions. It is also important to note that in this type of analysis, the context and other complex conditions related to the selection must be studied to understand the object integrally. The case study helps to answer the questions, whether they are descriptive – what is happening or has happened? – or clarifying questions – how or why did something happen? (Yin, 2012). The case study is also valuable for allowing information to be collected from a real-world setting, avoiding derived data. In these particular researches, various clusters are taken into account to examine their conditions and gain a closer understanding of a study's hypothesis.

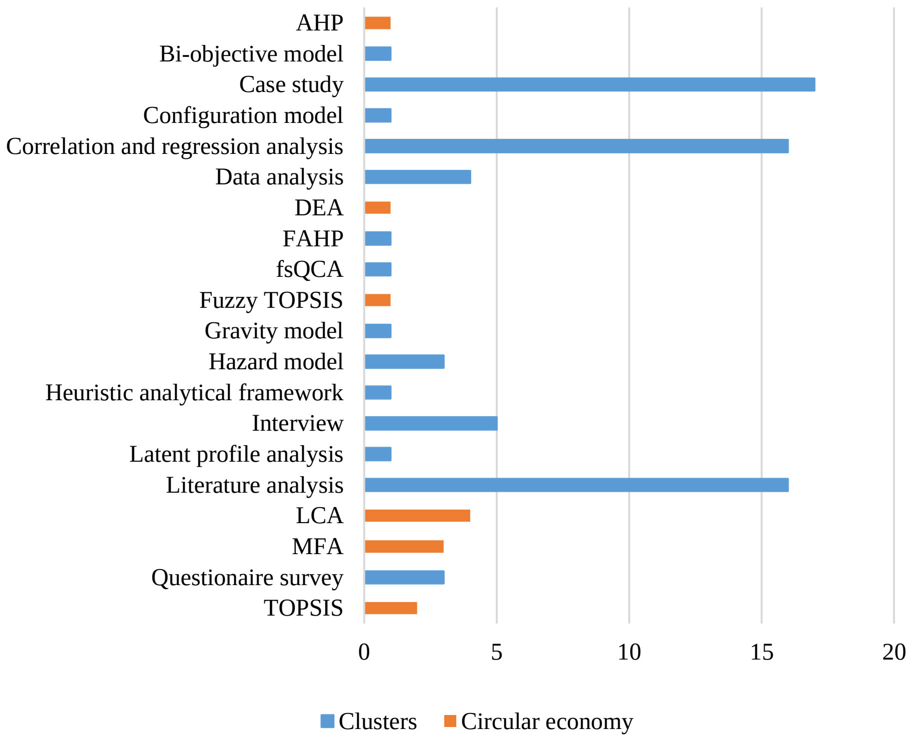


Fig. 1.7. Methods used for cluster and circular economy analysis, Web of Science (Claritive Analytics) database 2013–2015
(Source: Composed by the author based on Web of Science (Claritive Analytics), 2018)

Correlation – regression analysis are among the most popular methods of analysis and are used by scholars in cluster research. Correlation allows the association between two variables which are not designed as dependent or independent to be measured, while regression is used to examine the relationship between one dependent and one independent variable.Regression consists of statistics prediction capabilities of performed analysis that can be used to predict the dependent variable if the independent variable is known. In cluster analysis, different variables include localization, concentration and market efficiency (Alcácer and Chung, 2014); social networks and innovation (Casanueva et al., 2013); knowledge sharing (Crespo et al., 2014); human resource management, networking and the company's experience (D'Angelo et al., 2013); eco-innovation and competitiveness (Daddi et al., 2012); localization externalities (De Vaan et al., 2013); industry cluster effects, urbanization effects and proximity to a research university (Fallah et al., 2014); local networking (He & Wong 2012);

corporate knowledge management and innovation performance (Lai et al., 2014); network relational characteristics (Li et al., 2013); outsourcing of innovation activities, geographic clustering of companies and mobility of labour (Stanko & Olleros, 2013); innovative performance, ties between companies and colleges, ties between companies and industrial associations, and ties between companies (Tan et al., 2013); variety and intensity of internal and external knowledge (Tavassoli & Carbonara, 2014), and innovation, regional environment, inter-company relations, company attributes, company size and technological intensity (Wang & Lin, 2013; Wang et al., 2014).

Literature analysis is used by Ben Letaifa and Rabeau (2013), Boschma et al. (2013), Carswell (2013), Crane et al. (2014), D'Agostino et al. (2013), D'Este et al. (2013), Dobusch and Schüßler (2013), Feldman (2014), Hervas-Oliver et al. (2015), Ketels (2013), Lazzeretti et al. (2014), Lorenzen and Mudambi (2013), Maskell (2014), Nathan and Overman (2013), Tanner (2014), Tokatli (2013), and Zhu et al. (2014).

Bibliometric analysis was used in the study by Lazzeretti et al. (2014) to review the cluster literature and its evolution by considering the works of the most prominent researchers. An original database of 1,586 academic articles was created by the authors, consisting of articles about clusters and industrial districts published from 1989 to 2010 in international scientific journals. The clustering algorithm was used to group articles into sub-communities after backward citation analysis. Hervas-Oliver et al. (2015) suggested a prospective review, employing bibliometric techniques of literary analysis to identify emerging topics or lines in the cluster literature. A bibliographic coupling method was introduced to cluster analysis, allowing the detection of current trends and future cluster analysis priorities among scholars. Bibliometric analysis is regarded as a traditional method of analysis with direct citation counts, and bibliometric coupling is invoked to verify the validity of this method in identifying emerging topics or lines in the cluster literature.

As a method, an interview can be defined as a research technique involving a small number of respondents elaborating on a particular idea, situation or programme. Interviews can be conducted in different formats: structured, semi-structured, or unstructured. The most significant advantage of an interview is that a researcher has direct control over the process of collecting detailed information on research questions and can clarify specific details during the process. Bouncken and Kraus (2013), Isaksen (2015), Tanner (2014), Tokatli (2013), Zhu et al. (2014), and other authors use this method in their research.

Data analysis is used as a method to obtain a considerable amount of information from a particular database and is used by Boschma et al. (2013), Castellani et al. (2013), Crespo et al. (2014), D'Angelo et al. (2013), and Tanner (2014) in cluster research.

A questionnaire can be used to gather a considerable amount of data in a relatively short period of time by means of specific questions planned by a researcher. In this way, it outweighs data analysis. On the other hand, the answers cannot be clarified during the process, as is possible during an interview. A questionnaire was chosen by Li et al. (2013), Tan et al. (2013), and Wang and Lin (2013).

Lifecycle assessment (LCA) is used by several authors. An LCA-based model was used by Walker et al. (2018) to test several business models that aim to achieve greater material efficiency. The conclusions of their study suggest that the CE supports reducing resource consumption and reusing, remanufacturing, and recycling materials, and complex indicators should be included to evaluate the circulation.

Wuttke et al. (2017) consider that the reduce, reuse, recycle (3R) concept ensures environmental conservation and economic growth through the effective use of resources. Two of these constituents, reduce and reuse, are considered to be of high priority for development as they work to prevent waste. Several methods are employed in the Wuttke et al. (2017) research, such as material flow analysis (MFA), LCA, substance flow analysis (SFA), lifecycle cost (LCC), analytic hierarchy process (AHP) and technique for order of preference by similarity to ideal solution (TOPSIS).

A combination of two MCDM methods is proposed by Boutkhoum et al. (2016) for industrial organizations in application of green supply chain management solutions in practice.

Guo et al. (2016) view eco-efficiency as an essential sustainable development to interact with industrial output, resource utilization, and environmental impacts. The study identifies that data envelopment analysis (DEA)-based models are usually used to analyse eco-efficiency, supplemented by the decomposition approach. The results show that changes in industrial structure have an impact on eco-efficiency and economic development.

The hazard model used by De Vaan et al. (2013), Giuliani (2013), and Wang et al. (2014) can be defined as survival-time outcomes on one or more predictors. It is used to investigate the effect of several variables when a specified event happens.

Latent profile analysis, used by Bouncken and Kraus (2013), attempts to estimate the likelihood of each variable, the probability of each observation falling into each class, and any observation falling into a class.

Castellani et al. (2013) employ the gravity model, which helps to identify the influence of phenomena on each other that varies according to the distance between them.

The configuration model is used by Longoni and Cagliano (2015); it is commonly employed to study the complexity of the interactions among operations priorities. The multi-dimensional model is often used to chart relationships between variables that are too complex to be modelled.

Stanko and Olleros (2013) use fuzzy set qualitative comparative analysis (fsQCA), an analytical technique that implements principles of comparison for both intensive and integrative analysis. Information can be processed regarding different combinations of conditions that give a specific outcome.

The bi-objective model is built by Zhang and Huang (2012) to aid analysis. It is widely used to model supply chain configuration problems, as it naturally fits to evaluate trade-offs between costs and lead times.

Zhu et al. (2014) formulated a heuristic analytical framework to demonstrate how environmental regulation, political environment, and regional hub effect impact a company's strategies, while these impacts are also affected by the company's attributes and capabilities.

The methods used by authors are employed to evaluate clusters or CE as independent entities. They do not aim to analyse clusters when the transition to CE considered. The originality of the thesis is revealed through the results of literature analysis. The results indicate that the methodology of evaluation for cluster performance in transition to CE was not suggested before.

These considerations determined the choice of evaluation methods for cluster performance regarding CE, described in later chapters.

1.6. Conclusions of Chapter 1 and Formulation of the Tasks of the Thesis

1. The literature analysis suggests that the definition of a cluster varies depending on the context where it is used. In this dissertation, clusters are defined as a form of cooperation among companies and associated institutions which can supplement or complete each other by completing vertical (buying and selling chains) and horizontal (complementary products and services, the use of similar specialized inputs, technologies or institutions, and other linkages) links using geographical proximity to achieve competitive advantage through cooperation. This definition reflects the main features that clusters must reflect.
2. Nine groups of indicators were identified after the literature analysis that may be used in clusters' performance evaluation. These include proximity, innovation, knowledge, networking-related indicators, economic, research, government, resource and sustainability indicators. Scholars view them as having a different impact on clusters' performance. Some groups of indicators are interrelated or

can be divided into smaller units, which suggests that some aspects should get more attention while others can be omitted when composing the system of indicators for clusters' performance evaluation.

3. Resource efficiency is becoming more important for SMEs. They are interested in reducing energy, material and water costs, and they are starting to look at circular business models to turn their waste into assets. Clusters and clusters' organizations can play a considerable role in SMEs becoming more resource-efficient.
4. Literature suggests that the CE is an essential and promising concept, as it attracts the business community to more sustainable development. The CE is meaningful in cluster development, and it may be one of the most significant competitive advantages. Different units, individual companies, or clusters can use it in their activities. Clusters emphasize the importance of competitive advantage in their activity. Thus, the CE should be emphasized by individual companies in clusters.
5. Competitive advantage is what makes companies cooperate in clusters. CE may help companies achieve this goal, as clusters can connect with corresponding parties to target resource efficiency, recycling, re-use of materials, and other activities within a unit. The necessity to propose cluster performance evaluation in transition to CE economy tool is seen when development and improvement of cluster is expected.

2

Methodology of Evaluation Tool for Cluster Performance in Transition to Circular Economy

This chapter describes the methods used to form an evaluation tool for cluster performance in transition to CE, and selected indicators. The MCDM process is explained, and two methods, SAW and TOPSIS, are characterized in data processing and calculation of the results. The correlation method is suggested in the final stage of the research. The indicators selected to include in the evaluation of clusters' performance and transition to CE are characterized in detail, and the tool is presented.

The findings of Chapter 2 have been published in scientific papers (Razminienė, 2019b, Razminienė & Tvaronavičienė, 2018b, Tvaronavičienė & Razminienė, 2017, Tvaronavičienė & Razminienė, 2017b).

2.1. Formation of Evaluation Tool for Cluster Performance and Transition to Circular Economy

The monitoring and evaluation of performance are crucial for clusters in the process of management. Economic growth may be achieved by applying these procedures as necessary measures, and up-to-date data are taken into account. The selection of methods was performed after the literature analysis and in line with the actual situation with data accessibility.

There are several studies where clusters are assessed in some way. Different aspects are viewed in the analysis of clusters. Despite attempts to identify the essential components and indicate their influence on each or several factors analysed by scholars, it is still complicated to evaluate cluster performance. Different methods are applied to analyse qualitative and quantitative data, such as correlation – regression analysis (Casanueva et al., 2013; Crespo et al., 2014; D'Angelo et al., 2013; Lai et al., 2014; Tavassoli & Carbonara 2014), the gravitation model (Castellani et al., 2013), and case analysis (Ben Lafeita & Rabeu, 2013; Boschma et al., 2013; Bouncken & Kraus, 2013; Carswell, 2013; Dobusch & Schüßler, 2013; Lorenzen & Mudambi, 2013; Morrison et al., 2013; Tokatli, 2013). The problem of providing the most effective way to evaluate the data on different phenomena mentioned in cluster studies could be solved by performing a quantitative evaluation of cluster performance (Ginevičius, 2007; Rutkauskas & Ginevičius, 2011).

From a variety of methods used in research on clusters and CE analysis, several were selected for further consideration. Literature analysis was already employed, which enabled the tracing of how cluster and CE research has evolved over time, how interest in these topics has changed, and what thematic issues are still to be considered. This method helped to reveal that clusters and the CE are gaining popularity, and these topics should be considered together in terms of how they can be affected by each other, and what might be the consequences of this interaction in the future. Literature analysis has also revealed that scholars have made no attempt to evaluate how clusters contribute to the transition to CE, which validates the thesis's novelty.

Other methods were selected to complement the study and refine the results. The use of interviews and questionnaire surveys for cluster analysis confirms the assumption that researchers may experience a lack of reliable statistical data. This happens because clusters are composed of companies that differ in size, specialization, and degree of involvement in everyday activities. This is an explicit limitation when the collection of data is considered. Most of the information required in the following research is considered confidential at the company level, although it should be available when a cluster as a unit is viewed. Researchers need to collect this information through different channels. One way is to arrange interviews with the coordinators of clusters. This method requires a high level of engagement on the part of coordinators with in-depth knowledge of every member, and it takes time to proceed with data collection. The other option is a questionnaire survey that allows the collection of information and verification of data with members of clusters until an answer is arrived at. The data's reliability might be questionable when either of these methods is used to collect data as it is somewhat subjective. However, it is not obligatory to submit data describing clusters' performance to any state authority, and no official source of information was available at the time of data collection. Hence, a questionnaire survey was used as one method of inside data collection in this research.

A case study is unquestionably relevant in cluster analysis, and the popularity of the method among scholars confirms that. When choosing a case study as a research method, it is considered that a researcher examines phenomena in context without influencing the environment. This method is easy to adapt to previous methodological choices and complements the tool when a research strategy is adopted. In the literature, scholars usually apply a multiple case study where several clusters are selected within the same industry. An embedded case study is selected in this thesis to provide practical validation of the suggested methodology, as just some aspects of cases are examined.

It is complicated to evaluate cluster performance as the data for the indicators to be included in the tool are expressed in different units of measurement. These aspects should be formalized in the most appropriate solution. Many methodologies are used in decision-making that share common characteristics of conflict among criteria, incomparable units, and difficulties in selecting alternatives. Scholars suggest different multi-criteria evaluation methods for quantitative evaluation of a particular phenomenon (Chen, 2012; Ginevičius et al., 2013; Simanaviciene & Ustinovichius, 2010).

Several MCDM methods were seen to be used in both cluster and CE studies. Methods such as AHP, DEA and TOPSIS are mentioned in the literature (Boutkhoum et al., 2016; Guo et al., 2016; Wuttke et al., 2017) as being used in CE studies, while some methods can be integrated into the research strategy to involve clusters.

Ginevičius et al. (2013) emphasize the importance of developing a set of criteria as a stage of multi-criteria evaluation of a complex phenomenon. A single level set of criteria can be provided for experts to determine each criterion's weight if number criteria is small and possible to conceive. On the other hand, if more criteria make it difficult to separate the most important ones from the less important, their number must be reduced by forming a hierarchical structure where each hierarchical level is evaluated, starting with the lowest. Hence, the weight of the criteria at each hierarchical level must be determined.

Correlation – regression analysis is one of the most frequently used cluster analysis methods, where the degree of association between quantitative variables is identified. This method is selected for use in the final stage of the cluster performance in transition to CE evaluation tool. Correlation – regression analysis enables us to draw conclusions when two variables – clusters' performance and transition to CE – are considered.

Attention is paid in this work to cluster performance evaluation and transition to CE evaluation, and the final step seeks to track the relationship between these two variables. The tool presented in this chapter can be used for selection of possible indicators for cluster performance and transition to CE evaluation or for monitoring and improving cluster performance in transition to CE.

2.2. Selected Indicators for Evaluation of Cluster Competitiveness through Circular Economy

Clusters' development may enhance the competitiveness of the economy. Governments should contribute by encouraging and improving clustering.

The following are aspects of clusters' development (Lietuvos klasterių plėtros koncepcija, 2017):

- Developing clusters' innovative potential.
- Encouraging the export of products created by cluster members and connection to international value chains.
- Enhancing the efficiency of the activities of cluster members.
- Forming a friendly environment for clusters' establishment, activities, and development (ecosystem).
- Encouraging cross-sectorial, interregional and international cooperation.
- Spreading the benefits and potential of clustering.
- Encouraging SMEs' resource efficiency through clustering.

On the national level, clusters usually cannot compare their performance, for there is no system to serve this purpose. Close analysis of cluster performance indicators will enable a cluster evaluation tool to be formed to serve this purpose at the national level. Authors have made earlier attempts to compose a system of indicators for cluster efficiency evaluation at the national level by identifying indicators and applying benchmarking techniques to verify the methodology's reliability. A system of indicators previously suggested by the author needs to be supplemented by the inclusion of indicators that enable the identification of how engagement in a CE adds to the competitiveness of companies belonging to the cluster.

Resource efficiency is attracting more interest in Europe and globally (Shahbazi, Wiktorsson, Kurdve, Jönsson, & Bjelkemyr, 2016). Environment-oriented clusters have escalated this topic, and many have adopted a CE as their specific focus to help SMEs learn about CE and resource efficiency through initiated projects. Clusters are essential agents for demonstrating how SMEs can become more resource-efficient and innovative, and gain competitive advantage. Companies' circular value chains may be developed, as clusters usually unite companies that share such activities and may cultivate links to corresponding partners.

There have been attempts to evaluate CE cluster development using objective information entropy, a subjective AHP model (Zhang, Wang, & Hong, 2013), and green supply chain performance (Jun, 2009; Zhu, Geng, & Lai, 2010), although these studies need to be improved and require more in-depth analysis. Industrial symbiosis in the form of eco-industry that represents resource flows of geographically clustered companies is studied by scholars from a CE point of view (Yu, Han, & Cui, 2015). Eco-industrial parks may have developed from standard industrial parks but they still encounter barriers to development (Bellantuono, Carbonara, & Pontrandolfo, 2017; Geng, Fu, Sarkis, & Xue, 2012; Shi, Chertow, & Song, 2010; Zhu et al., 2015).

Using the results of the literature analysis of clusters' performance and CE (Genovese, Acquaye, Figueroa, & Koh, 2017; Kazancoglu, Kazancoglu, & Sagnak, 2018; Mesa, Esparragoza, & Maury, 2018), a hierarchical structure was arranged according to the universal themes to enable experts to evaluate the importance of each criterion. The most significant intention is to provide an adequate number of criteria in one group, not exceeding 12 criteria. In the presented tool the maximum number is ten: it is still possible to process this number of criteria, and they are divided into groups according to theme. The main components are intercommunication, financial resources, human resources, marketing activities in cluster performance, and other CE components. The criteria that are singled out give the measures for these components.

The main aim of cluster monitoring is to create conditions to adopt evidence-based solutions to improve the competitiveness in the economy through promoted and efficient clustering. The Agency for Science, Innovation, and Technology (MITA) is responsible for monitoring and evaluating clustering in Lithuania. Currently, this agency is working as a coordinator on implementation of the Promotion and Development of Innovation Networking (InoLink) project, funded by the European Fund for Regional Development. The Lithuanian Innovation Centre works to implement the project. The project's main aim is to encourage companies to merge into clusters to increase cluster maturity and promote growth and international collaboration (KlasterLT, 2018).

The suggested tool for clusters' competitive advantage includes two groups of components: clusters' performance criteria and CE performance measures. The first group is unquestionably essential to measure a cluster's performance and see how it links to competitive advantage and enables the detection of areas that need to be developed for the cluster's better performance. The second focuses on the CE economic indicators through the perspective of clusters.

Lots of attention has been paid to the selection of indicators to form the evaluation tool for cluster performance in transition to CE. The close literature analysis in Chapter 1 helped to indicate nine separate groups of cluster performance indicators. These groups needed clarification and more specific points. The choice was determined by the author when the alternative national and international tools were viewed and intersecting points recognized. The criteria that were selected for clusters' performance evaluation are based on the literature analysis (Chapter 1), the national document Lietuvos klasterizacijos studija (2017), and the European Secretariat for Cluster Analysis (ESCA), which suggests benchmarking and quality labelling for clusters worldwide. The selected experts were asked to approve the suggested indicators. This procedure resulted in 25 indicators that included features from the mentioned sources and underwent a procedure of verification by the experts. The second group of indicators suggests measures of the CE, which may add to a cluster's competitiveness if implemented in cluster activities. This group is based on EC planned actions in monitoring the process of transfer to CE (Eurostat, n.d.) and is described below.

In previous research, the importance of clusters' performance evaluation was emphasized and a possible methodology for clusters' performance evaluation was suggested. Here, the system for cluster performance evaluation in transition to CE is presented. It consists of 35 indicators and starts with two fundamental parts: clusters' performance evaluation and transition to CE evaluation.

Here, clusters' performance includes four components: intercommunication, financial resources, human resources, and marketing activities (Figure 2.1). Three components – intercommunication, financial resources, and marketing activities – include six indicators, while human resources include seven indicators. All components do not exceed the recommended number of indicators, which leaves them undivided into smaller categories.

Intercommunication activities include indicators that can help cluster members to share their knowledge, create interpersonal relations, and communicate through different channels (Table 2.1).

Regular meetings of cluster members can be arranged according to need. In this case, it is essential to indicate how often the members should meet in person to ensure that they are seen often. These regular meetings can include personal visits of the cluster coordinator to a cluster member. Whether there are any cluster integration events should be indicated, and how often they take place. A typical communication platform would enable coherent information flow for all members and allow convenient access to the shared pool of information. Different cluster publications can be released, such as booklets, newsletters, and others. Other important activities include cooperation when creating new products or technologies and when creating innovations. Innovations can be organizational, marketing, and others. Cluster members can also participate in training, workshops, conferences, and internships to uphold their interpersonal relations while raising their qualifications. Smooth knowledge transfer can be ensured by a common database and informal sharing of knowledge and experience. Technology transfer must also be ensured in a cluster.

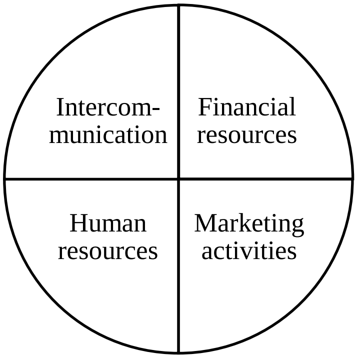


Fig. 2.1. Clusters' performance evaluation components
(Source: Composed by the author)

Table 2.1. Intercommunication criteria in cluster performance evaluation
(Source: Composed by the author)

No.	Criterion
C1	Cooperation when creating new products or technologies
C2	Cooperation when creating innovations (organizational, marketing and other)
C3	Joint training, workshops, conferences, internships
C4	Common database
C5	Informal sharing of knowledge and experience
C6	Transference of technologies

Marketing activities include indicators which enable promotion of the cluster in the society (Table 2.2). This can be achieved through joint supply and ordering schemes, as well as distribution channels. Cluster members can prepare tenders to reach external clients. Common market information should be exchanged between cluster members to help identify companies belonging to the same unit. Leaflets, media and other means of communication could be used for cluster advertisements. Exhibitions and fairs can work as suitable means of cluster promotion with cluster members' participation as representatives. The internet can help inform the public about the cluster and promote visibility. A logo or brand as visual identification helps cluster to be easily recognizable in any context. Advertising can work on different channels, although the cluster's image in mass media should be highlighted and maintained.

Table 2.2. Marketing activities criteria in cluster performance evaluation (Source: Composed by the author)

No.	Criterion
C7	Common supply and order scheme
C8	Common distribution channels
C9	Common cluster members' tenders for external clients
C10	Exchange of common market information between cluster members
C11	Common participation in exhibitions and fairs
C12	Visual identification (common logo, brand)

Human resources indicate the qualifications of personnel in a cluster, what kind of training they get, how the cluster is coordinated, and other necessary information (Table 2.3).

Table 2.3. Human resources criteria in cluster performance evaluation (Source: Composed by the author)

No.	Criterion
C13	Increase in cluster members' employees in two years
C14	Number of employees upgrading qualifications in two years
C15	Average salary of cluster members
C16	University graduates working at cluster companies
C17	Number of cluster members – companies, R&D subjects, supporting organizations
C18	Number of members that coordinates cluster
C19	Years of cluster establishment

The indicators in human resources criteria include the increased number of employees in member companies during the last two years to indicate growth, the number of employees who participated in internal cluster training during the same period, and the number of trainings organized by the cluster in two years. How many employees have upgraded their qualifications in the last two years needs to be indicated? The number of university graduates working in cluster companies helps to indicate the qualifications of personnel. Was there an increase in direct employment in innovative cluster activities, and how many employees work for R&D activities? The cluster members' structure should be clear, naming companies, R&D subjects, supporting organizations, educational institutions, and the number of members that coordinates cluster.Financial resources are composed to include indicators that determine financial information about cluster initiatives (Table 2.4).

Table 2.4. Financial resources criteria for evaluation of cluster performance (Source: Composed by the author)

No.	Criterion
C20	Common cluster projects in last two years
C21	Financed common cluster projects in two years with cluster initiatives co-financing
C22	External financing of cluster initiatives in two years
C23	Number of joint submitted/funded EU SF projects in two years
C24	Number of joint international R&D projects, not funded by EU SF, in two years
C25	Total amount of cluster members' investment in cluster initiatives in two years

Clusters are highly dependent on funding, which is why different means of funding are selected for evaluation. The number of joint cluster projects should be indicated. Co-financing of cluster initiatives is crucial in cluster development, so the number of such financed cluster projects in two years should be provided. External financing of cluster initiatives should be stated in the same period. European institutions demonstrate the importance of R&D, and investment is promoted, which means that the part played by R&D expenses in the same period needs to be provided. Projects submitted and funded by the European Union Structural Funds (EU SF) need to be indicated, and international R&D projects prepared by cluster members with backing other than by the EU SF. How many cluster members have invested in cluster initiatives in the last two years?

These cluster performance criteria give information that can be evaluated using other methods. Categories can be supplemented or replaced by other criteria according to need, although attention should be paid to the importance of every criterion so as not to reduce the survey's quality.

The extensive literature analysis regarding the CE in Chapter 1 yielded crucial results. Scientists emphasize the importance of a CE for SMEs, whereas the CE criteria were selected according to literature analysis. Clusters are identified as accelerators for SMEs to become involved in a CE and turn to resource efficiency.

The CE component is also organized in a hierarchical structure. The CE includes ten indicators that are not further divided into sub-components, because this number of criteria is suitable for experts' processing. The CE component is supplementary, adding to the cluster's competitiveness, while the cluster performance component is viewed as giving preliminary information about a cluster.

The EC suggests a set of indicators when transition to a CE is identified in EU countries (Table 2.5). Some of the indicators may apply to clusters. Here, the median of two years is calculated for all types of waste to get a more reliable result. Municipal waste includes the total amount of waste that is declared by cluster members. It involves packaging waste (excluded plastic packaging and wooden packaging), which can be recyclable or non-recyclable but is not distinguished by these features. Plastic packaging and wooden packaging are identified separately. e-Waste is a specific waste stream which includes parts that can be recycled or reused. Construction and demolition waste has the highest potential to be recovered. Trade in recyclable raw materials is considered for closing the loop as the materials and products can be reused in other materials and products. This is very important when the extraction of natural resources is considered and possibly reduced. Trade-in recyclable raw materials are considered in terms of imports and exports with companies outside of the cluster. The exchange of recyclable raw materials within a cluster may show the cluster's circularity and potential to cooperate in the CE transition.

The information for CE indicators is complicated to collect and measure. A cluster comprises several components, such as companies, organizations, and educational or research centres. They can be enrolled in a CE to different degrees and through various activities. Hence, numbers will vary depending on the activities that companies are engaged in. Engagement in a CE is highly dependent on the sector in which a cluster operates.

The indicators selected in the suggested system of indicators for evaluation of cluster performance and transition towards CE are considered the most appropriate to serve the research's purpose. However, CE indicators suggested by the EC needed to be adapted as recycling rates were considered, and here we have generation of different types of waste without recycling rates. On the company level, the recycling rate cannot be calculated as the specific companies that are members of selected clusters do not account for recycled waste.

Table 2.5. Circular economy criteria in evaluation of clusters' transition to the circular economy (Source: Composed by the author)

No.	Criterion
C26	Generation of municipal waste per cluster
C27	Packaging waste
C28	Plastic packaging waste
C29	Wooden packaging waste
C30	e-Waste
C31	Biowaste
C32	Construction and demolition waste
C33	Trade in recyclable raw materials: imports
C34	Trade in recyclable raw materials: exports
C35	Trade in recyclable raw materials: intra

The collection of data went through several stages, as different sources had to be trusted (Table 2.6). Cluster performance indicators in intercommunication activities and marketing activities were evaluated by cluster coordinators through a questionnaire. Data on human resources – mainly the increase in the number of cluster members' employees in two years, the number of employees upgrading qualifications in two years, and the number of university graduates working at cluster companies – were provided by cluster coordinators through a questionnaire. Data about the average salary of cluster members were collected from open company data provided by the State Social Insurance Fund Board under the Ministry of Social Security and Labour, State Budgetary Institution (SODRA). The number of cluster members (companies, R&D subjects, supporting organizations), the number of cluster coordinating members and years of cluster establishment were collected from the official website KlasterLT, created and administrated by MITA, where information about clusters is provided. Data on financial resources were provided by cluster coordinators through a questionnaire.

The data on transition to a CE were also taken from different sources: all data about the generation of waste – generation of municipal waste per cluster, packaging waste, plastic packaging waste, wooden packaging waste, e-waste, bio waste, construction and demolition waste – were collected from the Environment Protection Agency (EPA), and cluster coordinators provided data on all three indicators of trade in recyclable raw materials – imports, exports and exchanges of recyclable raw materials within a cluster – through a questionnaire. As a long view needs to be taken to achieve better results for the workforce in terms of achieving a competitive advantage, assuming that proper management is applied (Pfeffer, 1995), two years (2017–2018) were chosen for this work. The median of these two years was calculated because it is more informative in this case.

Table 2.6. Types of data source by criteria (Source: Composed by the author)

Category	Crite-rion	Description	Source
Cluster performance evaluation	C1	Evaluation on 1–8 scale	Questionnaire
	C2	Evaluation on 1–8 scale	Questionnaire
	C3	Evaluation on 1–8 scale	Questionnaire
	C4	Evaluation on 1–8 scale	Questionnaire
	C5	Evaluation on 1–8 scale	Questionnaire
	C6	Evaluation on 1–8 scale	Questionnaire
	C7	Evaluation on 1–8 scale	Questionnaire
	C8	Evaluation on 1–8 scale	Questionnaire
	C9	Evaluation on 1–8 scale	Questionnaire
	C10	Evaluation on 1–8 scale	Questionnaire
	C11	Evaluation on 1–8 scale	Questionnaire
	C12	Evaluation on 1–8 scale	Questionnaire
	C13	Percentage growth in 2 years	Questionnaire
	C14	Number of employees	Questionnaire
	C15	Two-year median	Sodra.lt
	C16	Number of employees	Questionnaire
	C17	Number of members	KlasterLT
	C18	Number of coordinators	KlasterLT
	C19	Age of a cluster	KlasterLT
	C20	Number of projects	Questionnaire
	C21	Number of projects	Questionnaire
	C22	Two-year median	Questionnaire
	C23	Number of projects	Questionnaire
	C24	Number of projects	Questionnaire
	C25	Two-year median	Questionnaire
Transition to CE evaluation	C26	Two-year median	EPA
	C27	Two-year median	EPA
	C28	Two-year median	EPA
	C29	Two-year median	EPA
	C30	Two-year median	EPA
	C31	Two-year median	EPA
	C32	Two-year median	EPA
	C33	Share of trading members among all members	Questionnaire
	C34	Share of trading members among all members	Questionnaire
	C35	Share of trading members among all members	Questionnaire

The most significant limitation of the thesis was available open public data, which are only obtainable to a certain degree, making it difficult not only to proceed with the assessment of the results when the methods are applied, but even in the earlier stages. Due to this limitation, most of the data were collected through a questionnaire survey directly from cluster coordinators, and official reports presented by MITA and Eurostat. Clusters do not collect data about the companies that belong to them until required for joint projects. Information on the company level is usually not available due to data protection, which further complicates the task for a cluster coordinator who cannot access it without the company's permission.

The two groups of components – clusters' performance criteria and transition to CE criteria – can increase clusters' competitive advantage when they are evaluated regularly. The set of criteria was composed to serve universal needs. These evaluation criteria can be applied to a cluster from any sector when the need to monitor and assess performance and transition to CE is identified.

2.3. Selected Methods for Evaluating Cluster Performance in Transition to Circular Economy and their Relationship

When clusters performance in transition to a CE need to be evaluated, a particular scheme must be applied and certain steps followed. Several methods are used. When the data are collected, they must be processed by applying mathematical tools: MCDM methods and correlation – regression analysis. Two MCDM methods are applied in this study: simple additive weighting (SAW) and the technique for order of preference by similarity to ideal solution (TOPSIS). These methods are appropriate for the tool.

MCDM is a well-known branch of decision-making. It deals with decision problems that involve several decision criteria. MCDM as a discipline is relatively young: the models and techniques of modern MCDM started to develop in the 1950s and 1960s, when many scholars began to propose new models and MCDM techniques. Interest in this field has grown, and the number of studies has grown continuously in the past decades (Vinogradova, Podvezko, & Zavadskas, 2018; Zavadskas, Turskis, & Kildiene, 2014).

MCDM is most directly characterized by a set of multi-criteria methods. The methods developed since the 1950s differ in the required quality and quantity of additional information, the methodology used, the simplicity, the sensitivity of tools used, and the mathematical properties they verify (Zavadskas et al., 2014). The main features shared by different methodologies are conflict among criteria, incomparable units, and difficulties in selecting alternatives. The alternatives are not predetermined in MCDM: a set of objective functions is optimized by a set of constraints. The best solution is sought by evaluating a small number of alternatives against a set of criteria that are often hard to quantify. The alternatives are sought by comparing the selections considering each criterion. The MCDM process is shown in Figure 2.2.

MCDM methods can be used to solve both theoretical and practical problems. They are universal in their potential to evaluate quantitatively any complicated object described by a set of criteria (Ginevičius & Podvezko, 2008). Quantitative multi-criteria evaluation methods differ in their concept, type of data normalization, the way of combining the data, the criteria weights determination, the range of variation of criteria values, and the influence of the initial data (Ginevičius & Podvezko, 2010). The critical point is that it is possible to make decisions based on multi-criteria analysis results, to compare them, and to analyse the reasons for some alternatives to demonstrate better results than others (Ginevičius & Podvezko, 2008). In order to apply multi-criteria evaluation methods, the following procedures should be performed in three steps: a set of criteria describing the object considered should be developed; the criteria weights and significances should be determined; and an appropriate multi-criteria evaluation method should be chosen.

The purpose of quantitative evaluation of cluster performance in transition towards a CE is the effective management of the cluster after the targeted criteria are examined and all possibilities of improving them are considered and applied. Multi-criteria analysis should perfectly serve this purpose and allow valuable observations of cluster performance in transition to CE improvement to be made after the evaluation. A hierarchical structure must be considered for cluster performance evaluation, then SAW and TOPSIS methods applied to process the data.

A socioeconomic system is vast and complicated. Therefore, the main goal is grouping the criteria describing its performance according to particular characteristics rather than searching for their interrelations (Ginevičius, Podvezko, & Ginevičius, 2013). Before providing the criteria for evaluation by the experts, a hierarchical structure must be created with different hierarchical levels for experts, who cannot cope with numerous criteria. As mentioned before, the number of criteria must not exceed twelve, so a hierarchical structure must be divided into hierarchical levels depending on the connecting theme of the criteria. It has been proved that the accuracy of the decisions made by experts does not decrease if the evaluations are close to equal (Libby & Blashfield, 1978). If the number of experts is seven, the accuracy of evaluations is more than 90 percent, and there is no significant change when the number of experts is increased.

The next step includes expert evaluation, with the weights assigned by the experts. Their given weights must be reasonable and coincide to a certain degree.

The expert evaluation is based on the assumption that a decision can only be reached after assessing the compatibility of experts' opinions. The weights of indicators are determined in that way. Notably, expert evaluation depends on the expert's qualifications, work specifics, and other measures. In this work, all these recommendations were followed: experts are selected according to their competences, which makes expert evaluation reliable and suitable for determining the significance of indicators. Any measurement scale can be applied to the assessment – units of indicators, percentages, a ten-point system. Experts evaluate the indicators by ranking them. Ranking is a procedure in which the most critical indicator is given a rank equal to one, and others are ranked according to importance.

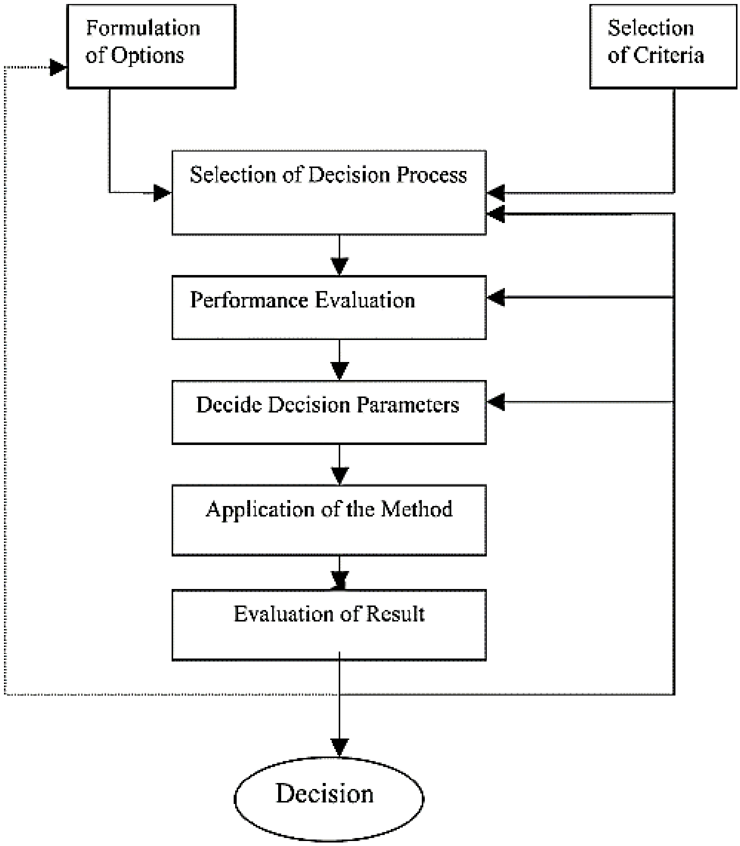


Fig. 2.2. Multicriteria decision-making process
(Source: Pohekar, Ramachandran, Pohekar, and Ramachandran, 2004)

Since experts give the weights of criteria, the consistency of their evaluations should be checked. This is usually done using Kendall's concordance coefficient W (1) and criterion value χ^2 (Podvezko, 2007):

$$W = \frac{12S}{T^2(m^2 - m) - T\sum_{t=1}^{T} R_t}, \tag{2.1}$$

where m is the number of comparators or elements, T is the number of experts, S is the deviation of the sum of the squares of the expert assessments from the overall average (3), and R_t is the associated rank indicator (4).

If the expert opinions are consistent, the value of the concordance coefficient $W$is close to one; if the estimates differ significantly, the value is close to zero.

$$\chi^2 = \frac{12S}{Tm(m+1) - \frac{1}{m-1}\sum_{t=1}^{T} R_t}. \tag{2.2}$$

According to the chosen significance level (in practice, the value is usually 0.05 or 0.01), we find the critical value χ^2_{kr}. If the value of χ^2 calculated according to formula (2) is higher than χ^2_{kr}, it means that the expert estimates are consistent.

$$S = \sum_{i=1}^{m} (s_i - \overline{s})^2, \tag{2.3}$$

when s_i is the sum of the ranks of each comparator, $\overline{s}$ is the total average

$$R_t = \sum_{g=1}^{G_t} \left(l_g^3 - l_g\right), \tag{2.4}$$

where $l_g$is the number of tied ranks in each (l) of G_t groups of ties.

When the consistency of experts' opinions is calculated, the weights of the indicators are determined. All weighting methods are based on an expert survey. The most common methods of determining weights are direct and indirect ranking. The direct weighting method is most commonly used in practice. The method is as precise and logical as the ranking of indicators, but its accuracy is much higher. The sum of weights of each expert's assessments must be equal to one, or 100 percent, when the direct method of determining weights of indicators is used.

Further processing of the results must include a multi-criteria evaluation. Multi-criteria methods are used for both theoretical and practical tasks since they are universal and enable a quantitative study to be carried out for any complex phenomenon with many indices (Ginevičius & Podvezko, 2008, 2010; Ginevičius et al., 2013).

Various aspects should be formalized in the evaluation of cluster performance, which means that the criteria should be developed and integrated into one generalized quantity. This is not a trivial task, because the criteria may be multidimensional and oppositely directed, which implies that some criteria's increasing values may indicate that the situation is getting better while an increase in the values of other criteria shows that the situation is worsening. To solve these problems, multi-criteria evaluation methods, widely used in recent years, may be applied (Ginevičius et al., 2013).

The SAW method was developed in 1968 and has been applied for MCDM in various fields, including MCDM problems, group decision-making, contractor ranking, performance assessment models in a sector, and the evaluation of certain zones, analysis and ranking (Zavadskas et al., 2014). This method is one of the simplest and most often used methods in MCDM techniques (Malczewski, 1997). The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by the decision-maker, then summing the products for all criteria.

SAW's underlying logic is to obtain a weighted sum of the performance ratings of each alternative overall attribute.

$$K_p = \sum_{i=1}^{n} w_i q_{ij}. \quad (2.5)$$

Here, K_p is the value of the multi-criteria evaluation by the SAW method, w_i is the weight of the i -th indicator, and $q_{ij}$is the normalized value of the indicator.

The initial data if the criterion is minimizing are normalized according to the formula

$$\bar{r}_{ij} = \frac{r^{min}}{r_{ij}}, \quad (2.6)$$

where $\bar{r}_{ij}$ is the value of the i -th criterion of the j -th alternative.

If the criterion is maximizing, it is normalized according to the formula:

$$\bar{r}_{ij} = \frac{r_{ij}}{r^{max}}. \quad (2.7)$$

The best values of the maximized indicators are the highest: the situation of the phenomenon improves with increasing value of the indicator. The best values of the minimized indicators are the lowest: with increasing value of the indicator, the situation deteriorates. This normalization process transforms all the ratings in a linear (proportional) way so that the relative order of magnitude of the ratings remains equal. The higher the value (K_p), the more preferred the alternative (j) is (Chang & Yeh, 2001).

Bublienė, Vinogradova, Tvaronavičienė, and Monni (2019) have suggested an ideal solution to the SAW method. This ideal solution is found by selecting the the best value from a sample for every indicator. Attention should be paid to whether an indicator has a minimizing or maximizing effect. This way of comparison allows turning SAW results in numerical value or percentage towards the ideal solution.

Among various MCDM methods, TOPSIS, proposed by Hwang and Yoon (1981), is used widely and is based on the concept of the compromised solution. Generally, in the TOPSIS method, the alternative is chosen that should simultaneously have the shortest distance from the positive ideal solution (PIS) and the longest distance from the negative ideal solution (NIS). The PIS is a solution that maximizes all the benefit criteria and mimimizes all the cost criteria, whereas the NIS is a solution that maximizes all the cost criteria and mimimizes all the benefit criteria. However, neither the PIS nor the NIS exists; otherwise making decisions would be very easy. Therefore, the question of balancing the alternatives from the PIS and the NIS plays an influential role in realistic decision-making. The application of TOPSIS requires a decision matrix with a set of alternatives over a set of criteria and the specification of relative weights defining these criteria.

Suppose the values of each indicator are continually increasing or decreasing. It is then possible to determine the ideal solution, which consists of the best indicator values, and the negatively ideal solution, which consists of the worst indicator values. It is necessary to construct a decision matrix X to apply the proximity point approach. The process takes several steps, which are further explained in Annex A, until the gathered results allow the alternatives to be ranked.

In many situations, the alternatives that can be considered are initially infinite (Abdulgader, Eid, & Rouyendegh, 2018). Multi-criteria methods are an excellent solution for cluster performance evaluation, as specific criteria are depicted and structuralized, experts determine their weights, the consistency of the experts is checked, and the values are calculated using two MCDM methods, SAW and TOPSIS, to check the result.

The tools with their descriptions and methods of application are presented in this sub-chapter. MCDM methods are recognized as suitable for use in the study for cluster performance in transition towards CE evaluation, as they are comprehensive, easy to apply, allow evaluation of data using different measures, and give adequate results, which is very important in quantitative analysis.

Correlation – regression analysis is applied when a relationship between two variables is to be detected. The correlation coefficient shows the strength of the relationship between the factors and its type (positive or negative). The correlation coefficient only measures linear dependence. Once the statistically significant correlations are identified, the plot of estimates of these factors is drawn and a linear function is determined, linking both factors (Muller & Fairlie-Clarke, 2001).

$$y = ax + b. \tag{2.8}$$

Here, x is estimates of the first factor, y is estimates of the second factor, and a and b are coefficients of the linear regression model.

The coefficient of determination R^2 of the correlation relationship is determined, which can be interpreted as a part of the data that corresponds to the established correlation. The formula determines the coefficient of determination:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Y_i - \widehat{Y_l})^2}{\sum_{i=1}^{n}(Y_i - \overline{Y_l})^2}, \tag{2.9}$$

where, $\widehat{Y_l}$ is the estimates of the variable y calculated from the regression equation, $\overline{Y_l}$ is the average of the variable y, and n is the sample size.

2.4. Proposed Methodology for Evaluation of Cluster Performance in Transition to Circular Economy

A cluster performance evaluation tool that allows assessment of clusters' contribution to the transition to CE is created and includes indicators suitable to evaluate cluster performance in transition to CE selection process, requirements for clusters and CE experts, tools for evaluating clusters and transition to CE performance, and a tool for detecting if there is a relationship between these two variables.

A detailed description of the proposed tool implementation is provided in this subchapter. It takes several stages to complete.

Economic growth is inseparable from new jobs, business opportunities, new markets and possible earnings. These factors go along with changing mindsets, business models, innovative products, and services. SMEs are usually unable to follow the desirable direction of contribution to economic growth with limited resources.

World-class innovations, technologies, knowhow and new inventions are usually ascribed to large companies with generous financial benefits. Clusters can also create economic growth conditions with all these conditions created by contributing members in clusters, usually united SMEs, higher education institutions (HEIs), research centers (RCs), non-governmental institutions (NGOs), and other constituents with necessary features.

Implementation of the cluster performance in transition to CE evaluation tool starts with identifying indicators suitable for cluster performance evaluation and evaluation of the cluster's transition to a CE (Figure 2.3). A cluster is a compact unit, and when its performance is evaluated attention needs to be paid to related parties and different operations. In this step, it is necessary to compose two separate systems of indicators to fulfil the requirement to identify the relationship between the cluster's performance and its transition to a CE.

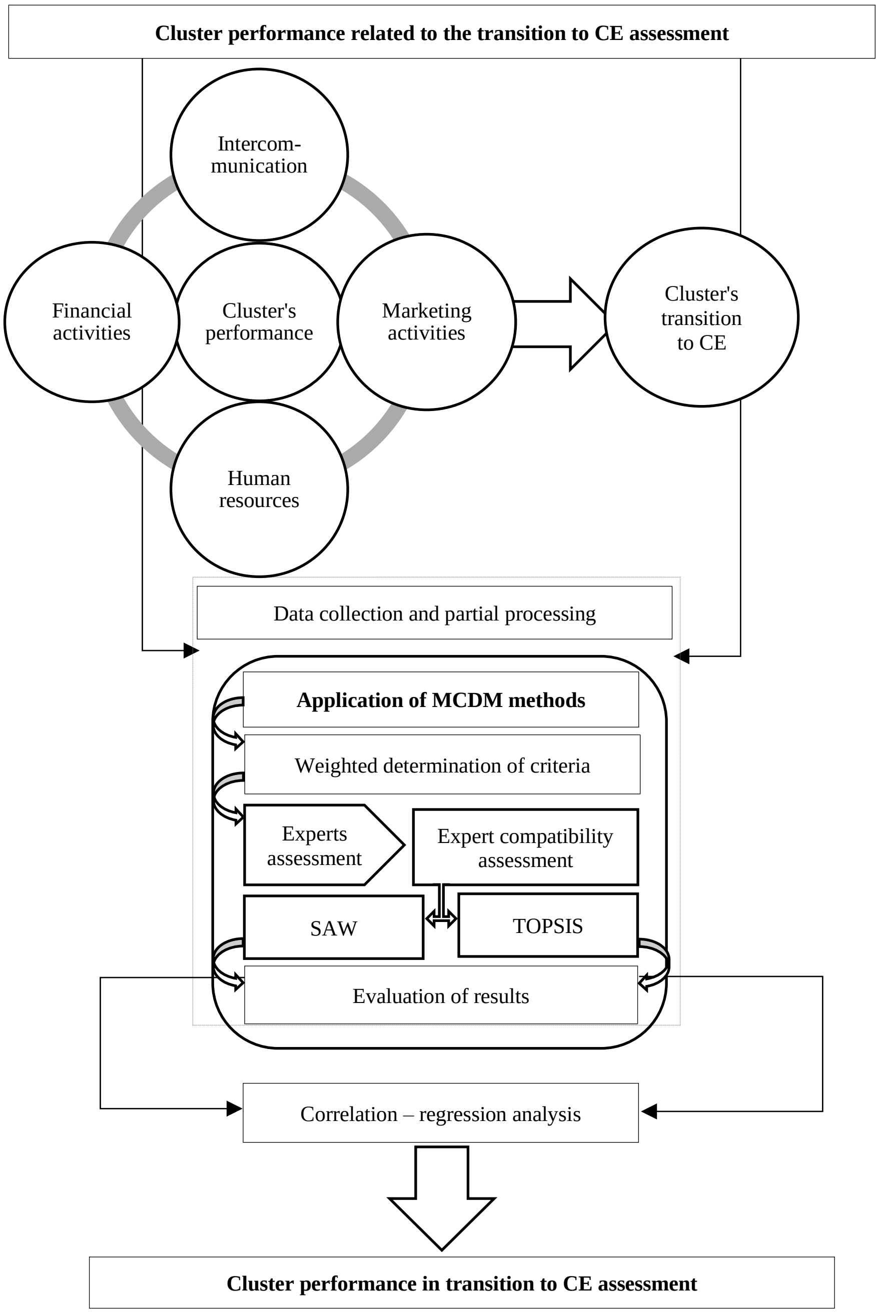


Fig. 2.3. Cluster performance in transition to circular economy evaluation tool (Source: Composed by the author)

The detailed literature analysis performed in Chapter 1 of this work helps to identify the indicators that are most representative for the task to be completed.Then, data need to be collected according to the selected indicators. Several sources may be needed to gather all the information. The most accessible information is from official/public/open sources. The official sources used in this work are the State Social Insurance Fund Board under the Ministry of Social Security and Labour (Sodra), with open access to information on a company level; the EPA, with limited access to information on a company level; and KlasterLT, with general information on the cluster level. Another source of reliable information is cluster coordinators, who can collect data from primary sources on request. Experts are addressed to approve the indicators and highlight their importance by ranking the indicators and assigning weights. Experts are chosen according to their experience in the field.

The next step requires the application of appropriate tools to evaluate the cluster performance and transition to CE. The evaluations for these two subjects are done separately through the application of SAW and TOPSIS methods. These two methods were chosen as they are simple to apply and give numerical evaluations. SAW gives a result that may be somewhat scattered when several samples are to be compared, while TOPSIS suggests a scale from 0 to 1 or can be easily transferred into a percentage. The two methods are chosen to check the tool's reliability when the final step is implemented.

The last step reveals a connection between cluster performance and transition to CE. Correlation – regression analysis is used, which is the most frequently used statistical mathematical method when a relationship between two variables needs to be checked. It is important to note that all the results need to be reviewed by an expert to get reliable outcomes.

The results and findings must be revised and resolved by decision-makers. Decisions on what to emphasize when the resources are allocated can be made according to the results, as different criteria are included in the evaluation tool. Some indicators are cumulative and depend on every member of a cluster. Financial and other resources on the cluster level should have an impact on individual members. It is necessary to examine a cluster in detail in terms of its members and their possible contribution to a cluster while cluster performance regarding transition to the CE should evaluated regularly.

2.5. Conclusions of Chapter 2

1. Clusters can represent ideal local ecosystems to recycle, use waste as a resource, and foster a CE. Cluster organizations' ability to connect and facilitate collaboration between the different stakeholders of value

chains has been stressed as a critical element in the success of CE implementation. The need to create a cluster performance in transition to CE evaluation tool was identified here as clusters members seek competitive advantage and transition to a CE may add to it.

2. Two groups of components were proposed in the cluster performance in transition to CE evaluation tool: clusters' performance evaluation and transition to CE evaluation. These components include indicators that show performance on a cluster level and cumulative indicators that refer to cluster members' overall performance.
3. Combining these two groups of components – cluster performance criteria and CE criteria – may upgrade the cluster's competitive advantage. Data collection for the determined indicators may be complicated, as only some are available from readily accessible open sources. Another part is provided by cluster coordinators that have to gather it directly from cluster members.
4. Methods were selected for the assessment of the results. Expert evaluations were suggested to estimate the weights of both groups of components: cluster performance evaluation and transition to CE evaluation. Two MCDM methods are described as applicable for assessment of the results: SAW and TOPSIS. Both methods are accessible and easy to apply and can be used to evaluate a complex phenomenon. Correlation – regression analysis is used as a method to detect the relationship between two variables.

3

Evaluation of Cluster Performance in Transition to Circular Economy: The Case of Lithuania

This chapter seeks to approve the proposed cluster performance in transition to CE evaluation tool, applied to a case of Lithuanian clusters. An overview is presented with a suggested cluster map, the adoption of expert evaluations, and calculation of cluster performance evaluation in transition towards CE. The proposed cluster performance in transition to CE evaluation tool has been tested in seven Lithuanian clusters. This tool was applied according to the sequence of steps presented in the previous chapter. This tool can be applied in Lithuania by repeating the procedure every year and benchmarking the results. Such continuation would serve to detect areas which need improving.

The research is published in three scientific articles (Razminienė, 2019, Razminienė, Tvaronavičienė & Zemlickienė, 2016, Tvaronavičienė & Razminienė, 2017a).

3.1. Case Analysis: Lithuanian Clusters Overview and Clusters Map

Clusters in Lithuania differ in many aspects, while the main reason for their establishment is to promote cluster members' activities. According to a 2019 Lithuanian clustering study (Vaiginienė, 2019), 57 clusters were identified in Lithuania in 2019 involving 777 members. The longest acting cluster has been in existence for 25 years, while most of the clusters are around four years old. Some are still at the formation stage or are a group of companies gathered together but do not carry out common activities. The highest number of members is 69 per cluster. The average number of cluster members is 14 (Vaiginienė, 2019). Some clusters share the same specialization, which suggests that their activities should be unified to make links rather than increasing the number of clusters, developing connections to encourage active cooperation and development.

Of all the clusters identified in Lithuania, only one in four is formed naturally through long-term cooperation in the development of new products or services, by joint work aiming at a more significant part of the market, and by increasing the competitiveness of cluster companies (KlasterLT, n.d.).

The greatest concentration of the clusters is in the service sector. Some clusters can be ascribed to several categories. Information and communication technologies (ICT) are dominant in clusters. Manufacturing and engineering go after and may be supplemented with energy and construction. Creative industries also play a significant part. Tourism and health follow and may also go together. The least clusters are working in food and agriculture, and transport (Figure 3.1).

Clusters in Lithuania are initiated in the most economically influential cities (Vilnius, Klaipeda, Kaunas, Alytus), where the concentration of operating entities and the employed population are highest. There are micro clusters in smaller regions where the specifics of activity are characteristic of that region (Birzai, Druskininkai, Kedainiai, Mazeikiai, Ignalina, and others).

Clusters in Lithuania mostly participate in international projects (Baltic Sea Region 2007–2013, Eureka Eurostars, EU SF-initiated projects, and others). Other EU initiatives help create areas of knowledge and innovation, and develop commercial cooperation with foreign partners. Lithuanian clusters' main strength is an activity-friendly environment, with a relatively cheap and qualified workforce, convenient location in terms of logistics, a developed logistics structure, and a high basic level of technology.

It is impossible to find a single cluster's development model which could apply to everyone. There are different forms of development of a cluster; some clusters change their specialization, and newly emerging clusters may replace others. Clusters emerge naturally in developed economies and the cluster is used as a form of organization of business activities, enhancing the economic efficiency of products and services, adding value through the cooperation of companies and other institutions, and increasing companies' competitiveness.

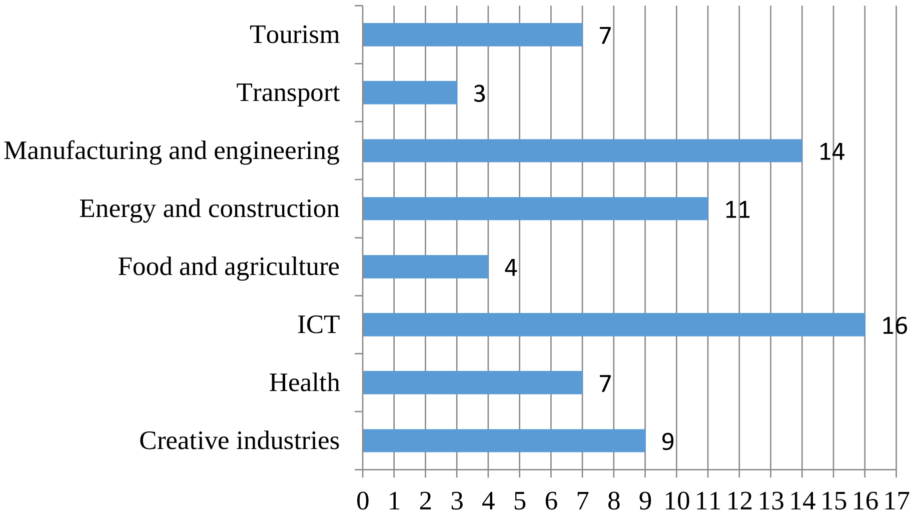


Fig. 3.1. Sectors where clusters operate in Lithuania, 2019, by number of clusters (Source: Composed by the author based on KlasterLT)

The concept of Lithuanian cluster development (Lietuvos klasterių plėtros koncepcija, 2017) describes clusters' development levels following the criteria that should be satisfied (Table 3.1). Clusters can exist on four levels: emerging clusters, formed clusters, developing clusters, and mature clusters. Clusters that are involved in joint initiatives and that started cooperating in various economic activities seeking economic efficiency, knowledge sharing, technology transfer, new product development, and others less than two years ago are emerging clusters. Formed clusters have cooperated for more than two years, and their members have already implemented at least three initiatives, with at least 50 percent of members involved in one or more initiatives. Five or more members belonging to a cluster form the organizational structure, approve short-term and long-term plans, and form a cluster's budget. Cluster members' operational efficiency is no less than the operational efficiency of the sector in which the cluster is run.

Members of developing clusters have cooperated for more than two years and have implemented at least five initiatives, in at least one of which 50 percent or more cluster members participated.

Table 3.1. Cluster development levels
(Source: Concept of Lithuanian clusters’ development, 2017)

Criteria of cluster development		Emerging clusters	Formed clusters	Developing clusters	Mature clusters
Experience of joint initiatives (members of a cluster communicate with each other in various economic activities, seeking economic efficiency, knowledge sharing, technology transfer, new product development, and others)		Less than two years	More than one year	More than two years	More than two years
The number of initiatives implemented by cluster members			At least three	At least five	At least eight
The degree of involvement of the cluster’s members			At least 50%	At least 50%	At least 60%
The degree of cluster management: this degree of development meets cluster cirteria of the European Cluster Excellence Initiative (ECEI) quality label	Number of cluster members		At least five	At least five	At least ten
	Organizational structure is formed				
	Short-term and long-term plans are approved (strategy)				
	Cluster’s budget is formed				
Cluster efficiency	Proportion of export of cluster members’ products or services in the cluster’s sales structure			5%	15%
	Operational efficiency of cluster members (added value)		*	*	*

End of Table 3.1

Criteria of cluster's development		Emerging clusters	Formed clusters	Develop-ing clus-ters	Mature clusters
	Cluster members' annual proportion of R&D expenses from turnover			1%	3%
Interna-tionaliza-tion of a cluster	International initia-tives			One	Three
	Participation in in-ternational networks (platforms)				One

*Operational efficiency of cluster members is no less than the operational efficiency of the sector in which the cluster is run.

There should be at least five cluster members, who have formed the organizational structure, approved short-term and long-term plans, and formed a cluster budget. Export of cluster members' products or services in the cluster's sales structure is 5 percent, while 1 percent of cluster members' annual turnover is devoted to R&D. Cluster members' operational efficiency is no less than the operational efficiency of the sector in which the cluster is run. Cluster members take part in one international initiative. Mature clusters have experienced joint initiatives for more than two years with at least eight initiatives being implemented by cluster members and where at least 60 percent members were involved in at least one initiative. The cluster should involve at least ten members and have formed an organizational structure, approved short-term and long-term plans, and formed a cluster budget.

The proportion of exports of cluster members' products or services in the cluster's sales structure is 5 percent. The proportion of annual turnover devoted by cluster members to R&D is 3 percent. Cluster members should take part in three international initiatives and participate in one international network or platform.

Successful world-class clusters are key supporters of industrial policies in the EU, making cluster management a significant issue. Cluster companies need professional services provided by cluster organizations to expand to global markets, gain competitive advantage, and raise innovation capacity.

The European Commission launched the European Cluster Excellence Initiative (ECEI) in 2009. It was initiated to develop training materials that should help cluster managers improve their managerial capacity. A benchmarking methodology was created to encourage clusters' internal management processes and services, giving suggestions how to adapt improvements and be able to apply for the European cluster excellence label. The European Secretariat for Cluster Analysis (ESCA) is a private operator that has managed the European cluster excellence labels independently since 2012. The labelling system was improved due to the European Commission's support, which led to increased transparency and efficiency, and strengthening of the European dimension of cluster labelling. Eligibility criteria are involved in the process of obtaining a quality label. Organizations should fulfil the set of eligibility criteria for cluster management excellence labels to prove their status as a cluster organization.

Benchmarking is viewed as an efficient and effective way of identifying the potential of a cluster and providing recommendations for further development, which is not possible when evaluations and economic impact assessments are applied. The benchmarking is available online, and all interested parties can access it. An impartial ESCA expert interview is conducted when a cluster organization is willing to apply for ESCA cluster benchmarking. The interview is based on 36 indicators which cover six topics: the structure of the cluster; the cluster management and the governance structures of the cluster; financing of the cluster organization; services provided by the cluster organization; communication within the cluster; and achievements and recognition of the cluster and the cluster organization. A benchmarking report presents the analysis with a graphical comparison with the most excellent cluster in Europe from the same technological area. More than 500 clusters from 45 European and overseas countries are included in the database for benchmarking (ESCA, n.d.). Three levels of excellence may be evaluated through benchmarking and a quality label assigned: ECEI Bronze Label, ECEI Silver Label, and ECEI Gold Label. This quality label is not required as an official quality certification for clusters, although it indicates that clusters are active and are willing to improve their performance.

The number of clusters for the case analysis had to be chosen. As previously mentioned, the number of clusters listed in Lithuania's only database that assembles such information is almost 50. Specific measures for clusters' development are suggested by The concept of Lithuanian clusters' development (2017). This concept agrees with the ECEI, which requires more engagement by the clusters and agrees to the definition given in Chapter 1. Hence, clusters that are certified by the ECEI and have been nominated by a label are considered fully operating clusters in this thesis and are further selected for the case study. Currently, there are ten clusters with an ECEI Bronze label in Lithuania. In this case, the clusters analysed are iVita, LAuGEA, Lithuanian Plastics Cluster, LITEK, Smart Food Cluster, PrefabLT, VKK, FETEK, LitCare, and NaMŪK.

Clusters are analysed from several perspectives. First of all, the cluster is described with years of establishment, coordinators, the city where the coordinator is situated, the organization type, and the number of cluster members according to the website KlasterLT (n.d.). Then, the economic activities of members of each cluster are detailed in terms of Classification of Economic Activities (EVRK, n.d.), which is official in Lithuania and can be found in the Official Statistics Portal. Later, a map was produced showing each cluster's members by geographic location, type of business, number of employees and turnover. The map legend is given in Annex B. This information is taken from official websites rekvizitai.lt and sodra.lt.

According to the information on rekvizitai.lt, clusters' turnover can vary from EUR 0–5,000 to above EUR 100,000,000. The EC defines an SME (Directorate-General for Internal Market: Industry, 2017) as an entity engaged in an economic activity, employing fewer than 250 people, whose annual turnover does not exceed EUR 50,000,000 or annual balance sheet total does not exceed EUR 43,000,000. Turnover, as net sales generated by a business, is considered a reliable measure that defines a company's size. The size of a company is depicted by the size of a circle, and the number of employees in the circle provides additional information about the company. Companies are classified according to the size of the circle (this is clarified in Annex A). Companies' symbols are distributed according to geographical location, showing size according to turnover, number of employees, geographical location, and business type.

Health technology cluster iVita was established in 2011, coordinated by De Futuro Ltd in Kaunas. There are 21 cluster members, consisting of 14 private limited companies (Ltd) – De Futuro, Amžių linija, Anupriškių parkas, Baltec CNC Technologies, Ekofrisa, Elinta, Elintos matavimo sistemos, G Sportas, Impuls LTU, Pikotera, SatiMed, SDG grupė, Sportpoint, and Wiper Software; two public limited companies (Plc) – Audimas and Ortopedijos centras; one higher education institution (HEI), Lietuvos sporto universitetas; two non-profit organizations (NPO) – Robotikos mokykla and Sveikatinimo programos; one individual activity (IA), Oriental culture studio WUDANG TAO; and one platform, Lympo (Figure 3.2).The main aim of the cluster is to increase collaboration and synergies in the development of health products. The combination of different competencies that members have enables the cluster to create health products focused on various areas: products for an active lifestyle, products that increase human communication and increase products visibility in the environment, sports products, rehabilitation products, and prevention-oriented products.

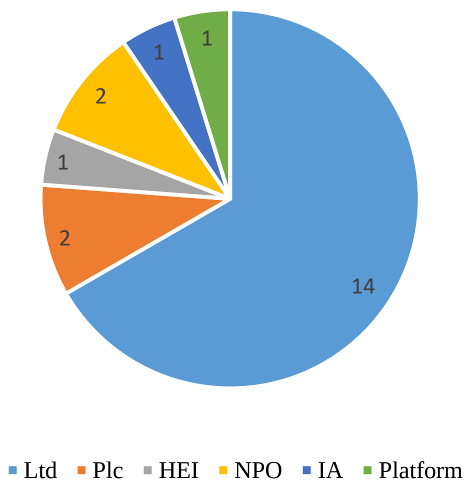


Fig. 3.2. Structure of Health technology cluster iVita by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

Members of the cluster carry out activities that supplement each other and add to the cluster's main aim (Figure 3.3). The list of companies can be started from the manufacture of food products: one member's economic activity is the production of groats. Another member specializes in the manufacture of wearing apparel for active leisure and sports. Manufacture of fabricated metal products, except machinery and equipment, is done by one company, which can manufacture precision machined components in the automotive, multi-purpose, medical rehabilitation, and energy industries. As for other manufacturers, one member specializes in the manufacture of medical and dental instruments and supplies; another focuses on repair of machinery, offering technologies and the latest different technological solutions to its customers for the development of complex and user-friendly automated management systems. One company is dedicated to wholesale of other machinery and equipment that delivers measuring equipment and a range of services. Retail trade with another retail sale of food in specialized stores presents food for everyone doing sports. Retail sale of clothing in specialized stores is represented by one member specializing in sports clothing. Food and beverage service activities with specialization in restaurants and mobile food service activities are delivered by one recreation and amusement business. Other software publishing activities are provided by one member, suggesting solutions to personal computer problems. One member is responsible for business and other management consultancy activities. There are three members specializing in scientific R&D: one in research and experimental development in biotechnology and two in R&D in technical sciences. Two education institutions are involved in cluster activities: one for higher university education and one for other training. Three members specialize in sports activities and amusement and recreation activities: one focuses on activities of sports clubs, one on fitness facilities, and the third on amusement and recreation activities.

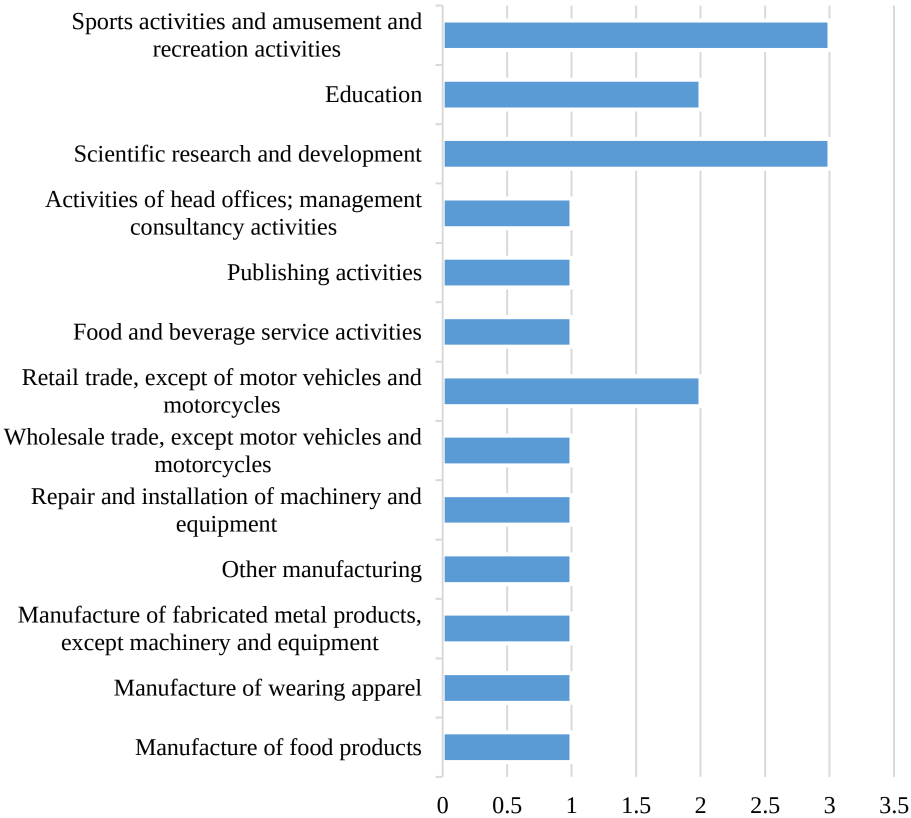


Fig. 3.3. Structure of Health technology cluster iVita by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

The majority of iVita members are situated in Kaunas (Figure 3.4). Together with the coordinator and one HEI, eight companies are founded in Kaunas, while three more companies are in the Kaunas district. One company is less than 50 kilometres away from Kaunas in the Prienai district, one is less than 100 kilometres away in the Trakai district, and three are around 100 kilometres away in Vilnius. The furthest distance from Kaunas is less than 150 kilometres away, with one company in Panevėžys and one in Utena. The number of employees in the companies varies from four (three companies) to 539. Turnover starts with the lowest of EUR 50,001–100,000 per year and reaches EUR 20,000,001–30,000,000 per year.

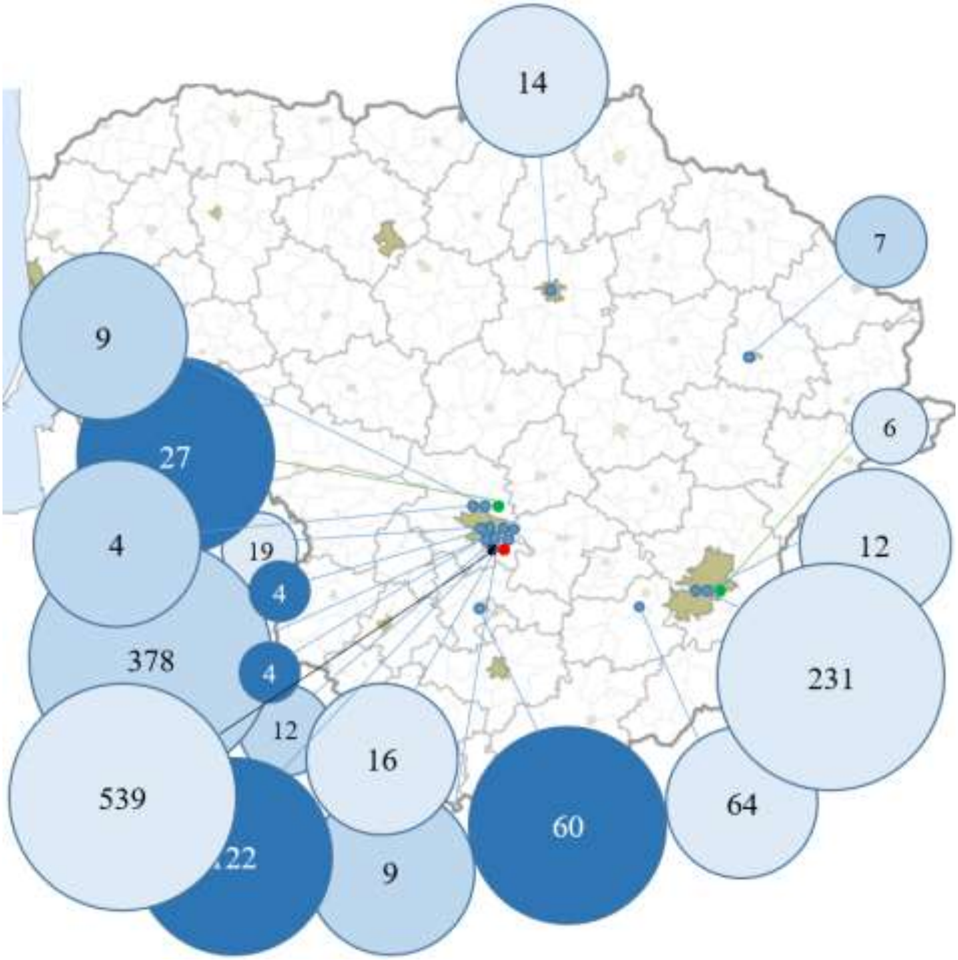


Fig. 3.4. Structure of Health technology cluster iVita by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

Geographical proximity is very clear in this case, as the majority of companies are situated around Kaunas. The range of economic activities that companies are engaged in is vast, although they complement each other by adding to the cluster's main aim.

Lithuanian Automotive Export Association LAuGEA was established in 2014, situated in Šiauliai. There are 16 cluster members consistinf of 13 Ltd – Gaschema Xirgo global, Baltic filter, Craft Bearings, Danushis Chemicals, Dažų ir Dangų fabrikas, Eoltas, Jubana, Jupojos technika, Neigiamas pagreitis, Papilio kibirkštis, Signeda, Lesta, Luft Master; two HEIs – Šiauliai state college, Šiauliai University (Figure 3.5).

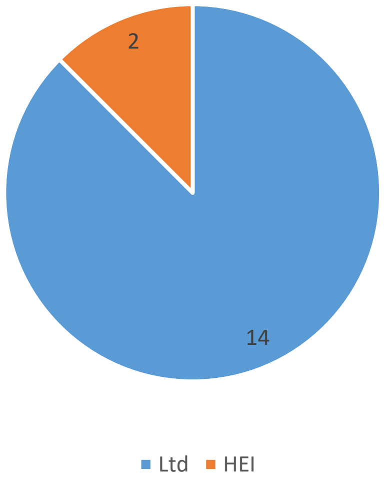


Fig. 3.5. Structure of Lithuanian Automotive Export Association LAuGEA by business type, 2018, number of members
(Source: Composed by the author according to KlasterLT)

The cluster's main aim is to become a center of excellence for research, development, and export in auto industry areas. LAuGEA is a cross-sectoral business cluster uniting Lithuanian companies and scientific organizations related to the automotive industry. Cooperation helps ensure more excellent product development, testing, sales in national and international markets for cluster members due to scientific potential. It also adds to more effective cost management within companies.

The cluster is composed of companies that are related to the automotive industry (Figure 3.6). Two companies specialize in the manufacture of chemicals and chemical products, specifically, one in the manufacture of paints, varnishes, and similar coatings, printing ink and mastics, and the other in the manufacture of soap and detergents, cleaning and polishing preparations. One member works with the manufacture of other non-metallic mineral products – manufacture of glass and glass products. Two members specialize in the manufacture of motor vehicles, trailers, and semi-trailers, both work with the manufacture of other parts and accessories for motor vehicles. Wholesale and retail trade and repair of motor vehicles and motorcycles involve four members correctly oriented to wholesale trade of motor vehicle parts and accessories. Wholesale trade, except motor vehicles and motorcycles, is carried out by three members, one of which is specialized in wholesale of other machinery and equipment, and two of them are working at wholesale of chemical products. One member implements computer programming, consultancy, and related activities. Architectural and engineering activities, together with technical testing and analysis, is represented by one member. Two institutions are involved in education with both higher non-university education and higher university education.

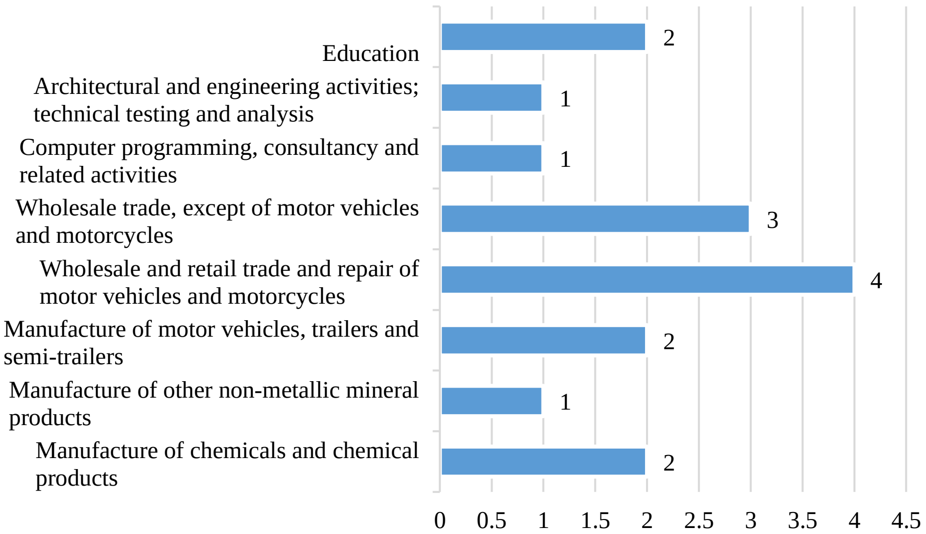


Fig. 3.6. Structure of Lithuanian Automotive Export Association LAuGEA by economic activity, 2018, number of members
(Source: Composed by the author based on atvira.sodra.lt)

The members of LAuGEA are scattered all around Lithuania (Figure 3.7). The coordinator is situated in Šiauliai, as well as two companies and two HEIs. The nearest members are about 100 kilometres away – one in Mažeikiai and one in the Biržai district. The further companies are less than 150 kilometres away – two in Klaipėda and one in the Jonava district. Three companies in Kaunas, one in the Kaunas district, and one in the Širvintos district are less than 200 kilometres away. The coordinator's furthest point is the Vilnius district, which is more than 200 kilometres away with two members. The number of employees of the companies varies from two (one company) to 170. The turnover starts with the lowest reported (information about the smallest company's turnover is not available) EUR 200,001–300,000 per year and reaches the highest of EUR 30,000,001–50,000,000 per year.

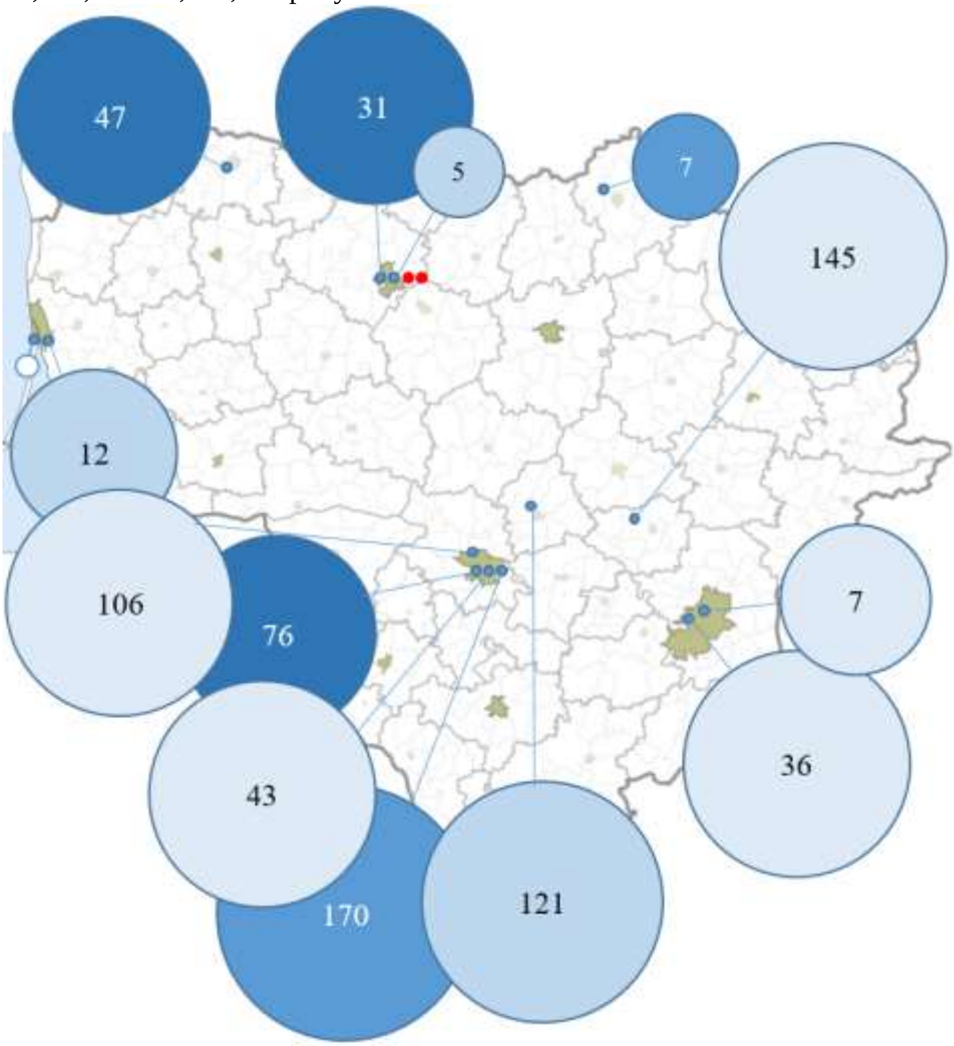


Fig. 3.7. Structure of Lithuanian Automotive Export Association LAuGEA by geographic location, type of business, number of employees and turnover, 2018 (Source: Composed by the author according to KlasterLT)

LAuGEA has members that are very closely related through economic activities that they carry out. Each economic activity which is applicable for one or more members supplements the others. Members are not closely situated as per geographical location but rather more connected through activities. The cluster is composed of companies that meet SMEs' definition as the highest number of employees is 170, and the yearly turnover of the same company is up to EUR 50,000,000.

Lithuanian Plastic Cluster was established in 2015 and is coordinated by the engineering industries association of Lithuania LINPRA. The cluster currently joins thirteen members. There are eight Ltds – Frillux, Hoda, Meteltera, Plasteksus, Premeta, Putokšnis, Terekas, Autoplasta; one secondary education institution (SEI) – Šiauliai vocational education and training center; HEIs – Šiauliai state college, Kaunas university of technology (KTU); two associations – LINPRA, Šiauliai industrialists association (Figure 3.8).

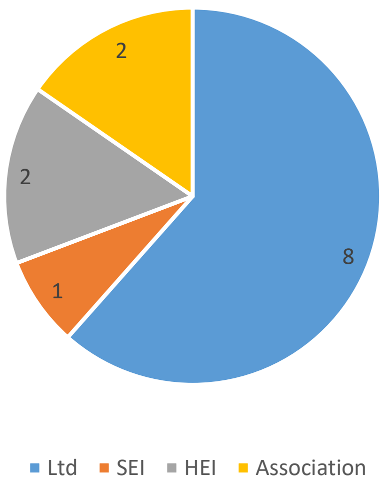


Fig. 3.8. Structure of Lithuanian Plastic Cluster by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

The cluster aims to facilitate informal networking among partners, identify opportunities by using different levels of expertise, increase competitiveness, the return on investment, and support partners in innovation and market. The plastics industry enterprises' network created by the Lithuanian Plastic Cluster is reliable, innovative, and competitive.

The cluster has a dense concentration of plastic production and supplemented with educational institutions and associations, which adds to their engineering skills, expertise, and R&D potential (Figure 3.9). Five companies specialize in the manufacture of rubber and plastic products. They are working with the processing of new or recycled plastics resins into intermediate or final products. Two of them are manufacturers of plastic articles for the packing of goods, and the others are into the manufacture of other plastic products. Two companies work with the manufacture of fabricated metal products, except machinery and equipment, to precisely treat and coating metals and manufacture other fabricated metal products. Wholesale of other intermediate products adds to the competitiveness of the cluster through competencies that supplement the others. There are three educational institutions in the cluster: technical and vocational secondary education, followed by higher non-university education and higher university education. Two membership organizations are involved, practicing activities of business and employers membership.

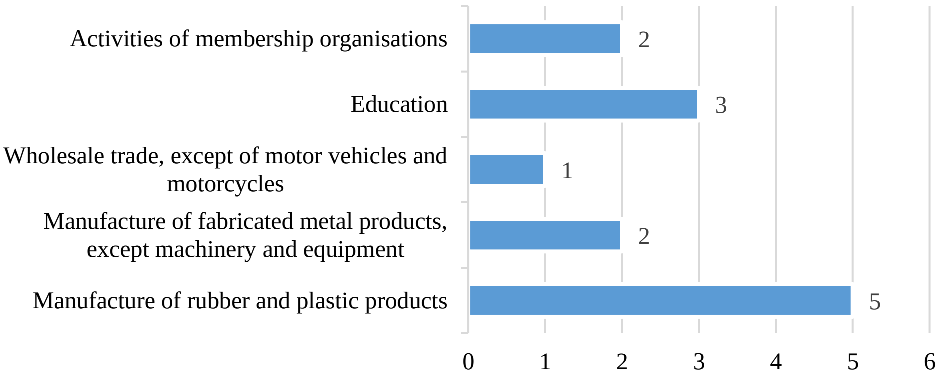


Fig. 3.9. Structure of Lithuanian Plastic Cluster by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

The highest concentration of members is in Šiauliai – three Ltd, SEI, HEI, and an association – more than 200 kilometres away from the coordinator situated in Vilnius (Figure 3.10). The coordinator's furthest location is Kretinga and the Kretinga district with one company in each – more than 300 kilometres away. The Panevėžys district with one member is less than 150 kilometres away. Two members in Molėtai and the Širvintos districts are less than 100 kilometres away. One more HEI is in Kaunas, which is around 100 kilometres away from the coordinator. The number of employees of the companies varies from nine to 183.

The turnover of Ltd starts with the lowest of EUR 500,001–1,000,000 per year and reaches EUR 50,000,001–100,000,000 per year.

Lithuanian Plastic Cluster is concentrated on the specificity of the cluster rather than on geographical proximity. The highest number of members is located relatively far from the coordinator and close to other educational institutions in the same location.

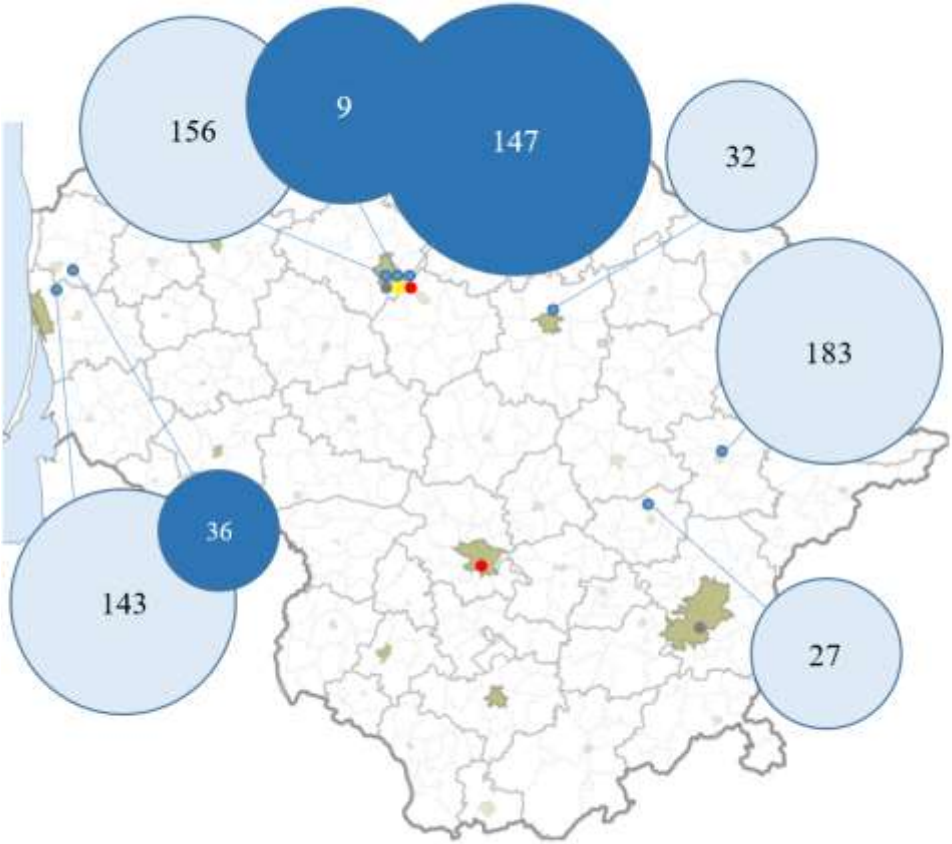


Fig. 3.10. Structure of Lithuanian Plastic Cluster by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

Laser & Engineering Technologies Cluster LITEK was established in 2010, but science and SMEs' cooperation continues for more than 20 years. The coordinator of LITEK activities is Public Entity Science and Technology Park of the Institute of Physics, situated in Vilnius. The number of cluster members is fifteen. It consists of twelve Ltd – Arginta Group, 3D prototipai, Altechna

Coatings, Eksma, Ekspla, Ekstremalė, Elas, Esemda, Integrali skaidulinė optika, Eksma Optics, Optonas, Progresyvūs verslo sprendimai; 2 NPOs – Intechcentras, Science and Technology Park of Institute of Physics; one State research institute (SRI) – Center for Physical Sciences and Technology (Figure 3.11).

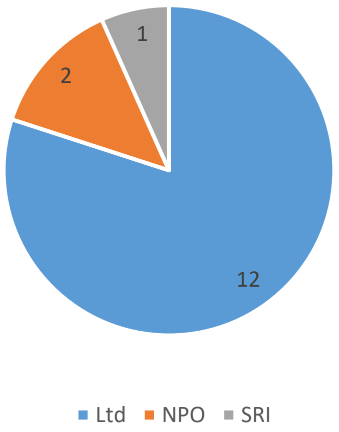


Fig. 3.11. Structure of Laser & Engineering Technologies Cluster LITEK by business type, 2018, number of members
(Source: Composed by the author according to KlasterLT)

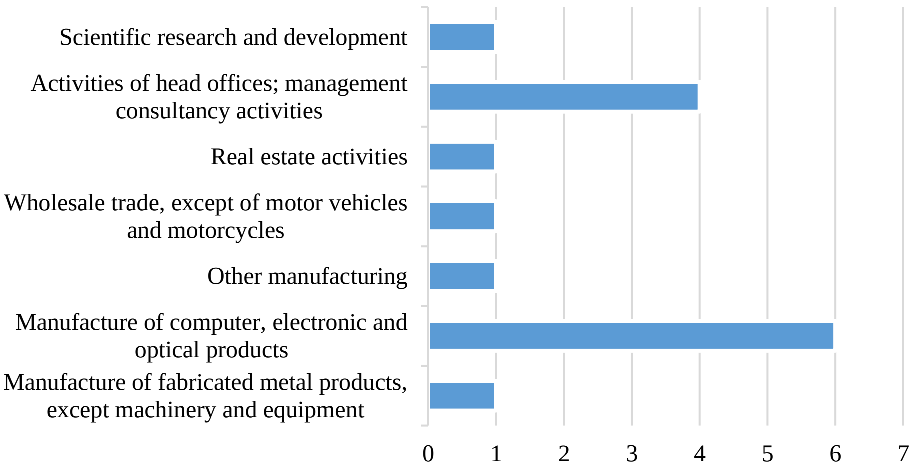


Fig. 3.12. Structure of Laser & Engineering Technologies Cluster LITEK by economic activity, 2018, number of members
(Source: Composed by the author based on atvira.sodra.lt)

Cluster companies and scientific institutions realized the combination of knowledge in different fields, close cooperation, sharing of interdisciplinary (photonics and engineering) ideas, and a user-friendly environment could give outstanding results in more efficient operations and growing results. Belonging to a cluster allows its members to combine resources and knowledge rather than compete, making it easier to enter new markets when the energy is directed to completion in international markets.

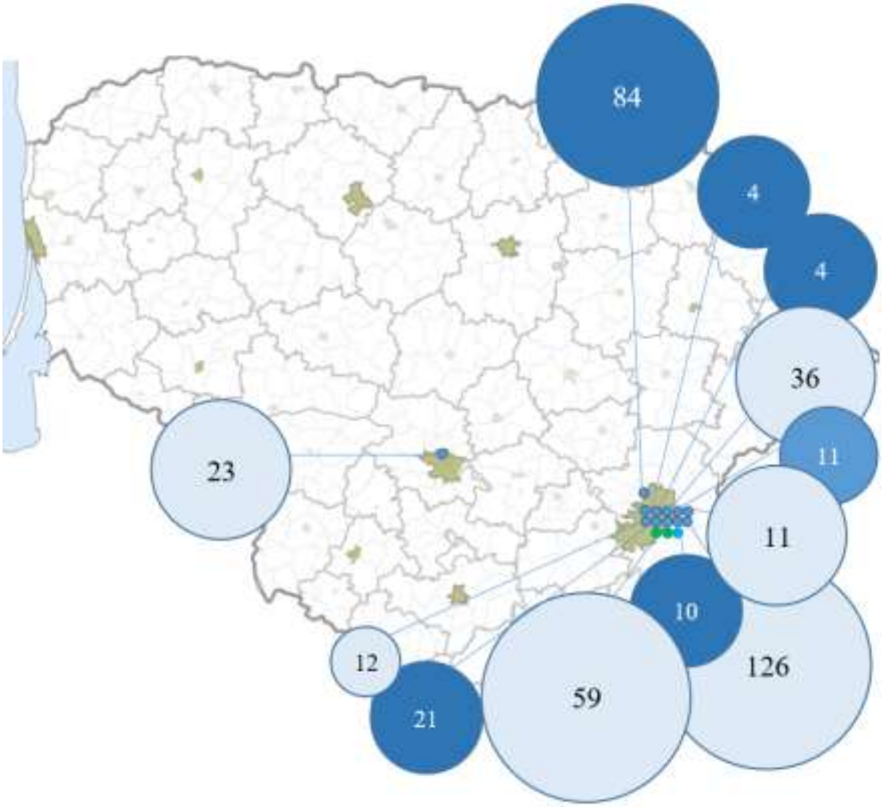


Fig. 3.13. Structure of Laser & Engineering Technologies Cluster LITEK by geographic location, type of business, number of employees and turnover, 2018 (Source: Composed by the author according to KlasterLT)

Companies and organizations of LITEK are operating in the field of laser and related engineering technologies and carry out joint R&D activities (Figure 3.12). The list of activities carried out by companies in the cluster can be started with fabricated metal products, treatment, and coating of metals operated by one member. Manufacture of computer, electronic and optical products are prescribed for six companies, one of which specializes in the manufacture of loaded electronic boards and the others – manufacture of optical instruments and photographic equipment. One more company is in other manufacturing. Wholesale of electronic and telecommunications equipment and parts are implemented by one company and the renting and operating of own or leased real estate. Activities of head offices – management consultancy activities like head offices (one company) and business and other management consultancy activities (three companies) add to the cluster activities. One member carries out scientific R&D through other research and experimental development on natural sciences and engineering.

Only one of LITEK members is distanced from the coordinator and the rest of the cluster members (Figure 3.13). This member is in Kaunas, which is around 100 kilometres from Vilnius. The number of employees varies from four and reaches the highest number of 126. The turnover starts at EUR 100,001–200,000 per year and reaches EUR 10,000,001–20,000,000 per year.

There is evident geographical proximity seen on the map where the highest concentration of members is in one city. LITEK members are also tightly related through activities similar by their nature or may add to the competitive advantage when companies work together instead of competing. The cluster comprises companies that meet the definition of SMEs as the highest number of employees is 126, and the yearly turnover of the same company is EUR 10,000,001–20,000,000 per year.

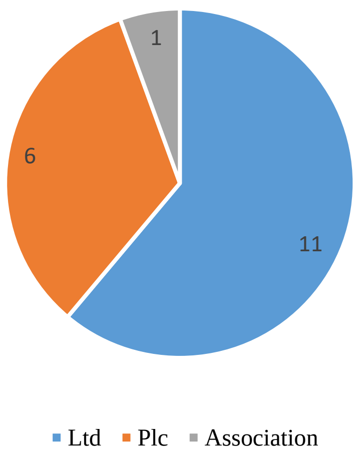


Fig. 3.14. Structure of Smart Food Cluster by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

Smart Food Cluster was established in 2013 and is coordinated by the Lithuanian food exporters association (LitMEA), situated in Vilnius. The number of cluster members is eighteen. It consists of eleven Ltd – Biržų duona, Boslita ir Ko, Cerera Foods, Danvita, Dora, Grainmore, Limstar Group, Liūtukus ir Ko, Rūta, Švenčionių vaistažolės, Ūkininko rojus; six Plc – Kauno grūdai, Klaipėdos pienas, Vilniaus paukštynas, Kaišiadorių paukštynas, Volfas Engelman, Žemaitijos pienas; one association – LitMEA (Figure 3.14).

Smart Food Cluster aims to create and improve healthy, safe, ecological, functional food and beverages using existing knowledge and adding scientific experience and latest innovations from Lithuania and abroad. The cluster encourages the export of Lithuanian origin products by developing joint activities and discovering new international markets. Cluster members work together on non-competitive relations to use up a cooperation potential and create market offers or pool resources in Lithuania and abroad.

The cluster consists of food industry companies representing separate industrial sectors which do not consider each other as their direct competitors in the domestic and foreign markets and see opportunities for mutual trust and cooperation (Figure 3.15).

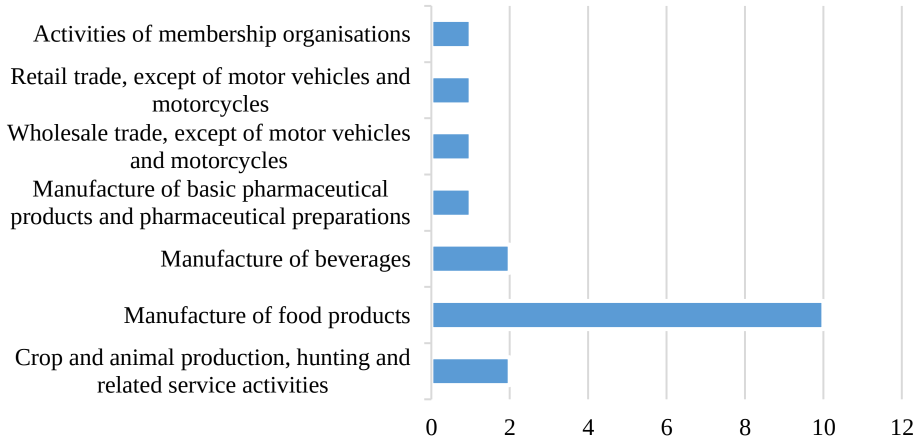


Fig. 3.15. Structure of Smart Food Cluster by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

Two companies specialize in raising poultry for meat and production of eggs while the other ten companies work in different manufacturing of food products areas.

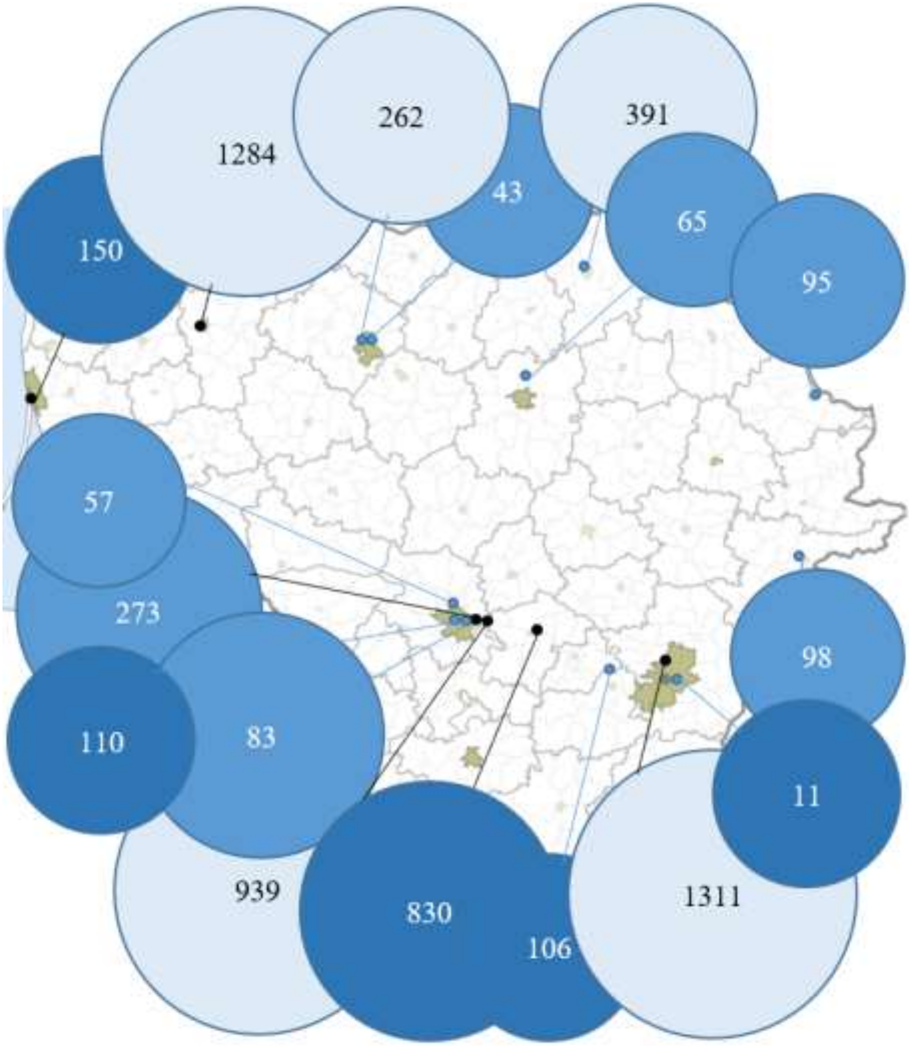


Fig. 3.16. Structure of Smart Food Cluster by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

These are a production of meat and poultry meat products, operation of dairies and cheese making, manufacture of ice cream, manufacture of grain mill products, manufacture of bread; manufacture of fresh pastry goods and cakes, manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes, manufacture of cocoa, chocolate and sugar confectionery, manufacture of prepared meals and dishes, manufacture of prepared feeds for farm animals. These areas are supplemented by the manufacture of beverages, manufacture of beer, and pharmaceutical preparations. Wholesale trade, specifically, agents involved in the sale of food, beverages, and tobacco, are involved in the activities and retail sale of meat and meat products in specialized stores. The list is finished with the activities of membership organizations.

The cluster coordinator is situated in Vilnius, together with one member in the same city and one in the Vilnius district (Figure 3.16). The nearest location is the Trakai district less than 50 kilometres away. The Kaišiadorys district and Švenčionys are less than 100 km away with one member in each location. Kaunas and the Kaunas district is less than 150 km away with five members and a similar distance to Zarasai with one member and Panevėžys with one member. Biržai and Šiauliai are less than 250 km away with one and two members. Telšiai, with one member, is less than 300 km away from the coordinator, and Klaipėda is more than 300 km away. Members are located in thirteen different cities or districts. The number of employees of the companies varies from eleven to 1311. The turnover starts with the lowest of EUR 3,000,001–5,000,000 per year and reaches the highest of more than EUR 100,000,000 per year.

Companies in Smart Food Cluster are very closely related in the sector and production of food. As can be seen in the map, members are scattered around Lithuania. Almost half of the companies do not comply with the definition of SMEs. The cluster is composed of big companies in the food sector regardless of their size or geographical location.

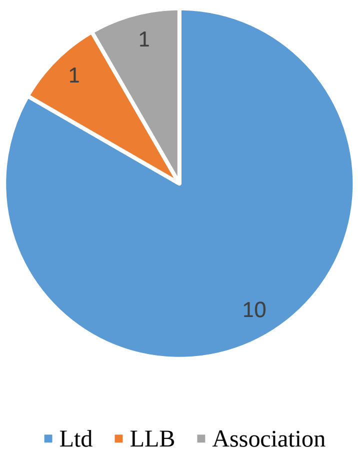


Fig. 3.17. Structure of Lithuanian Prefabricated Wooden House Cluster PrefabLT by business type, 2018, number of members
(Source: Composed by the author according to KlasterLT)

Lithuanian Prefabricated Wooden House Cluster PrefabLT was established in 2014 and coordinated by association Energy-efficient and passive house cluster in Kretinga. The number of cluster members is twelve. It consists of ten Ltd – LHM House, SVM Baltic, HTCC, Kegesa, Knauf, Kriautė, Liskandas, Mirosta, Skado medis, Timber Design LT, Medžio bitės; one Limited liability partnership (LLB) – SVM Baltic; one association – Energy-efficient and passive house cluster (Figure 3.17).

PrefabLT unites Lithuanian manufacturers of wooden panels and modular houses and design companies. The cluster members offer high-quality products and services to the market that fully meet companies' requirements with a good reputation and occupy leading positions among other Lithuanian manufacturers. PrefabLT members focus on exporting goods and services – 90 percent of their production is exported to Norway and Sweeden.

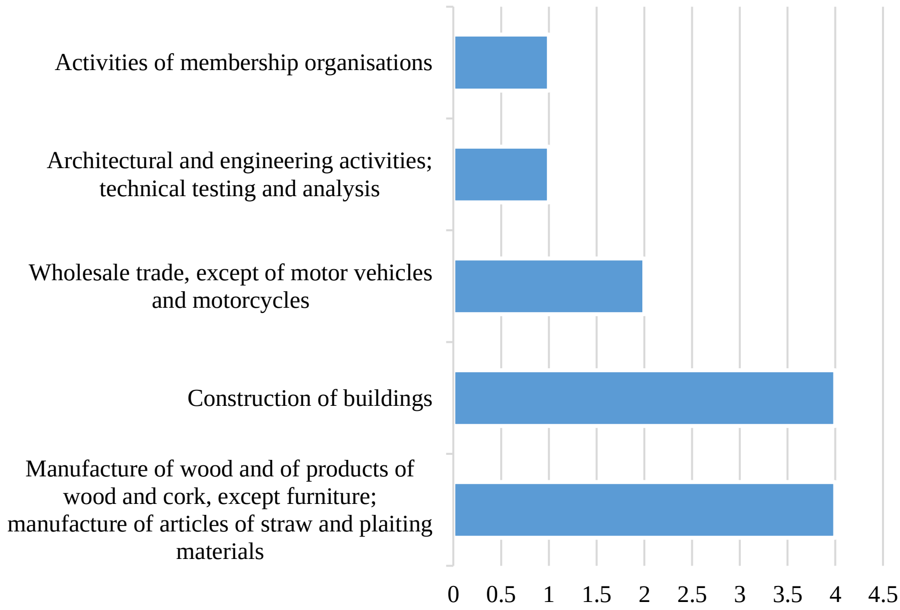


Fig. 3.18. Structure of Lithuanian Prefabricated Wooden House Cluster PrefabLT by economic activity, 2018, number of members
(Source: Composed by the author based on atvira.sodra.lt)

The cluster members are wooden frame panel and modular house production and design companies, manufacturers, and wooden construction products (Figure 3.18). Four members practice manufacture of wood and products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials, two of them specialize in the manufacture of other builders' carpentry and joinery, and the other two in the manufacture of prefabricated wooden buildings or elements thereof. Construction of buildings takes the construction of residential and non-residential buildings practiced by four members. Wholesale trade is taken by two members that are agents involved in the sale of timber and building materials. Architectural and engineering activities are added to the cluster as design and construction activities. Activities of membership organizations are needed for cluster coordination.

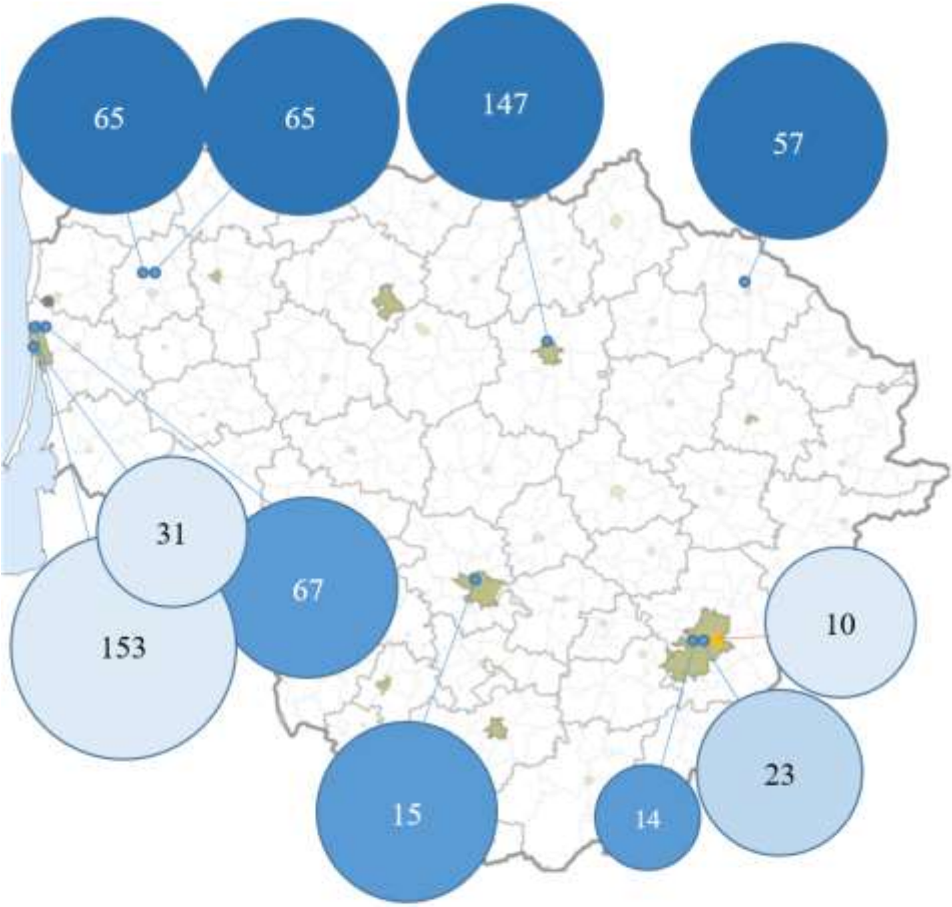


Fig. 3.19. Structure of Lithuanian Prefabricated Wooden House Cluster PrefabLT by geographic location, type of business, number of employees and turnover, 2018 (Source: Composed by the author according to KlasterLT)

Less than half of the cluster members are situated less than 50 km away from the coordinator in Kretinga (Figure 3.19). Two companies are less than 250 km away – one in Panevėžys and one in Kaunas. The rest are more than 300 km away – one in Rokiškis and three in Vilnius. The number of employees of the companies varies from ten to 153. The turnover starts with the lowest of EUR 300,001–500,000 per year and reaches the highest of EUR 10,000,001–20,000,000 per year, which applies to SMEs.

The members of the cluster are very closely related through economic activities that they apply to. A geographically great distance between members is seen, which might be used up for the cluster's primary purpose is export.

Vilnius Film Cluster VKK was established in 2011, coordinated by Association Vilnius Film Cluster. The number of cluster members reaches 25. It consists of seventeen Ltd – Artbox, Cinefx, Cinema Ads, Cineskopė, Cinevera, Dansu, Editos Kastingas, Europos Kinas, Hipė, Idee Fixe, Madstone, Meinart, Oak9, Entertainment, Roofsound, The Magic, Ultra Nominum, Video Projektai; 1 HEI – VILNIUS TECH; six NPOs – Arlekinas; Ateities visuomenės institutas, Kino Pasaka, Kino pavasaris, Menų Fabrikas, Artshot; one association (Figure 3.20).

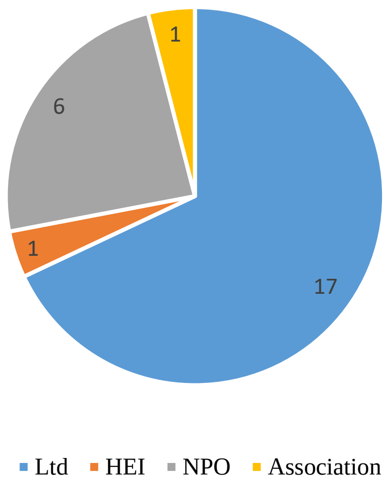


Fig. 3.20. Structure of Vilnius Film Cluster by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

VKK offers high-quality film and TV production, equipment rental, decorations, post-production, and other audiovisual sector services. Members of the clusters work for the same goal – to create and provide a full package of audiovisual production services in Lithuania for a project of any size, at any stage. VKK provides the highest quality services, actively cooperates with Lithuanian and foreign partners, supports young filmmakers, and organizes professional development events for film specialists, master classes.

The cluster has gathered leading film, animation and TV production, and production services companies (Figure 3.21).

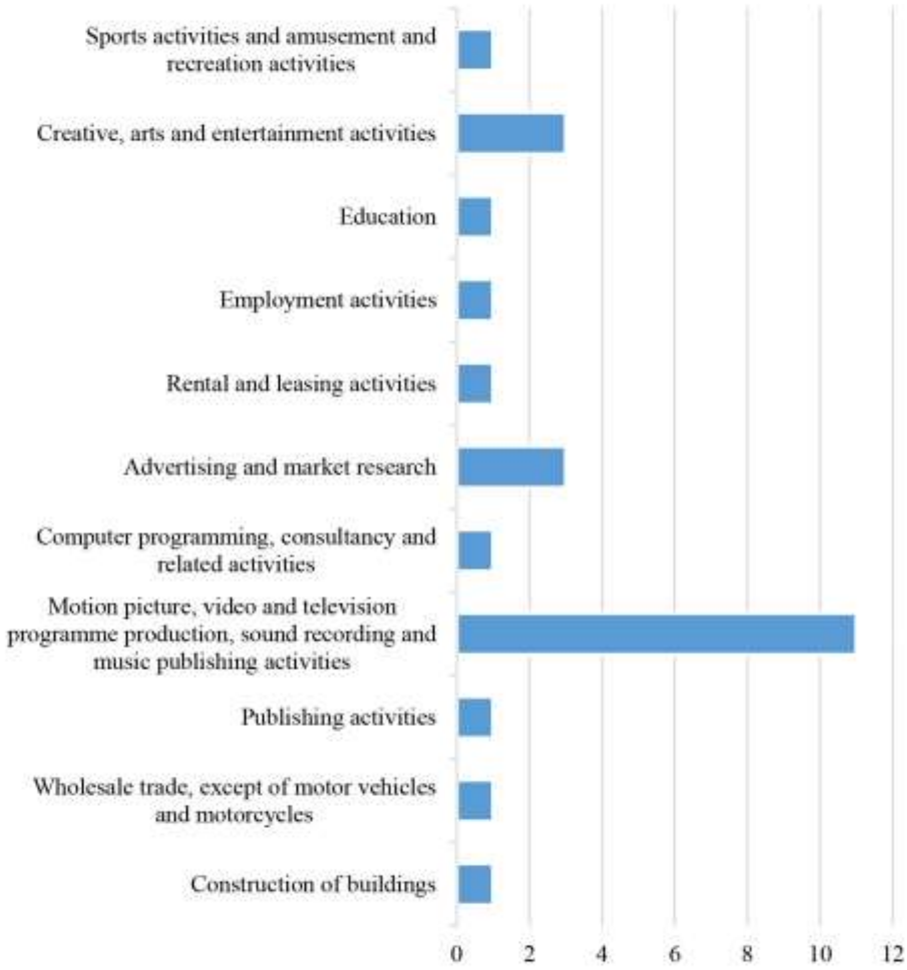


Fig. 3.21. Structure of Vilnius Film Cluster by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

The expertise in different cluster members' fields enables to provide the client with full world-class service for any stage of production. The list of economic activities can be started with repair, restoration, and reconstruction of buildings practiced by one company. One member is working with wholesale trade – agents involved in selling food, beverages, and tobacco. One member carries out the publishing of books, periodicals, and other publishing activities. Motion picture, video and television program production, sound recording, and music publishing activities contain eleven members, six of which are into a motion picture, video and television program production activities, one into a motion picture, video and television program post-production activities, one into a motion picture, video and television program distribution activities, two into motion picture projection activities and one into sound recording and music publishing activities. One member specializes in computer programming activities. Advertising and market research, explicitly advertising agencies, are taken by three members.

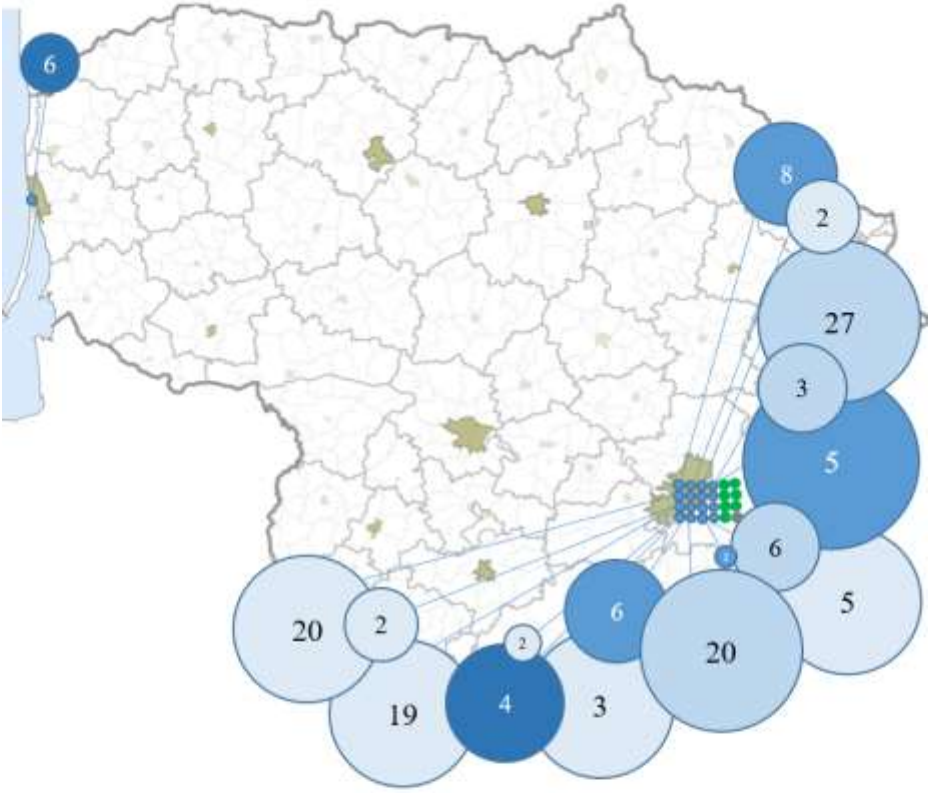


Fig. 3.22. Structure of Vilnius Film Cluster by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

Renting and one member carries out leasing of other machinery, equipment, and tangible goods. One member takes care of the activities of employment placement agencies. One member provides higher university education. Creative, arts, and entertainment activities, specifically support activities to performing arts, are carried out by two members and the operation of art facilities by one member. The list is finalized by other amusement and recreation activities given by one member. Geographical proximity is explicit in this case for a dense concentration of cluster members in one city (Figure 3.22). Almost all of the cluster members are located in Vilnius, and only one is in Klaipėda, which is more than 300 km away. The number of employees of the companies varies from two to 27. The turnover starts with the lowest of EUR 0–5,000 per year and reaches the highest of EUR 3,000,001–5,000,000 per year.

Geographical proximity is explicit in this case for a dense concentration of cluster members in one city. VKK members are engaged in the same or complementary activities, which enable them to satisfy all customers' needs through close cooperation.

Photovoltaic Technology Cluster FETEK was established at the beginning of 2008 in Vilnius as a non-governmental group that unites industry and R&D institutions and is coordinated by the Applied Research Institute for Prospective Technologies (Protech).

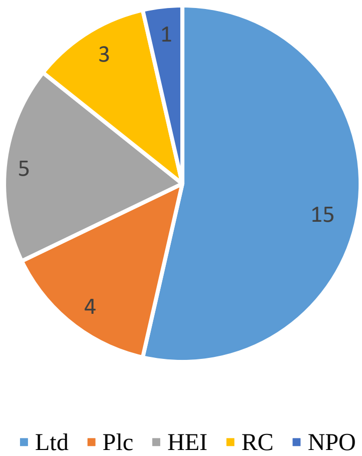


Fig. 3.23. Structure of Photovoltaic Technology Cluster FETEK by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

The number of cluster members now reaches 28. It consists of fifteen Ltds – BOD Group, GlassbelEU, Elaterma, Saulės Vėjo Aruodai, Soli Tek R&D, Soli Tek Cells, Altechna, Europarama, Modern E-Technologies, NB Mechanika, Precizika Metrology, Saulės Energija, Telebaltikos importas ir eksportas, Kemek Engineering, Via Solis; four Plc – Anykščių kvarcas, Precizika, Viti, Modus Energija; five higher education institutions – Vilnius University (VU), Kaunas technology university (KTU), Vilnius Gediminas' technical university (VILNIUS TECH), Mykolas Romeris University (MRU), Vilniaus kolegija / University of applied sciences (VIKO), three research centers (RC) – Center for Physical Sciences and Technology (FTMC), the Applied Research Institute for Prospective Technologies (Protech), Institute of Lithuanian Scientific Society (ILSS), one non-profit organization – Northtown Technology Park (Figure 3.23).

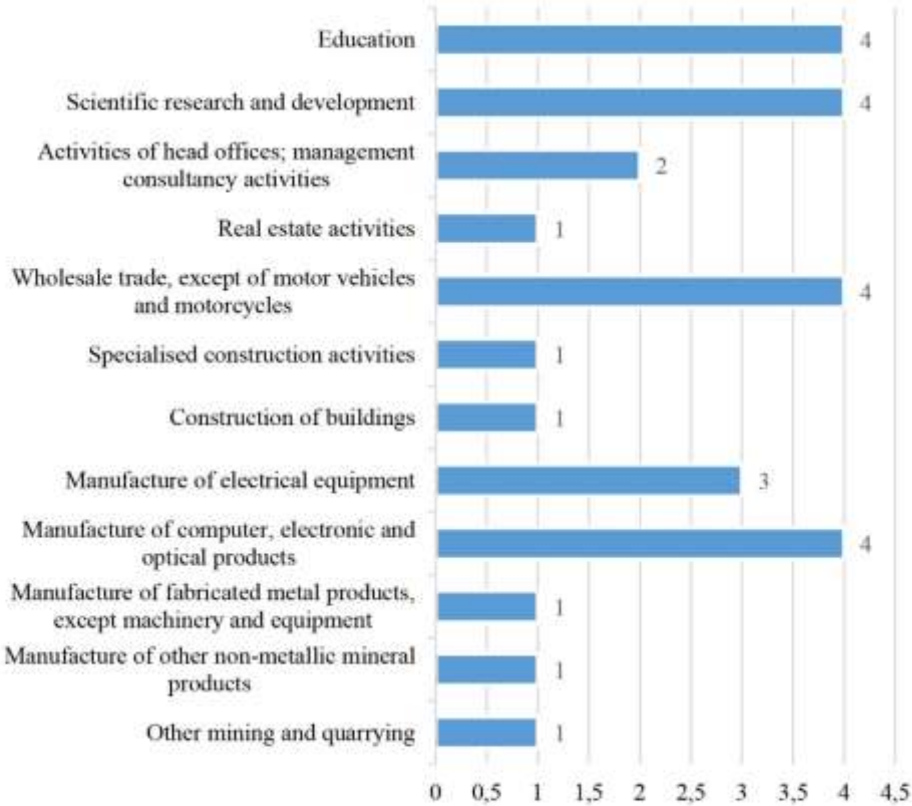


Fig. 3.24. Structure of Photovoltaic Technology Cluster FETEK by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

The cluster's main aim is to increase the sustainability and competitiveness of the national photovoltaic (PV) sector. Many other principles are viewed as being achieved during the collaboration, such as analysis of evolution and tendencies of photovoltaic technologies, industry, and markets as well as R&D; identification of competitive advantages of the FTK members and their present and future needs; improvement of social image and investment attraction of PV sector. All the members in the cluster are oriented to view cluster activities through this perspective.

State and private research centers, companies operating in various sectors related to PV technologies, and a company operating in non-PV related sectors joined the cluster (Figure 3.24). These companies and research institutions started cooperation to encourage innovation and facilitate investments, raise markets for PV products and services in Lithuania and abroad, and foster the technological modernization of the Lithuanian PV sector. One member carries out quarrying of stone, sand, and clay. Manufacture of other non-metallic mineral products, precisely shaping and processing flat glass, is performed by one member. One member carries out the manufacture of fabricated metal products, except machinery and equipment, to manufacture tools. Manufacturers of computer, electronic and optical products are distributed by three members in the manufacture of electronic components and one member in the manufacture of instruments and appliances for measuring, testing, and navigation. Manufacture of electrical equipment is taken by one member to manufacture electric motors, generators and transformers, and two other electrical equipment manufacturers. One member performs new buildings construction. One member takes specialized construction activities, specifically plumbing, heat, and air conditioning installation.

Wholesale trade, except motor vehicles and motorcycles, is practiced by four members in these areas – wholesale of electrical household appliances, Wholesale of electronic and telecommunications equipment and parts, wholesale of other machinery and equipment, non-specialized wholesale trade. Real estate activities, specifically the management of real estate on a fee or contract basis, are carried out by one member. Two members take activities of head offices – management consultancy activities and business and other management consultancy activities. Scientific R&D are divided within four members – two in other research and experimental development on natural sciences and engineering and two in research and experimental development on social sciences and humanities. Education is provided by one higher non-university education institution and three higher university education institutions.The most significant concentration of members is in Vilnius with the coordinator, education institutions, research centers, and other companies (Figure 3.25). One member is less than 50 km away in the Trakai district. Five companies are less than 150 km away – one in

Anykščiai, one in Alytus, two in the Kaunas district, and one in Kaunas. The furthest member is in Klaipėda, less than 350 km away.

The number of employees of the companies varies from two to 56. The turnover starts with the lowest of EUR 0–5,000 per year and reaches the highest of EUR 10,000,001–20,000,000 per year.

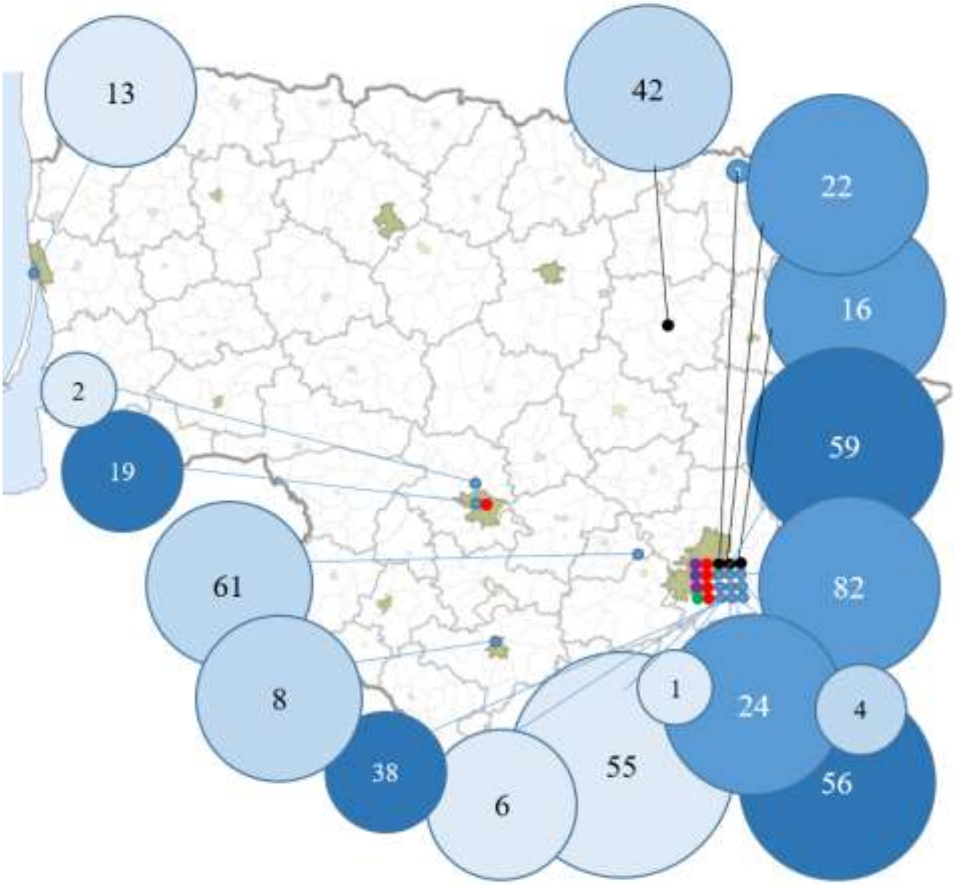


Fig. 3.25. Structure of Photovoltaic Technology Cluster FETEK by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

Most of the companies, research centers, and education institutions are concentrated in Vilnius. There is close geographical proximity, and members supplement each other by adding to activities that are practiced. The cluster members go within the definition of SMEs.

Lithuanian Medical Tourism Cluster LitCare was established in 2013, coordinated by association Lithuanian Medical Tourism Cluster, Vilnius. The number of cluster members is nine. It consists of seven Ltd – Bendrosios medicinos praktika, Flebologijos centras, Gradiali, Grožio Paslaugos, MCT – reabilitacijos centras UPA, Pro-Implant, SK Impeks Medicinos Diagnostikos Centras; one Plc – Eglės Sanatorija; one association – Lithuanian Medical Tourism Cluster (Figure 3.26).

The cluster aims to create value for the medical tourist by providing medical diagnostics, surgical and therapeutic treatment, rehabilitation, dentistry, sanatorium-spa treatment, SPA and accommodation, and other health, wellness, and travel organization. The cluster services cover an extensive range: from remote medical tourist consultations, travel and treatment planning, accommodation to therapeutic and surgical treatment, medical rehabilitation programs, aesthetic and therapeutic dentistry, beauty, sports, and many other medical fields. The organization of additional services for medical tourists is taken care of by the cluster partners: tour operators, planners of entertainment, local tourism, culture, and other service providers.

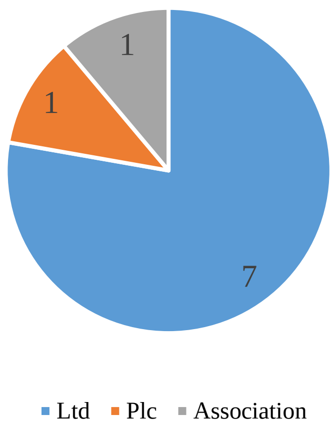


Fig. 3.26. Structure of Lithuanian Medical Tourism Cluster LitCare by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

The cluster members are medical diagnostic, treatment and rehabilitation centers, dental clinics, sanatoriums, spas, and hotels (Figure 3.27). One member is specialized in hotels and similar accommodation. One member provides information service activities. Human health activities are provided by six members and cover these activities: hospital activities, general medical practice activities, dental practice activities, other human health activities. Other personal service activities are provided by one member and cover hairdressing and other beauty treatment.

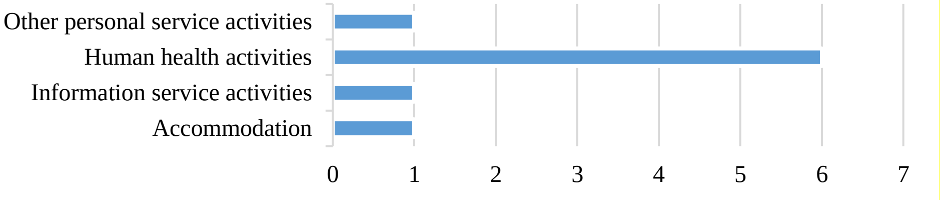


Fig. 3.27. Structure of Lithuanian Medical Tourism Cluster LitCare by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

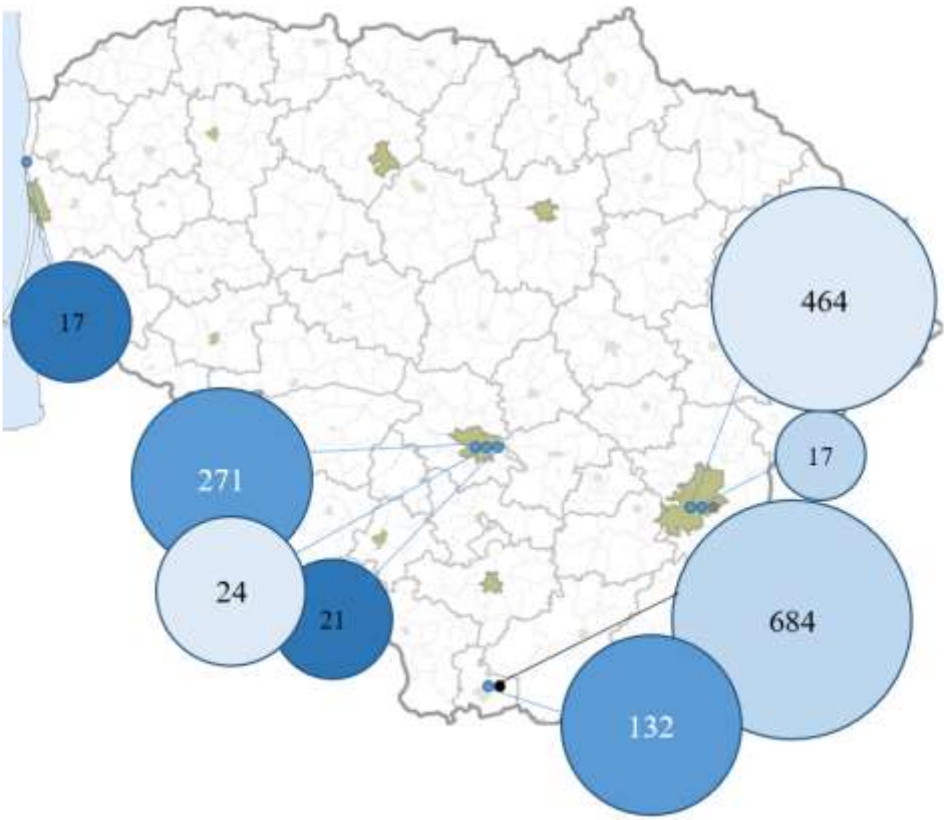


Fig. 3.28. Structure of Lithuanian Medical Tourism Cluster LitCare by geographic location, type of business, number of employees and turnover, 2018 (Source: Composed by the author according to KlasterLT)

The members of LitCare are not concentrated in one city, but they are relatively in a short distance (Figure 3.28). The coordinator is in Vilnius, together with the other two members. Three more members are in Kaunas and two in Druskininkai, less than 150 km away. Only one member is further away in Palanga, around 350 km away. The number of employees of the companies varies from seventeen to 684. The turnover starts with the lowest at EUR 200,001–300,000 per year and reaches the highest of EUR 20,000,001–30,000,000 per year.

The companies in the LitCare cluster are related through activities that are delivered rather than through geographical proximity. The concentration of companies is seen in several cities which are in the distance.

National Food Cluster was established in 2006, coordinated by association National Food Cluster, Kaunas. The number of cluster members reaches fourteen. It consists of ten Ltd – Baltic Food Technologies, Daumantai, Ekosula, Energenas, Hortiled, Judex, SatiMed, Paslaugos žemdirbiams, Rūta, Salpronė; one farmer – Šerkšno medus, one HEI – Vytautas Magnus University Agriculture Academy; one RC – Lithuanian Research Centre for Agriculture and Forestry; one association – National Food Cluster (Figure 3.29).

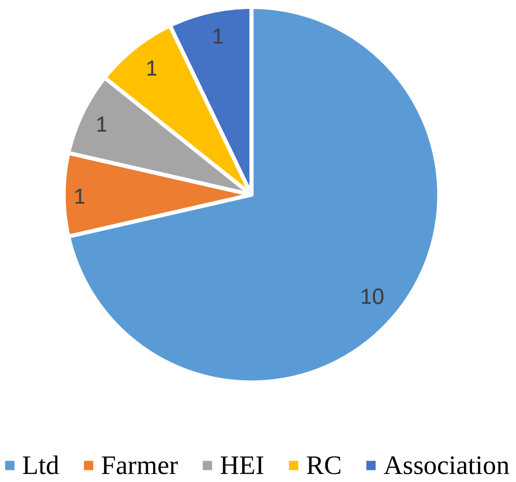


Fig. 3.29. Structure of National Food Cluster by business type, 2018, number of members (Source: Composed by the author according to KlasterLT)

The National Food Cluster is a cooperation network of Lithuanian food business enterprises and research institutions seeking to identify market niches based on which the Lithuanian food industry could replace low value-added chains with high value-added chains. The cluster aims to concentrate human, financial, organizational, infrastructural, and technological resources, Lithuanian companies occupying the planned market niches; to organize a continuous process of acquiring skills, knowledge, and information of the network allows becoming active and competitive market participants.

Several food manufacturing companies joined the cluster to seek synergy of the effectiveness of activity for cost-minimizing and innovation (Figure 3.30). The food industry and scientists have united to provide Lithuanian food manufacturers conditions to develop products capable of outrivaling international brands. Forestry and logging, specifically support services to forestry, are carried out by one member. Five members practice the manufacture of food products in these specializations: processing and preserving of fruit and vegetables, manufacture of cocoa, chocolate, and sugar confectionery, manufacture of condiments and seasonings, manufacture of prepared meals and dishes. One member carries out the repair and installation of machinery and equipment, installing industrial machinery and equipment. One member practices are wholesale of other machinery and equipment. Scientific R&D in different specializations are carried out by three members: research and experimental development on biotechnology; other research and experimental development on natural sciences and engineering; R&D in agriculture. Higher university education is presented by one institution. One member develops activities of other membership organizations.

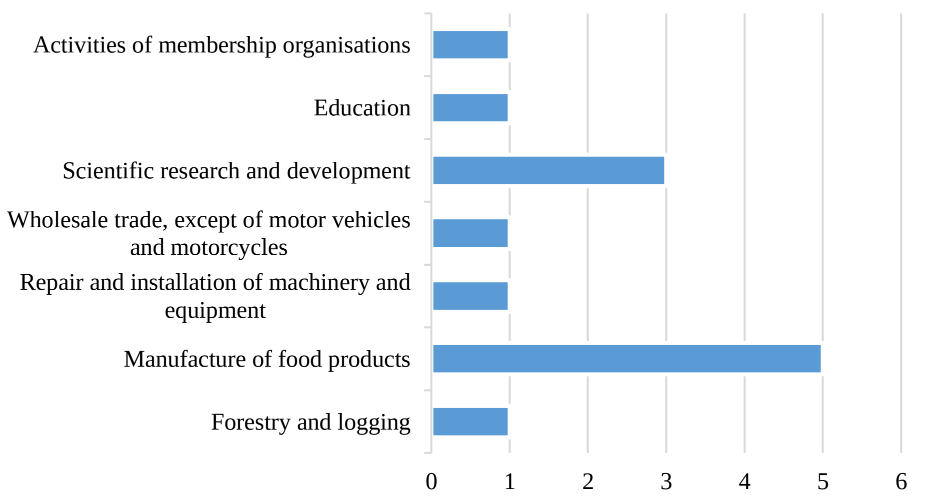


Fig. 3.30. Structure of National Food Cluster by economic activity, 2018, number of members (Source: Composed by the author based on atvira.sodra.lt)

The majority of National Food Cluster members are situated in Kaunas and the Kaunas district (Figure 3.31). Four companies are founded in Kaunas, while three more companies, together with the coordinator and 1 HEI, are in the Kaunas district. One company is less than 100 kilometres away from the Kaunas district in the the Kėdainiai district. Kaunas's furthest distance is less than 150 kilometres away from 1 company in Šiauliai and in Utena. The number of employees of the companies varies from one (three companies) to 263. The turnover starts with the lowest of EUR 0–5,000 per year and reaches the highest of EUR 10,000,001–20,000,000 per year.

Geographical proximity is evident in this case, as the majority of companies are situated around Kaunas.

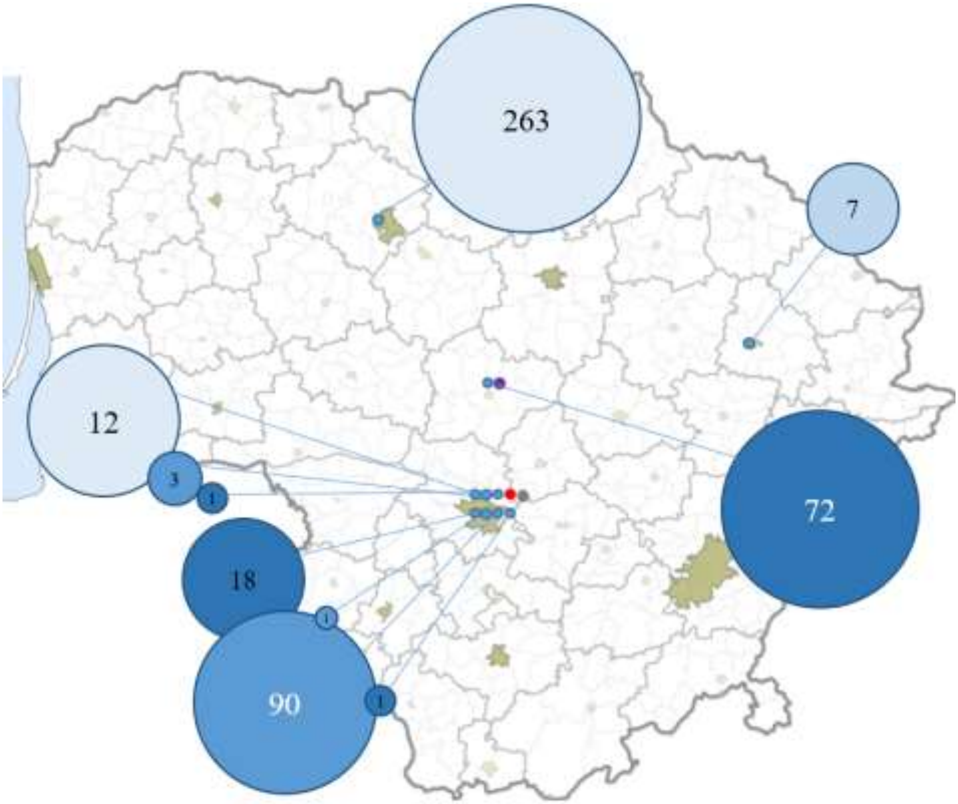


Fig. 3.31. Structure of National Food Cluster cluster by geographic location, type of business, number of employees and turnover, 2018
(Source: Composed by the author according to KlasterLT)

Analysis of Lithuanian clusters shows that clusters are operating because they want to gain a competitive advantage for their members while collaborating in all value-creation chains. Technological development and research potential are achieved when HEIs and RCs are involved in the activities of clusters. Geographical proximity is evident in the majority of cases, which allows closer collaboration. Cluster members' interrelated activities ensure that the cluster's aims are followed, and members supplement one another. The most critical factors that enable a company's successful progress are innovation, quality of production, and modern technologies. Belonging creates formal conditions for knowledge and technology transfer to a cluster.

3.2. Evaluation Process and Results for Cluster Performance in Transition to Circular Economy

The practical applicability of the evaluation tool for cluster performance in transition to CE proposed in the work is tested in the case of Lithuanian clusters. Empirical research is performed by analysing clusters operating in Lithuania.

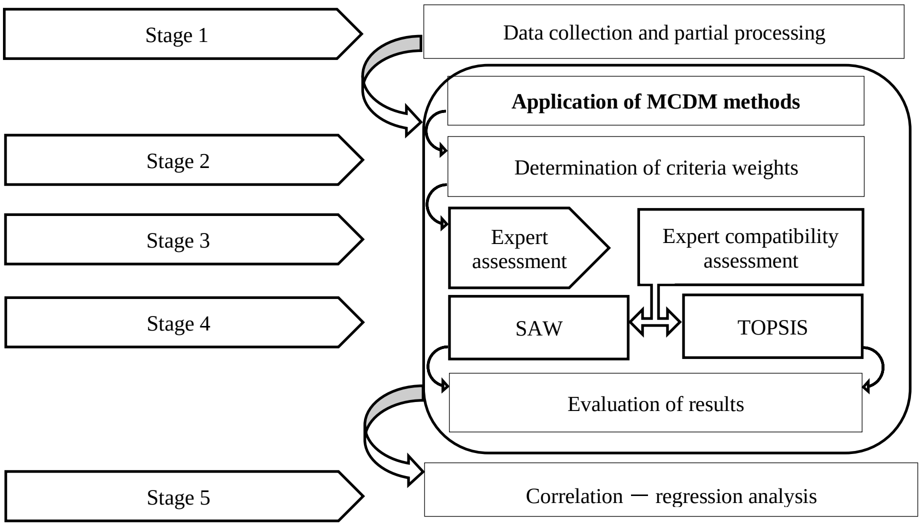


Fig. 3.32. The sequence of tool application for assessment of clusters' performance in transition to circular economy (Source: Composed by the author)

The sequence of stages when the cluster performance in transition to CE evaluation tool is applied is given in Figure 3.32 and followed throughout the chapter. Statistical databases and a cluster coordinators' questionnaire survey were used for data collection (Stage 1 in Figure 3.32). Ten clusters were selected for case analysis, but only seven completed the questionnaire given in Annex C. Other statistical data required were taken from official sources: Sodra, EPA, and KlasterLT.

The cluster coordinators evaluated intercommunication and marketing activities on a scale from 1 to 8 as follows:

1 – Very rarely
2 – Rarely
3 – Moderately rarely
4 – More rarely than often
5 – More often than not
6 – Moderately often
7 – Often
8 – Very often

The questionnaire answers show how cluster coordinators evaluate intercommunication within a cluster (Figure 3.33).

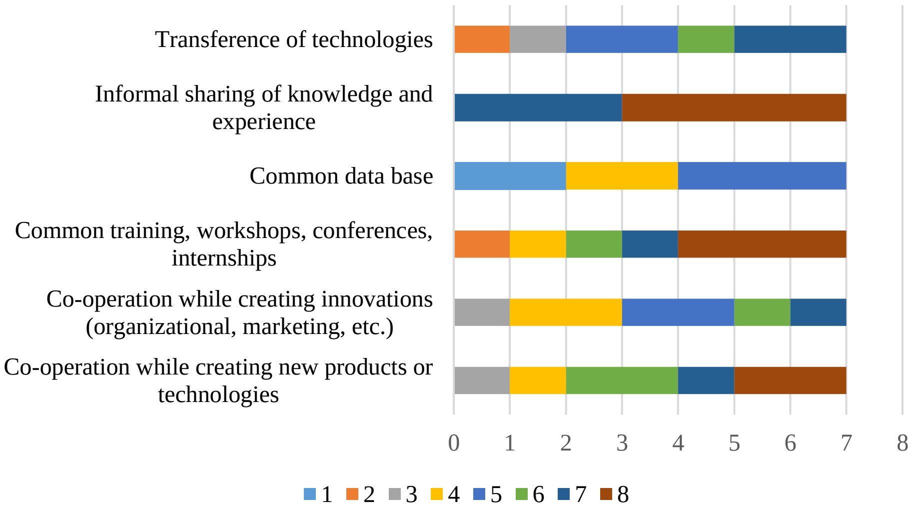


Fig. 3.33. Intercommunication results on a scale of 1–8 and number of clusters (Source: Cluster coordinators' evaluation)

It may be assumed that cooperation while creating new products or technologies satisfies the more significant part of the clusters, as only two clusters evaluated this indicator at 4 or less. The other five gave a score of 6–8, which indicates that the processes are happening often or very often. Cooperation in innovation creation (organizational, marketing, and other) shows less satisfaction, as three clusters gave 3–4 points and four clusters gave 5–7 points. Joint training, workshops, conferences and internships vary, with awards of 2 and 4 points by two clusters and 6–8 points by five clusters. Three clusters give 8 points, which indicates that the majority of clusters implement these activities very often. Clusters do not often practise a common database, as two clusters gave the lowest evaluation, 1 point, two gave 4 points, and the other three gave 5 points. Informal sharing of knowledge and experience got the highest scores, as three clusters gave 7 points and four clusters gave 8 points, which indicates that it is practised by cluster members very often. Transference of technologies happens often but does not fully satisfy the cluster members, as two of them gave 2 points and 3 points, and the values vary from 5 to 7 points. Although some of the clusters scored intercommunication activities relatively, they must be shared by cluster members according to the evaluations. The situation for marketing activities is a bit different (Figure 3.34).

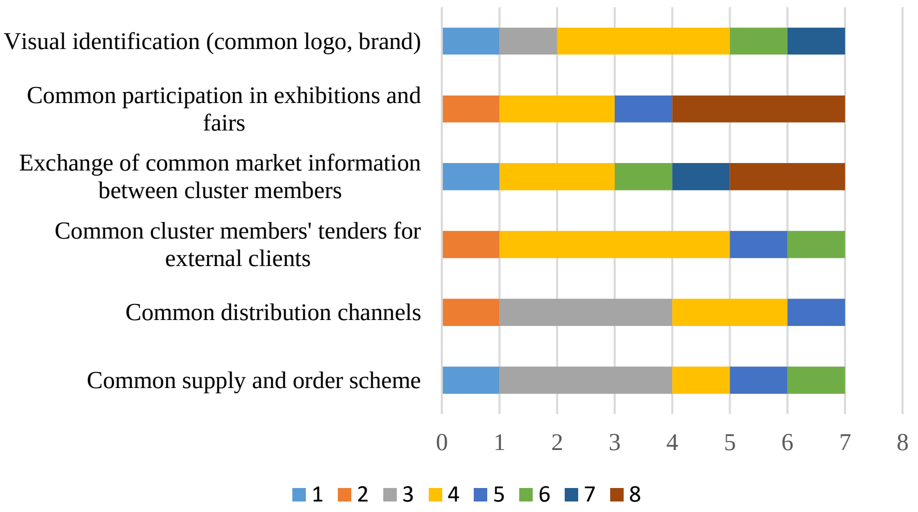


Fig. 3.34. Marketing activities results on a scale of 1–8 and number of clusters (Source: Cluster coordinators' evaluation)

Common supply and order schemes may not satisfy cluster members, as they got evaluations from 1 to 6 points, the majority giving up to 5 points. Common distribution channels might not be practised very often as only one cluster gave 5 points, while other evaluations varied from 2 to 4 points. Common cluster members' tenders for external clients are practiced more rarely with a tendency to do that more often as most of the clusters gave 4 points and others gave 5–6 points. One evaluation was 2 points. Exchange of current market information between cluster members has a wide evaluation from very rare to very often. In general, more clusters evaluate this activity as more satisfying, as four clusters gave 6–8 points while two clusters gave 1 point and 4 points. Four clusters highlighted the importance of collective participation in exhibitions and fairs, giving 7–8 points, and the other three gave 2–4 points. The greater part falls to higher points. Visual identification (logo, brand) does not appear to be used very often, with five clusters giving the lowest evaluations of 1–4 points and two clusters awarding 6–7 points. As seen generally, marketing activities are more often evaluated as rarely applicable by clusters or are less popular, but they have high intensity of involvement with the greater part of cluster members participating.

Human resources and financial activities include confidential information and can only be viewed generally. Analysis of human resources shows the increase of cluster members' employees in two years is around 5–7 percent. The growth may be determined by differences between members. Rapid growth in the number of employees may be seen in more substantial companies in absolute measures and in smaller companies in relative measures. The same goes to younger companies, high-tech companies, larger companies – the growth is seen in terms of employees and revenue and smaller companies show better results in productivity indicators (as discussed in Chapter 1).

Analysis of financial activities shows that cluster members often come together to prepare common project applications. According to the cluster coordinators, most clusters prepared at least two to four joint cluster projects in the two years 2017–2018. There have been between one and three joint-financed cluster projects in two years. The number of joint international R&D projects funded not from EU SF in two years varies from one to two. External financing for cluster initiatives was from EUR 50,000 to EUR 747,802. The sum of cluster members' investments for cluster initiatives in the two years varies from EUR 30,000 to EUR 500,000.

In most cases, external financing is more significant in investment in cluster initiatives. Clusters, which bring together excellent and more productive companies, are less likely to look for alternative financing sources. It is possible to acknowledge that financial support from external sources reduces cluster members' costs of developing cluster activities and provides opportunities to use resources for investment in innovative activities.

Seven out of ten indicators for transition to the CE were taken from the EPA and show the generation of different types of waste in tonnes per cluster. Six out of seven clusters provided information about waste. The generation of municipal waste per cluster varies from 63.96 tonnes to 6,657.49 tonnes, according to the EPA. Most clusters do not exceed 1,000 tonnes per year, which means that the greatest municipal waste producer generates twice as much waste as the other five combined.

The generation of plastic, wooden and other packaging waste, e-waste, biowaste, and construction and demolition waste highly depend on cluster specialization (Figure 3.35). The most waste in two clusters is construction and demolition waste, and this is the second most generated waste group in another two clusters. The second most generated waste type in each cluster is plastic packaging waste, followed by wooden packaging waste and other packaging waste. The packaging waste takes a greater part in four out of six clusters.

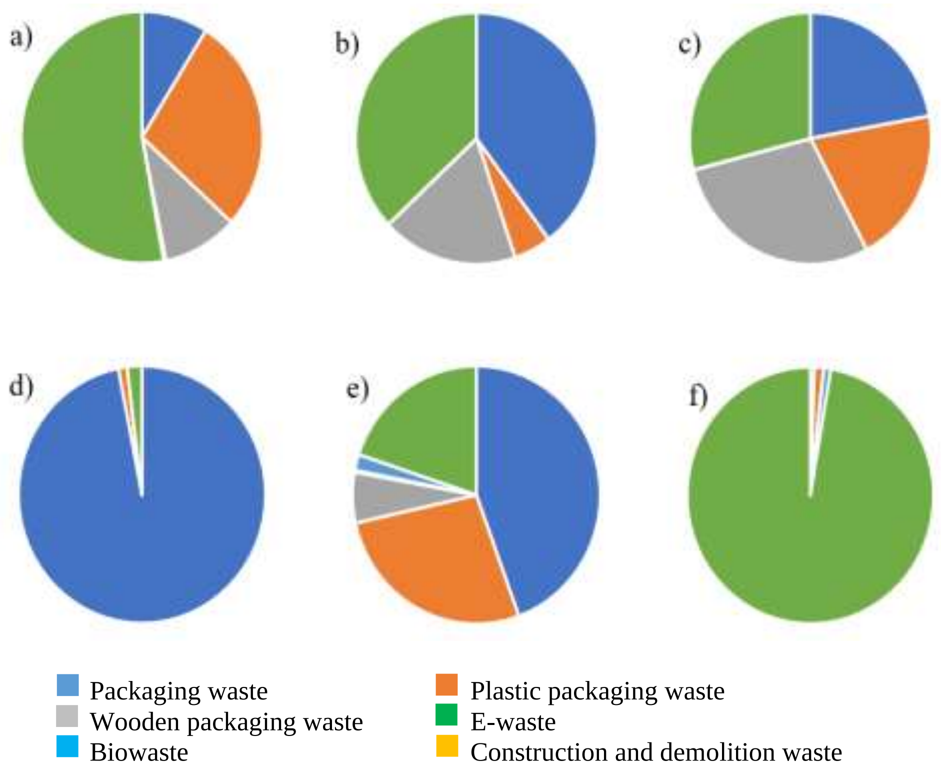


Fig. 3.35. Generation of waste results: share per year in 2018 in six clusters a) C1; b) C2; c) C3; d) C4; e) C5; f) C6 (Source: Cluster coordinators' evaluation)

Trade-in recyclable raw materials are not assessed in clusters. The food industry tends to use all products during production or pass it on to stock farms or other possible destinations using secondary raw materials. However, the food industry also produces high volumes of packaging waste, which might be recycled. Cluster coordinators indicate that more than 60 percent of cluster members operating in the automotive, plastics and manufacturing industries tend to import recyclable raw materials. The numbers are different from those of exports of recyclable raw materials, as they vary from 44 percent to 92 percent of cluster members. Only a few cluster members tend to trade recyclable raw materials within a cluster.

Clusters' performance in transition to CE is calculated using the methodology presented in Chapter 2. MCDM methods and Correlation – regression analysis were applied for calculation of the results, determining how cluster performance is related to the transition towards CE. The calculations are done according to the formed hierarchical system of indicators (Figure 2.2).

In a later stage (Stage 2 in Figure 3.32), experts were asked to confirm the eligibility of the criteria by evaluating the indicators and ascribing weights. As stated in Chapter 2, the number of experts may vary. Twelve experts with the required qualifications were selected to ensure that sufficient responses were received, and the questionnaires were sent. Directors, heads of departments, and coordinators from different institutions were approached: the Lithuania Innovation Center (LIC), LINPRA, MITA, NPO Circular Economy, VILNIUS TECH, and foreign experts who participated in the implementation of the project ClusDevMed. The experts' experience in the required fields varies from three to fifteen years in clusters and from four to ten years in CE, which indicates that their evaluations can be trusted. The final weights in this work were determined by seven experts.

Experts were asked to fill in the questionnaire (Annex D). Each indicator had to be evaluated by giving weights, for a total 100 percent. The main information about the work including the aim, purpose, and implication of methodology was provided in the questionnaire. Cluster performance and transition to CE evaluations were presented as different indicators requiring separate evaluations. Cluster performance evaluation includes additional components evaluated with the total sum of 100 percent for four groups of components.

Processing of the results was followed by calculation of the consistency of experts' evaluation (Stage 3 in Figure 3.32). The evaluation was done by ranking the indicators, assigning the highest value 1 to the most crucial element and 6 to the least important element. For each decision stage, the concordance coefficient W and criterion χ^2 were calculated to check the consistency of experts' evaluation. The values of χ^2_{kr} in Table 3.2 depend on the significance level α and the degree of freedom $m-1$. The concordance coefficient W is calculated according to formula (1), and criterion χ^2 according to formula (2). The concordance coefficients W, χ^2, and χ^2_{kr} of clusters' performance evaluation components are given in Table 3.2.

When the intercommunication component is viewed, W = 0.72 indicates a high degree of consistency among the expert opinions. Concordance coefficient χ^2 was calculated to evaluate the significance of the concordance coefficient. The value of $\chi^2_{\mathrm{kr}(\alpha = 0.05, \mathrm{m}-1 = 5)}$ = 11.0705. The coefficient χ^2 is twice as high as χ^2_{kr} = 11.07, which indicates that expert opinions are consistent. Marketing activities with W = 0.65 indicate the average consistency of expert opinions. The value of $\chi^2_{\mathrm{kr}(\alpha = 0.05, \mathrm{m}-1 = 5)}$ = 11.0705. The coefficient χ^2 = 22.84 is greater than χ^2_{kr} = 11.07, which means that W = 0.65 is not a random variable, and the obtained results make sense and can be used in further calculations. Human resources with W = 0.52 indicate the average consistency of expert opinions. The value of $\chi^2_{\mathrm{kr}(\alpha = 0.05, \mathrm{m}-1 = 5)}$ = 12.59159. The coefficient χ^2 = 21.95 is greater than χ^2_{kr} = 11.07, which means that W = 0.65 is not a random variable, and the results can be used in further calculations. Financial resources with W = 0.6 indicate the average consistency of expert opinions. The value of $\chi^2_{\mathrm{kr}(\alpha = 0,05. \mathrm{m}-1 = 5)}$ = 11.0705. The coefficient χ^2 = 21.1 is greater than χ^2_{kr} = 11.07, which means that W = 0.6 is not a random variable, and the results can be used in further calculations.

Table 3.2. The concordance coefficients $\boldsymbol{W}$, χ^2, and $\boldsymbol{\chi^2_{kr}}$ of clusters' performance evaluation components (Source: Composed by the author)

Components	W	χ^2	χ^2_{kr}
Intercommunication	0.72	25.33	11.07
Marketing activities	0.65	22.84	11.07
Human resources	0.52	21.95	12.59
Financial resources	0.6	21.1	11.07

Table 3.3. illustrates the compatibility of expert opinions for cluster performance evaluation and transition to CE evaluation. The concordance coefficients W, χ^2, and χ^2_{kr} of clusters' performance evaluation components are given in Table 3.3.

Cluster performance, with W = 0.65, indicates the average consistency of expert opinions. The value of $\chi^2_{\mathrm{kr}(\alpha = 0.05, \mathrm{m}-1 = 5)}$ = 7.81473. The coefficient χ^2 = 13.1, which is greater than χ^2_{kr} = 7.81, showing that W = 0.65 is not a random variable, and the obtained results make sense and can be used in further calculations. Transition to CE with W = 0.86 indicates a high degree of consistency among the expert opinions. Pearson's coefficient χ^2 was calculated to evaluate the significance of the concordance coefficient. The value of $\chi^2_{\mathrm{kr}(\alpha = 0,05, \mathrm{m}-1 = 5)}$ = 16.91898. The coefficient χ^2 = 54 is greater than χ^2_{kr} = 16.92, which means that W = 0.86 is not a random variable, and the obtained results make sense and can be used in further calculations.

Table 3.3. The concordance coefficients $\boldsymbol{W}$, χ^2, and $\chi^2_{\boldsymbol{kr}}$ of clusters' performance evaluation components (Source: Composed by the author)

Components	W	χ^2	χ^2_{kr}
Clusters' performance	0.62	13.1	7.81
Transition to CE	0.86	54	16.92

The concordance coefficient W results vary from 0.52 and 0.86, as seen in the above tables. The compatibility of expert opinions is confirmed, as all values $\chi^2$are higher than χ^2_{kr}.

When calculating the results with the application of SAW and TOPSIS methods (Stage 4 in 3.32)., data shortage occurs. As clusters still do not get enough attention, there is no obligation to collect and systemize data to evaluate cluster performance. The availability of data determined the further course of the tool application.

When MCDM methods are applied and the shortage of data is ignored, the results may be distorted. Hence a non-standard mathematically correct calculation method was applied. This calculation method was applied with every cluster; the indicators containing unavailable data were withdrawn, and the weights were recalculated accordingly. Such recalculation of weights enables the eligible application of MCDM methods and demonstrates the legitimacy of the proposed tool.

One cluster provided all the requested data in a reasonably short period, proving that all the indicators may be identified and information collected. This allowed us to verify that the proposed cluster performance evaluation regarding the CE transition tool is legit and can be exploited.

One cluster provided all the requested data in a reasonably short time, proving that all the indicators can be identified and information collected. This allowed us to verify that the proposed cluster performance evaluation regarding transition to the CE is legitimate and can be exploited.

The results obtained by SAW method are presented in a pie chart with the numerical values converted as a percentage towards the ideal solution. The values calculated by SAW method can be numerically distant from each other, so the evaluation is clearer when converted as a percentage towards the ideal solution. Percentage presentation of values allows to assess the approximation of the results of one cluster to the best value in the sample. This presentation of the results allows the cluster coordinators to compare the cluster results with the overall best result in the sample.

Figure 3.36 shows that the cluster performance corresponds to 54.83 percent when approaching the ideal solution. Consequently, the overall result of the cluster performance is closer to the best solution in the sample. The transition of the cluster to the CE corresponds to 90.15 percent when approaching the ideal solution. This shows that the result of the cluster transition to CE is very close to the best value in the sample. The final result may alternate depending on the number of samples included in the analysis with provided data.

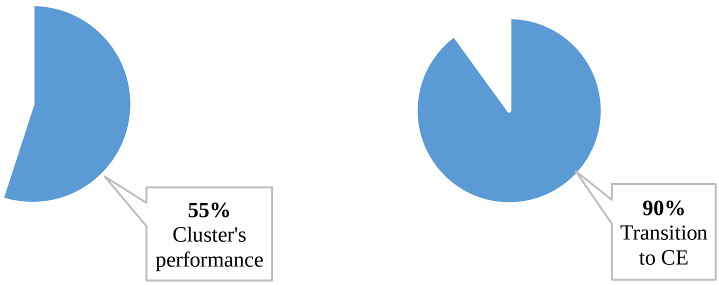


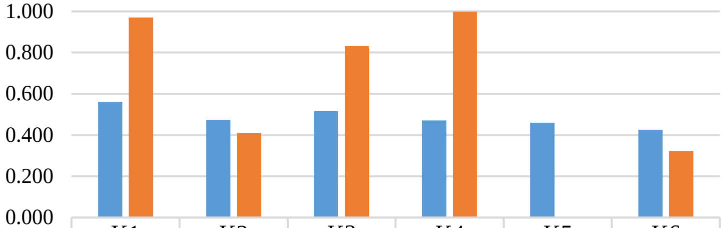
Fig. 3.36. Evaluation of cluster performance in transition to CE by the SAW method as a percentage towards the ideal solution (Source: Composed by the author)

Percentage towards the ideal solution for results assessed by SAW method was calculated according to the equation:

$$Recommendation = \frac{100 \times real}{ideal}. \quad (3.1)$$

A chart including the results obtained by the TOPSIS method can be provided to decision makers who review them make considerations (Figure 3.37). TOPSIS results are presented in numerical values in the range from 0 to 1. Such presentation allows the comparison of the clusters with each other or the change of the results of the same cluster in different periods when aiming at assessment of their distribution according to the area in which the cluster stands out. The chart shows that the performance of the clusters is distributed at the average and range from 0.425 to 0.561. Meanwhile, the results of the transition to CE are more fragmented, fluctuating throughout the range. Such distribution is possible due to the fact that the clusters belong to different sectors. Therefore, it is necessary to pay attention to the specifics of the cluster when making decisions.This work applies a non-standard approach to correlation – regression analysis (Stage 5 in Figure 3.32). In this case, it is suggested to use correlation – regression analysis to find the relationship between the results calculated, using different MCDM methods to select the best alternative. Here, the connection between the results obtained by MCDM methods, which incorporate measures in a particular system of criteria, is looked for instead of the connection between direct cluster estimates.

These estimates help measure cluster performance and transition to CE, while correlation – regression analysis allows us to trace if the results of SAW and TOPSIS methods show the relationship between the two sets of indicators. In this case, the interdependence of cluster performance and transition to CE is seen.



	K1	K2	K3	K4	K5	K6
Cluster performance	0.561	0.474	0.517	0.471	0.460	0.425
Transition to CE	0.971	0.410	0.831	0.999	0.000	0.324

Fig. 3.37. Evaluation of cluster performance in transition to CE by the TOPSIS method in the range from 0 to 1
(Source: Composed by the author)

Two sets of criteria define cluster performance and transition to CE. Seven clusters participated in the application of the proposed scheme. MCDM methods (SAW and TOPSIS) were used to combine the values of criteria and their weights into one estimate for each set of criteria that determines the numeric value. Hence, two separate tasks were solved by evaluating clusters' performance and transition to CE using the proposed criteria. The estimates that were calculated for these areas show a statistical correlation.

The linear regression model was determined from the estimates of six clusters, as one cluster did not provide statistics for the calculations of transition to CE. Assuming that this cluster does not belong to the industrial sector, only cluster performance was calculated. The omission of the data was not considered zero value because that could distort the results' reliability. Therefore, one cluster was eliminated from the application of the tool when the correlation – regression-regression analysis was performed.

Here, we take statistical variables x and y, where x is transition to the CE and y is clusters' performance in numerical values when the results of SAW and TOPSIS were calculated.

As seen from the results when both SAW and TOPSIS methods were applied, clusters' performance and transition to CE follow a linear pattern. When the TOPSIS method is applied, the equation is $y = 5.6307x – 2.1391$. The scatterplot of our data with the results calculated using the TOPSIS method indicates a positive direction. The two variables have a positive linear relationship: when one variable moves in a particular direction, the other tends to move in the same direction with positive covariance. The determined relationship is recorded analytically using a linear regression model.

The estimates when the SAW method was applied are more distant from each other than those of TOPSIS. The results determined by the SAW method are related to the following relationship: $y = 0.868x + 16.617$. The obtained linear regression models extrapolate the results outside the obtained result ranges by making specific predictions. In the equations, the values x and y are the approximate estimates of the respective clusters obtained after the cluster performance results and after transition to CE is calculated.

The correlation – regression analysis results with the coefficient of determination R^2 when the results of SAW and TOPSIS analyses are applied are given in Table 3.4. The closer the value of the coefficient is to 1, the stronger the relationship detected. The coefficient of determination R^2 equals 0.66 when TOPSIS analysis results were applied. The result shows a moderate positive relationship. The results of the SAW analysis also show a moderate positive relationship with R^2 equal to 0.51. It is possible to say that there is primary causation, as clusters' performance may cause a transition to CE.

Table 3.4. The coefficient of determination $\boldsymbol{R^2}$ when the results of SAW and TOPSIS analyses were applied (Source: Composed by the author)

	TOPSIS	SAW
R^2	0.66	0.51

The reliability of the results when correlation – regression analysis is performed might be determined by the volume of data. Too little data collected for the study may result in a lack of degrees of freedom due to large estimation errors. When the tool is applied, it is suggested to add more values to the data series in order to avoid the insignificance of variables due to too few degrees of freedom.

Correlation – regression-regression analysis was applied to examine whether there is a relationship between the cluster performance and transition to CE. The results show that although the data necessary for the research are not available in some cases, this is because they are not collected regularly for observation or there is limited access due to data protection on the company level. The suggested tool was applied in operating clusters in Lithuania. One cluster provided all the necessary data, which allowed us to adapt the methods and calculate the results.

The final result shows that there is a preliminary relationship between cluster performance and transition to CE.

The suggested tool was applied in seven active clusters operating in Lithuania to verify its reliability. The tool allows the evaluation of clusters' performance in transition to the CE, and the relationship between cluster performance and transition to the CE individually for a cluster or by comparing the results of several clusters. Here, the precision of the results of the applied tool depends on the number of clusters that are benchmarked and the time span when the data are collected (here, the years 2017 and 2018).

3.3. Overview of Obtained Results

When the whole world is moving towards a CE, it is impossible to ignore this. Companies search for partners that share similar ideas of how resources should be treated in different operation stages to turn to circular business models. They make partnerships with companies that turn waste into materials to make operations more efficient and save resources.

The growing interest in clusters is seen in Lithuania. Governmental institutions have promoted initiatives that should encourage existing clusters to involve members in joint activities and become mature. Cluster monitoring is carried out every two years with the aim of monitoring the overall trend of cluster change. Ten Lithuanian clusters have obtained ESCA Bronze labels, recognized and appreciated by the international community, showing their competence and maturity.

The proposed cluster performance in transition to CE evaluation tool has been tested in seven Lithuanian clusters. This tool can be applied in Lithuania by repeating the procedure every year and benchmarking the results. Such continuation would serve to detect areas which need improving. The cluster performance in transition to CE evaluation tool can be applied in other countries as the indicators are selected taking international documents into consideration.

The research has some limitations which occur due to the complicated structure of clusters. Some data on the company level are not available, making it impossible to assess the data on the cluster level. In some cases, interviews with cluster coordinators enabled them to fill the gap by adding the necessary data. The information provided by a cluster coordinator may lack objectivity. Interviews and questionnaire surveys are applicable as methods when no reliable statistical data are available. This suggests that information gathered using these methods might be subjective and inaccurate in some cases.

The transition to CE can be identified by the total quantity of waste suitable for use as a material (which is a priority use of waste), for recycling, and non-recyclable waste (incinerated or landfilled). Municipal waste, packaging waste, plastic packaging, wooden packaging, e-waste, bio-waste, and construction and demolition waste contain materials that may or may not be recyclable. Accounting for waste is complex as the remains of packaging can be reported as waste, which entails a heavy administrative burden for companies, or it can be sold without reporting. Unfortunately, this disadvantage applies to the entire waste management system, with enormous amounts of unaccounted waste.

The initial idea was to follow the indicators selected to monitor CE progress in each EU country as suggested by the European Commission This should include the recycling rate of packaging waste, plastic packaging, wooden packaging, and e-waste, and the recovery rate of construction and demolition waste. The Lithuanian Department of Statistics referred to the EPA for the data required: the response was that none of the members of any given cluster is a waste recycler, so recycling rates are not accounted for. The only data that can be provided are in relation to the amount of waste.

Here, the circularity of a cluster itself is evaluated. Therefore, other available data are selected to recognize industrial symbiosis if it takes place, being the median of waste volume over the last two years and the exchange of materials among cluster members.

3.4. Conclusions of Chapter 3

1. The case analysis of ten Lithuanian clusters awarded an ESCA Bronze label shows that these clusters correspond to the main description and demonstrate the main features. Most of the cluster members are SMEs engaged in similar or complementary activities related through geographical proximity. The only apparent deficiency is that none of the cluster members is a waste recycler. Clusters have everything needed for the supply chain – suppliers, manufacturers, distributors, marketing, service, R&D, innovations, and HR management
2. Clusters as a unit do not get enough attention, which results in a lack of accessible data. Hence, some of the necessary data are not available, as they are company data with limited access. One cluster provided all the information, allowing the application of SAW and TOPSIS methods and suggesting an ideal solution for calculating SAW results. The results of this cluster when cluster’s performance is evaluated by SAW equals to 54.83 percent towards the ideal solution and TOPSIS equals to 47.37 percent. Transition to CE by the same cluster is evaluated by SAW at 90.15 percent towards the ideal solution and TOPSIS at 41.04 percent.

3. The correlation – regression analysis includes SAW and TOPSIS results for six clusters which indicate a preliminary relationship between clusters' performance and transition to CE. The coefficient of determination R^2 equals 0.66 when the numerical values of SAW calculations are applied and 0.51 when the results of TOPSIS analysis are applied.
4. The tool's practical application in seven Lithuanian clusters and the obtained results show that the cluster performance in transition to CE evaluation tool can be used nationally and adapted for other countries.
5. The easiest way for clusters to become more circular is to involve a waste recycler as a member of a cluster or to act as a waste recycler by using one member's waste as other member's materials. The amount of waste could be reduced in this way and value created, giving the cluster a competitive advantage.

General Conclusions

1. The theoretical analysis revealed the ambiguity of the notions that were selected for analysis. General approaches were depicted for further analysis of clusters and CE. The scientific literature helped to identify that clusters are interested in resource efficiency, and reduction of energy, material, and water costs, showing the importance of clusters when SMEs are encouraged to turn to the CE. One of the most frequently detected features in clustering is the competitive advantage gained by SMEs through proximity. The CE may help SMEs achieve this, as clusters can connect corresponding parties involved in resource efficiency, recycling, re-use of materials, and other activities within a unit.
2. Literature analysis helped to identify the indicators that are most frequently used by scholars when clusters are studied. These were further combined with measures indicated by Lithuanian governmental institutions and ESCA. Four main groups of indicators that are viewed as highly representative in cluster performance were composed according to these sources: intercommunication, showing how close the relationship between cluster members is; financial resources, including possible financial information about projects and other investments; human resources, indicating the qualifications of

personnel in a cluster, the kind of training they get, and the way the cluster is coordinated; and marketing activities, including indicators that enable promotion of the cluster in the society.

3. Indicators defining the transition towards the CE were selected after literature analysis and followed a framework for monitoring progress suggested by the EC. Ten indicators included generating municipal and other waste, helping to follow the trend in waste control and trade in recyclable or reusable raw materials through imports, exports, and between cluster members.
4. The thesis's scientific novelty lies with incorporating two new systems of proposed indicators into one tool: cluster performance evaluation and transition of a cluster to CE evaluation. This tool is designed to be used in Lithuanian clusters, with possible applications in other countries. The evaluation tool monitors clusters' development regarding performance and transition to CE through a specific set of indicators. It can be used by cluster managers, coordinators, and authorities, and by governmental institutions to support the need for funding opportunities to develop clusters.
5. A case analysis was performed in operating clusters, which showed that clusters are undervalued in Lithuania. Data regarding clusters' performance should be collected and evaluated regularly for progress assessment. Clusters operating in different sectors were selected for case analysis, the result being that the performance of seven clusters and the transition to CE of six clusters were evaluated by applying MCDM methods (SAW, TOPSIS).
6. The collected data allowed the formation of a database to be initiated according to the proposed system of indicators. The results of clusters' performance in transition to CE evaluation show that there is a relationship between clusters' performance and transition to CE. This implies that clusters can be used as tools for the further development of resource-efficient companies.

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Summary in Lithuanian

Įvadas

Problemos formulavimas

Lietuvoje atkreiptas dėmesys į klasterių svarbą siekiant mažų ir vidutinių įmonių konkurencingumo skatinimo. Lietuvos klasterių tinklas susiduria su problemomis ir yra skatinamas prioritetinėmis laikyti tas pačias sritis kaip ir ES: skaitmenizaciją, žaliąją gamybą, ES pridėtinės vertės kūrimo grandines (Von Der Leyen, n.d.). Klasterius vienijantis MITA įgyvendinamas projektas "Inovacijų tinklaveiklos skatinimas ir plėtra (InoLink)" pradėtas 2016 metais ir pratęstas iki 2022 metų ("INOLINK | MITA," n.d.). Bendras projekto biudžetas (2,4 mln. Eur) skirtas klasterių įkūrimo, brandinimo, finansavimo, partnerių paieškos ir kitų klausimų sprendimui.

Eurostat (2019) duomenimis, Europos sąjungos (27 šalių) žiediškumas 2019 metais tesiekė 11,9 procento. Rodiklis vis dar žemas, tačiau pastebimas jo augimas 0,8 procentiniais punktais nuo 2014 metų ES vidurkio. Tuo tarpu Lietuvoje žiediškumas 2019 metais siekė vos 4 procentus ir nuo 2016 metų sumažėjo 0,6 procentiniais punktais. Siekdama tvarios ES ekonomikos, Europos komisija pasiūlė Europos žaliąjį kursą ("A European Green Deal | European Commission," n.d.) su veiksmų planu, kuriuo siekiama skatinti veiksmingą išteklių naudojimą ir sumažinti taršą.

Darbo aktualumas

Poreikis vertinti klasterius yra jaučiamas nacionaliniu lygmeniu. Siekiama nustatyti jų silpnąsias, stipriąsias puses ir jas įvardinus gerinti klasterių veiklos rezultatus. Klasteriai gali prisidėti skatinant įmones pereiti prie žiedinės ekonomikos, nes paprastai mažos ir vidutinės įmonės neturi galimybių taikyti novatoriškus sprendimus vien savo lėšomis. Klasterių veiklos vertinimo modelis, kuris leistų stebėti kaip klasteriai prisideda pereinant prie žiedinės ekonomikos, padės įvertinti klasterius. Perėjimas prie žiedinės ekonomikos gali būti vertinamas kaip konkurencinis pranašumas klasteriui priklausančioms įmonėms. Klasteriai ir klasterių organizacijos yra įvardinamos kaip galimi veiksniai, skatinantys mažų ir vidutinių įmonių įsitraukimą į žiedinės ekonomikos veiklas. Mažos ir vidutinės įmonės vis dažniau pastebi efektyvaus išteklių valdymo svarbą ir pradeda ieškoti žiedinės ekonomikos verslo modelių padedančių gauti naudos iš atliekų. Klasteriai ir klasterių organizacijos gali padėti mažoms ir vidutinėms įmonėms efektyviau valdyti išteklius. Nustatyta, kad parengtas klasterių veiklos vertinimo modelis, kuris apima perėjimą prie žiedinės ekonomikos parodančius rodiklius, gali būti naudingas siekiant klasterio narių plėtros.

Tyrimo objektas

Disertacinio tyrimo objektas yra klasterių veikla pereinant prie žiedinės ekonomikos.

Darbo tikslas

Disertacijos tikslas yra sukurti klasterių veiklos vertinimo pereinant prie žiedinės ekonomikos modelį.

Darbo uždaviniai

Darbo tikslui pasiekti buvo sprendžiami šie uždaviniai:

1. Atlikus mokslinės literatūros analizę, susisteminti klasterių ir ŽE koncepcijas.
2. Remiantis literatūros analize nustatyti klasterių veiklą nusakančius rodiklius ir sudaryti vertinimui tinkamą sistemą.
3. Sudaryti tarptautiniu mastu naudojamus rodiklius apimančią perėjimo prie ŽE vertinimo sistemą.
4. Suformuluoti vertinimo metodologiją, tinkančią klasterių veiklos pereinant prie ŽE vertinimui.
5. Patikrinti pasiūlyto klasterių veiklos vertinimo pereinant prie ŽE modelio pritaikomumą Lietuvoje skirtinguose sektoriuose veikiančiuose klasteriuose.
6. Pasiūlyti klasterių veiklą pereinant prie ŽE nusakančių rodiklių duomenų bazės koncepciją.

Tyrimų metodika

Darbe taikomi teoriniai analizės bei sintezės metodai, leidžiantys pasirinkti iškeltų uždavinių sprendimo paieškos strategiją ir atskleisti skirtingų mokslininkų požiūrį į klasterių veiklos vertinimo pereinant prie ŽE problemas. Sisteminė mokslinės literatūros analizė atlikta siekiant suformuoti klasterių veiklos pereinant prie ŽE vertinimo rodiklių sistemą, tinkamą daugiakriterinių metodų taikymui. Atvejų analizė pritaikyta pasirinktiems klasteriams, siekiant juos apžvelgti. Dalis duomenų dėl ribotos prieigos gauti atlikus interviu ir pateikus klausimynus klasterių koordinatoriams, kiti surinkti per paiešką duomenų bazėse. Atrinkti rodikliai pateikti klasterių ir ŽE ekspertams, aliktas ekspertinis vertinimas. Nustatytos rodiklių reikšmės, normalizuoti duomenys, taikyti SAW ir TOPSIS daugiakriterinio vertinimo metodai. Tiesinė regresinė analizė atlikta siekiant patikrinti ar egzistuoja ryšys tarp klasterių veiklos ir perėjimo prie ŽE.

Darbo mokslinis naujumas

1. Patikslinta klasterio koncepcija, kurioje teigiama, kad klasterį sudaro per vertikalius (tiekimo grandinės) ir horizontalius (papildantys produktai ir paslaugos, panašių specializuotų įvesčių, technologijų ar institucijų naudojimas ir kitos sąsajos) ryšius viena kitą galinčios papildyti įmonės ir susijusios institucijos besinaudojančios geografiniu artumu ir bendradarbiavimu konkurencinio pranašumo įgyjimui.
2. Siūlomos dvi naujos rodiklių sistemos, reikalingos klasterių veiklos pereinant prie ŽE stebėjimui. Rodikliai parinkti atsižvelgiant į įvairius klasterio veiklos komponentus: tarpusavio komunikaciją, finansinius išteklius, žmogiškuosius išteklius, marketingo veiklas ir kriterijų rinkinį, rodantį perėjimą prie ŽE. Šios dvi sistemos gali būti naudojamos atskirai, kai siekiama stebėti klasterio veiklą arba klasterio perėjimą prie ŽE. Jos leidžia rinkti duomenis, lyginti juos pasirinktu laikotarpiu ir peržiūrėti.
3. Pasiūlytas klasterių veiklos vertinimo pereinant prie ŽE modelis yra išbandytas pasirinktuose Lietuvos klasteriuose. Šiame modelyje sujungiamos dvi rodiklių sistemos, pritaikomi daugiakriteriniai sprendimų priėmimo metodai ir tiesinė regresinė analizė, kurie leidžia įvertinti klasterių veiklą pereinant prie ŽE. Modelyje naudojami universalūs rodikliai ir jis gali būti pritaikomas kitose šalyse. Gauti rezultatai rodo, kad klasteriai gali būti vertinami kaip perėjimo prie ŽE skatintojai.

Darbo rezultatų praktinė reikšmė

Klasterių vadovai ir koordinatoriai tolesniam klasterių vystymui gali naudoti dvi naujas rodiklių sistemas, kai siekiama stebėti klasterių veiklą pereinant prie ŽE.

Modelis, leidžiantis įvertinti klasterių veiklą atsižvelgiant į tai, kaip klasteriai prisideda pereinant prie ŽE yra svarbi priemonė, kuri leis valdžios institucijoms miesto, regioniniu, nacionaliniu ir Europos lygmeniu priimti sprendimus dėl paramos inicijavimo tolesniam esamų klasterių vystymui.

Ginamieji teiginiai

1. Klasterių veiklos vertinimui siūloma naudoti pateiktą rodiklių sistemą (apimančią šiuos komponentus: tarpusavio komunikacija, marketingo veiklos, žmogiškieji ištekliai, finansiniai ištekliai).

2. Siūloma rodiklių sistema, skirta klasterių perėjimui prie ŽE vertinimui (apimanti komunalinių ir kitų atliekų susidarymą ir prekybą perdirbamomis ar tinkamomis pakartotiniam naudojimui žaliavomis jas importuojant, eksportuojant ar vykstant prekybai tarp klasterio narių).
3. Siūlomas klasterių veiklos vertinimo pereinant prie ŽE modelis, pagrįstas SAW ir TOPSIS metodais ir vertinantis tarpusavio ryšį, gali būti naudojamas klasteriams įgyvendinant perėjimą prie žiedinės ekonomikos.

Darbo rezultatų aprobavimas

Disertacijos tema publikuota dešimt mokslinių straipsnių: penki Web of Science (Claritive Analytics) duomenų bazėse referuojamuose leidiniuose, neturinčiuose citavimo rodiklio (Razminienė, 2019a; Razminienė & Tvaronavičienė, 2017b, 2018a; Razminienė et al., 2016; Tvaronavičienė & Razminienė, 2017), penki – recenzuojamose tarptautinių konferencijų medžiagose (Razminienė, 2019b; Razminienė & Tvaronavičienė, 2017a, 2018b; Tvaronavičienė & Razminienė, 2017a, 2017b).

Disertacijoje atliktų tyrimų rezultatai buvo paskelbti septyniose mokslinėse konferencijose Lietuvoje ir užsienyje:

- 10-ojoje tarptautinėje taikomosios ekonomikos konferencijoje “Contemporary issues in economy”, Torūnė, Lenkija, Birželio 27–28 d. 2019.
- 6-ojoje tarptautinėje mokslinėje konferencijoje “Contemporary issues in business, management and economics engineering” (CIBMEE-2019), Vilnius, Gegužės 9–10 d. 2019.
- 10-ojoje tarptautinėje mokslinėje konferencijoje “Business and Management 2018”, May 3–4, 2018, Vilnius.
- 6-ojoje tarptautinėje vadybos, inžinerijos, mokslo ir technologijų konferencijoje ir 3-ojoje tarptautinėje mokslo, technologijų ir vadybos tyrimų konferencijoje 2017, Dubajus, Jungtiniai Arabų Emyratai, Lapkričio 1–2d., 2017.
- 3-ojoje tarptautinėje visą gyvenimą trunkančio švietimo ir lyderystės konferencijoje ICLEL 2017, Porto, Portugalija, Rugsėjo 12–14d., 2017.
- 5-ojoje tarptautinėje mokslinėje konferencijoje „Contemporary Issues in Business, Management and Education”, Vilnius, Gegužės 11–12d., 2017.
- Energetika, klasteriai ir socialinės inovacijos tvariam vystymuisi vasaros mokykla ir konferencija „Energy, Clusters and Social Innovations for Sustainable Development Summer School and Conference”, Vilnius, Rugsėjo 5–7d., 2016.

Doktorantūros metu buvo įvykdytos dvi mokslinės stažuotės:

- 2017–2018 m. Kaire, Egipte, „Mokslinių tyrimų ir technologijos akademijoje” (ASRT).
- 2017 m. Fese, Maroke, Sidi Mohamed Ben Abdellah universitete (USMBA).

Disertacijos struktūra

Darbą sudaro įvadas, trys pagrindiniai skyriai, bendrosios išvados, literatūros sąrašas, autoriaus publikacijų disertacijos tema sąrašas ir septyni priedai. Disertacijos apimtis (be priedų) – 158 puslapiai, 48 iliustracijos ir 21 lentelė.

1. Teorinė klasterių ir žiedinės ekonomikos literatūros analizė: pagrindinės sampratos

Pirmajame disertacijos skyriuje aprašoma literatūros šaltinių disertacijos tematika apžvalga. Analizė atlikta siekiant nustatyti rodiklius, kuriuos mokslininkai naudoja klasterių veiklai, efektyvumui ar konkurencingumui vertinti. Taip pat apžvelgiamos vyriausybės institucijų siūlomos klasterių plėtros priemonės. Skyriuje nurodomi sektoriai, kuriuose veikia klasteriai, apibūdinama ŽE ir pateikiamos klasterių įsitraukimo į perėjimą prie ŽE prielaidos. Vėliau atrenkami rodikliai ir metodai, tinkami klasterių veiklos pereinant prie ŽE vertinimui.

Terminas „klasteris" yra siejamas su Porterio (1990) apibrėžimu, kur jis apibūdinamas kaip geografinė tarpusavyje susijusių ir viena kitą papildančių įmonių ir institucijų koncentracija. Klasterių tyrimai nuo 1990 metų išpopuliarėjo įvairiose akademinėse srityse, tokiose kaip vadyba ir strategija, regionų plėtra ir augimas, miesto tyrimai ir ekonominė geografija. Klasteriai per pastarąjį dešimtmetį sulaukia didesnio susidomėjimo, nes jie suteikia galimybę naudotis užsienio rinkomis, pasauliniais žinių tinklais, bendru išteklių tiekėju, prieiga prie žinių, inovacijų. Klasteriai yra sudėtinga organizacijos forma, kurioje bendrumas yra formuojamas socialinių ryšių, produktyvių vietinių įmonių ir institucijų tinklų. Klasteriai natūraliai formuojasi atsižvelgiant į geografinį artumą ir prisideda prie regionų plėtros per inovacijas, mokslinius tyrimus ir plėtrą, naujų įmonių steigimo ir kitas veiklas. Įprastai jie kuriasi artimoje aplinkoje, nors jų paskirtis yra sukurti konkurencinį pranašumą klasterio nariams didesniu mastu – nacionaliniu ir tarptautiniu. Šiandien mes susiduriame su gerai išvystytais klasteriais, kurie prisideda prie konkurencinio pranašumo kūrimo klasteriui priklausančioms įmonėms ir prie regionų vystymosi.

Klasterių svarba matoma mokslinėje literatūroje dėl vis augančio atvejo analizės skaičiaus skirtinguose kontekstuose ne tik lokaliai, bet ir visame pasaulyje. Atlikta išsami literatūros analizė leido nustatyti rodiklius, kurie aptariami mokslo darbuose. Autorių minimi rodikliai gali būti padalinti į septynias grupes: artumą, kurį galima išskaidyti į geografinį, institucinį, organizacinį, kultūrinį, socialinį, santykinį ir pažintinį, inovacijas, žinių perdavimą, finansinius rodiklius, investicijų rodiklius, valdymo rodiklius, tvarumo rodiklius. Ryšių tarp šių veiksnių nustatymui yra naudojama koreliacinė – regresinė analizė, gravitacijos modelis taikytas įtakai nustatyti, atvejo analize tikrinami mokslinės literatūros teiginiai ir kuriami modeliai, siekiant nustatyti vienų veiksnių įtaką kitiems. Mokslinės literatūros analizė leidžia palyginti mokslininkų teiginius ir tyrimų rezultatus, pateikti reikšmingas įžvalgas. Klasterių veiklos vertinimui reikalingi duomenys yra pateikiami skirtingais matais. Duomenims susisteminti ir apdoroti galima taikyti daugiakriterinio vertinimo (TOPSIS, Fuzzy TOPSIS, DEA, AHP, FAHP) metodus.

Mokslinėje literatūroje teigiama, kad ŽE yra labai svarbi ir perspektyvi sritis, gebanti pritraukti verslo bendruomenę į darnesnę plėtrą. Per pastaruosius šimtą metų dėl žmogaus išsivystymo gamtos išteklių naudojimas išaugo precedento neturinčiu mastu. Dėl didėjančio išteklių išgavimo visame pasaulyje, kuris labiausiai paveikė Europos, Šiaurės Amerikos ir kitų pasaulio šalių ekonominę plėtrą, perėjimas prie ŽE tampa sudėtinga užduotimi, kurią turi įgyvendinti vyriausybė per galimai ilgą laikotarpį. Pagal apibrėžimą žiedine ekonomika laikoma pramonės sistema, suprojektuota ar skirta atkurti ar regeneruoti ir skatinama mokslininkų, politikos formuotojų, nevyriausybinių organizacijų ir korporacijų.

ŽE yra labai svarbi plėtojant klasterius, nes ji gali būti vienas veiksnių, prisidedančių prie konkurencinio pranašumo didinimo. Paprastai mažos ir vidutinės įmonės negali savarankiškai įsitraukti į žiedinę ekonomiką, nes joms trūksta žinių, išteklių, finansavimo. Šiuos apribojimus gali pašalinti klasteriai per įgytą konkurencinį pranašumą.

ŽE mokslininkų yra vertinama kaip priemonė siekiant geresnių veiklos rezultatų. Tai galima pasiekti skirtingais kanalais: per išteklių efektyvumą, ekologinį efektyvumą, atliekų laikymą ištekliais, pritaikant uždarojo ciklo principus ir pateikiant metodus, kaip paskatinti pakartotinį naudojimą ir perdirbimą, gyvavimo ciklo įvertinimo nagrinėjimą. ŽE vyksta keliais lygiais: įmonėje, tarp įmonių, tarp verslo ir vartotojų bei tarp vartotojų. Taip pat reikia įtraukti viešąjį sektorių. Klasteriuose dalyvauja skirtingi veikėjai, kurie gali paskatinti perėjimą prie ŽE.

Efektyvus išteklių valdymas tampa vis svarbesnis mažoms ir vidutinėms įmonėms, jos tampa suinteresuotos sumažinti energijos, medžiagų ir vandens sąnaudas ir pradeda ieškoti alternatyvių ŽE modelių, kad liktų kiek įmanoma mažiau atliekų. Klasteriai gali vaidinti didžiulį vaidmenį prisidedant prie mažų ir vidutinių įmonių išteklių tausojimo. Įmones jungtis į klasterius skatina jų kuriamas konkurencinis pranašumas. Klasterio suteikiamos galimybės sujungus atitinkamas šalis gali paskatinti perėjimą prie ŽE, padėti įmonėms įsitraukti į efektyvų išteklių panaudojimą, perdirbimą, medžiagų pakartotinį naudojimą ir kitas veiklas.

Europos Komisija paskelbė ŽE veiksmų planą, kuriuo siekiama skatinti perėjimą prie naujo modelio. Pabrėžiama pažangos stebėjimo svarba. Šis procesas nėra lengvas, nes apima skirtingas sritis ir reikalauja pereinamojo laikotarpio. ŽE stebėsenos priemonė turėtų padėti piliečiams ir politikos formuotojams nustatyti sėkmės veiksnius ir sritis, kurios reikalauja daugiau dėmesio. ŽE yra ilgalaikis tikslas, kuriam pasiekti reikia nustatyti naujus prioritetus ir tuomet galima tikėtis gerų rezultatų.

Į Europos Komisijos siūlomą ŽE stebėsenos sistemą, kuri apima ŽE veiksmų planą, įtraukta dešimt rodiklių iš keturių sričių: gamybos ir vartojimo, atliekų tvarkymo, antrinių žaliavų ir konkurencingumo bei inovacijų. Siūloma rodiklių sistema atspindi ciklo uždarymo idėją.

Šiame tyrime klasteriai yra įvardijami kaip ŽE skatintojai. Klasteriai gali paskatinti savo narius pereiti prie ŽE, taip padidindami konkurencinį pranašumą ir papildydami klasterio veiklas. Klasterio veiklos vertinimo būtinybė yra ryški nacionaliniu lygmeniu, nes nustačius trūkumus ir stipriąsias puses galima prisidėti prie klasterio tobulinimo. Klasterio veiklos vertinimo pereinant prie ŽE modelis sudaro galimybę vertinti klasterius.

Mokslinėje literatūroje aptinkami metodai paprastai mokslininkų naudojami klasteriams arba žiedinei ekonomikai kaip nepriklausomiems veiksniams vertinti. Šiomis metodikomis nesiekiama reaguoti į klasterių veiklos pokyčius, kai svarstomas perėjimas prie ŽE. Literatūros analizės rezultatai, vertinant mokslininkų naudojamus metodus, patvirtina darbo originalumą, nes tokia metodika anksčiau nebuvo siūloma.

2. Klasterių veiklos vertinimo pereinant prie žiedinės ekonomikos modelio formulavimo metodologija

Antrajame darbo skyriuje aprašyti metodai, kurie naudojami formuluojant klasterių veiklos vertinimo pereinant prie ŽE modelį, pasirinktus rodiklius ir siūlomą metodiką. Toliau aiškinamas daugiakriterinio vertinimo procesas ir apibūdinami du metodai – SAW ir TOPSIS – pasirenkant juos duomenų apdorojimui ir rezultatų apskaičiavimui. Paskutiniame tyrimo etape siūloma tiesinė regresinė analizė. Apibūdinti rodikliai, įtraukti į klasterių veiklos vertinimo pereinant prie ŽE modelį ir pateiktas modelio apibendrinimas.

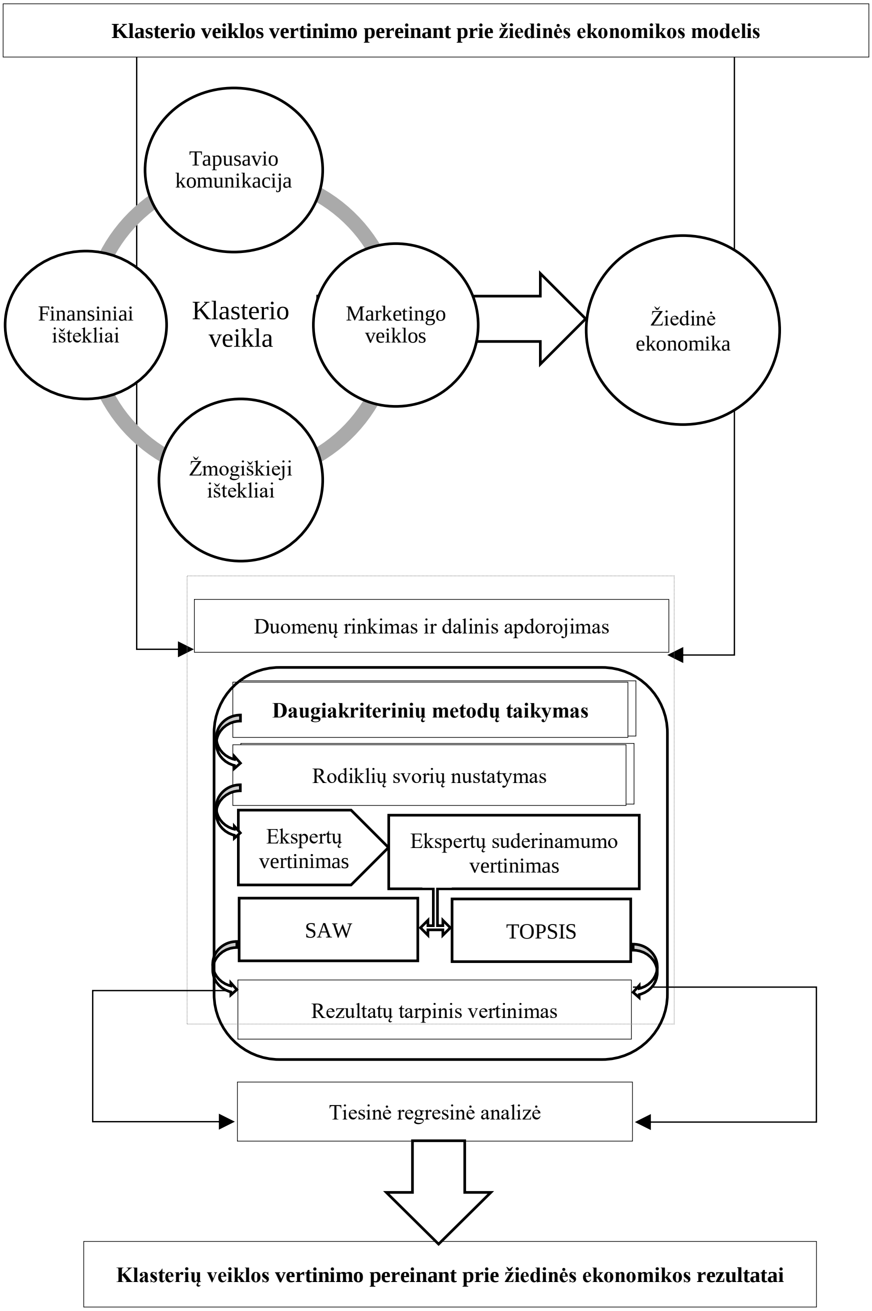
Veiklos stebėjimas ir vertinimas yra labai svarbus klasterių valdymo procese. Šie veiksmai gali prisidėti prie klasterių augimo, nes jiems atlikti reikalingi naujausi duomenys ir kitos svarbios priemonės. Metodai, įtraukti į klasterių veiklos vertinimo pereinant prie ŽE modelį, buvo atrinkti pagal literatūros analizę ir esamą duomenų prieinamumo situaciją.

Sudarytas klasterių veiklos vertinimo pereinant prie ŽE modelis apimantis šiuos veiksnius: rodiklius, tinkamus klasterių veiklos vertinimui pereinant prie ŽE; reikalavimus klasterių ir ŽE ekspertams; metodus, tinkamus klasterių veiklos vertinimo pereinant prie ŽE; metodus, ryšiui tarp šių kintamųjų nustatyti. Siūlomas modelis (S2.1.pav.) įgyvendinamas keliais etapais.

Ekonominis augimas yra neatsiejamas nuo naujų darbo vietų kūrimo, verslo galimybių, naujų rinkų ir galimo uždarbio. Besikeičianti mąstysena, verslo modeliai, novatoriški produktai ir paslaugos yra neatsiejama to dalis. Paprastai MVĮ turi pakankamai ribotą laiką ir išteklius, todėl negali nuosekliai laikytis ekonomikos augimo krypties. Pasaulinės klasės inovacijos, technologijos ir kompetencija, naujų išradimų kūrimas dažniausiai siejamas su didelėmis įmonėmis, turinčiomis pagrįstą finansinę naudą. Klasteriai taip pat gali sudaryti sąlygas finansiniam augimui dėl juos sudarančių narių: MVĮ, aukštojo mokslo institucijų, tyrimų centrų, nevyriausybinių organizacijų ir kitų.

Klasterių veiklos vertinimo pereinant prie ŽE modelio įgyvendinimas pradedamas nuo rodiklių, tinkamų šių veiksnių vertinimui. Klasteris yra sudėtinga organizacijos forma, todėl vertinant jo veiklą reikia atkreipti dėmesį į jo narius ir skirtingas jų atliekamas funkcijas. Šiame etape būtina sudaryti dvi atskiras rodiklių sistemas, siekiant nustatyti klasterio veiklos ir perėjimo prie ŽE tarpusavio ryšį.

Siūlomą klasterių veiklos vertinimo pereinant prie ŽE modelį sudaro 35 rodikliai, sudarantys dvi komponentų grupes: pirmąją sudaro klasterio veiklos kriterijai, o antrąją – perėjimo prie ŽE rodiklių grupė. Pirmoji grupė yra neabejotinai svarbi norint įvertinti klasterio veikimą ir leidžia aptikti sritis, kurias reikia išplėtoti siekiant geresnių klasterio veiklos rezutatų. Ši rodiklių grupė sudaryta atsižvelgiant į *Lietuvos klasterizacijos studija* (2017), remiantis literatūros analize ir Europos klasterių analizės sekretoriatu (ESCA). Atrinkti 25 rodikliai.



S2.1 pav. Klasterių veiklos ir perėjimo prie žiedinės ekonomikos vertinimo modelis (sudaryta autorės)

Antroji grupė siūlo ŽE rodiklius, kurie gali padidinti klasterio konkurencingumą. Ši grupė yra sudaryta iš 10 rodiklių, atsižvelgiant į Europos Bendrijos perėjimo prie ŽE suplanuotus veiksmus ("Overview – Eurostat," n.d.).

Klasterių veiklos vertinimą sudaro keturi komponentai: tarpusavio komunikacija, finansiniai ištekliai, žmogiškieji ištekliai ir marketingo veiklos. Tris komponentus – tarpusavio komunikaciją, finansinius išteklius ir marketingo veiklas – sudaro po šešis rodiklius, o žmogiškuosius išteklius sudaro septyni rodikliai. Visi komponentai neviršija rekomenduojamo rodiklių skaičiaus, todėl galima jų toliau nebedalinti.

ŽE komponentas taip pat buvo pateiktas hierarchine tvarka. Šis komponentas apima 10 rodiklių, todėl nebuvo skaidomas siekiant pritaikyti jį ekspertiniam vertinimui. ŽE komponentas yra papildantis, padidinantis klasterio konkurencingumą. Tuo tarpu klasterio veiklos rezultatai vertinami kaip teikiantys pagrindinę informaciją.

Šie klasterio veiklos rodikliai suteikia informacijos, kurią galima įvertinti taikant daugiakriterinius vertinimo metodus. Komponentai gali būti papildyti arba pakeisti kitais kriterijais pagal poreikį, tačiau siekiant nepakenkti tyrimo kokybei, reikėtų atkreipti dėmesį į kiekvieno kriterijaus svarbą.

Vėliau renkami duomenys, kurie reikalingi pagal pasirinktus rodiklius. Norint surinkti visą informaciją, gali prireikti kelių šaltinių. Lengviausia gauti informaciją iš oficialių, viešų ir atvirų šaltinių. Šiame darbe buvo naudojami tokie oficialūs šaltiniai: „Sodra" su atvira prieiga prie informacijos įmonės lygiu, aplinkos apsaugos agentūra (AAA) su ribota prieiga prie informacijos įmonės lygiu, „KlasterLT" su informacinio pobūdžio informacija klasterio lygiu. Kitas patikimas informacijos šaltinis yra klasterių koordinatoriai, nes paprašius jie gali surinkti duomenis tiesiogiai iš klasterio narių. Dalinai apdorojus duomenis, kreipiamasi į ekspertus.

Kitame žingsnyje pritaikomi metodai, leidžiantys įvertinti klasterių veiklą ir perėjimą prie ŽE. Ekspertų prašoma patvirtinti rodiklius ir parodyti jų svarbą priskiriant jiems svorius. Ekspertai parenkami atsižvelgiant į jų patirtį tiriamoje srityje. Buvo pasirinkti du metodai – SAW ir TOPSIS – dėl jų lengvo pritaikomumo ir rezultatų skaitinių reikšmių. SAW rezultatai gali būti plačios aprėpties ir ganėtinai nutolę vienas nuo kito, kai lyginami keli atvejai, tuo tarpu TOPSIS įverčiai svyruoja nuo nulio iki vieneto ir gali būti lengvai išreikšti procentais. Pasirinkti du metodai siekiant patikrinti modelio patikimumą, kai įgyvendinamas paskutinis žingsnis.

Paskutinis žingsnis reikalingas norint nustatyti ar egzistuoja ryšys tarp klasterių veiklos ir perėjimo prie ŽE. Čia naudojama tiesinė regresinė analizė, kuri yra dažniausiai naudojamas statistinis matematinis metodas, kai siekiama nustatyti ryšį tarp dviejų kintamųjų.

Rezultatus ir išvadas rekomenduojama peržiūrėti sprendimų priėmėjams. Skirtingi kriterijai leidžia priimti sprendimus dėl išteklių paskirstymo atsižvelgiant į gautus rezultatus. Į modelį įtraukti rodikliai, kurie priklauso nuo kiekvieno klasterio nario, todėl taip pabrėžiamas kiekvieno nario indėlis. Atitinkamai, finansiniai ir kiti ištekliai turėtų turėti įtakos atskiriems nariams. Klasterio veiklos vertinimas pereinant prie ŽE turėtų būti atliekamas reguliariai, išsamiai išnagrinėjus klasterį, atsižvelgiant į jo narius ir galimą jų indėlį į klasterio veiklas.

3. Klasterių veiklos vertinimas pereinant prie žiedinės ekonomikos: Lietuvos atvejis

Šiame skyriuje pateikiamas siūlomo klasterių veiklos vertinimo pereinant prie ŽE modelio, išbandyto Lietuvos klasterių atveju, aprobavimas. Pasirinkti klasteriai apžvelgiami pagal siūlomą klasterių žemėlapį, taikomas ekspertinis vertinimas, pateikiamas klasterių veiklos vertinimas pereinant prie žiedinės ekonomikos.

Pagrindinė klasterių steigimo Lietuvoje priežastis yra siekis skatinti klasterio narių veiklas. Lietuvos klasterizacijos studijos 2019 (Vaiginienė, 2019) duomenimis, Lietuvoje klasteriai dažniausiai inicijuojami ekonomiškai stipriausiuose miestuose (Vilniuje, Klaipėdoje, Kaune, Alytuje), kur didžiausia darbuotojų ir įmonių koncentracija. Kituose regionuose yra mikroklasterių, kuriuose veiklos specifika būdinga tam regionui (Biržai, Druskininkai, Kėdainiai, Mažeikiai, Ignalina).

Dažniausiai klasteriai dalyvauja tarptautiniuose projektuose (Baltijos jūros regionas 2007–2013 m., EUREKA EurostarsES SF inicijuoti projektai), kitose ES iniciatyvose, padedančiose kurti žinių ir inovacijų erdvę, plėtoti komercinį bendradarbiavimą su užsienio partneriais. Pagrindiniai klasterių pranašumai Lietuvoje yra veiklai palanki aplinka (santykinai pigi ir kvalifikuota darbo jėga, patogi vieta logistikos srityje, išvystyta logistikos struktūra, aukštas technologinės bazės lygis).

Atvejo analizei klasterių skaičiaus pasirinkimą nulėmė klasterių įsitraukimas į iniciatyvas. Vieninteléje Lietuvoje informaciją apie klasterius kaupiančioje svetainėje KlasterLT klasterių skaičius siekia 50. Europos klasterių kompetencijos iniciatyva (ECEI) teikia klasteriams žymas, kurios nurodo klasterio išsivystymą. Pagal ECEI suteiktas žymas šiame darbe pasirinkti klasteriai atvejo analizei, turintys bronzinę žymą. Tokių Lietuvoje tyrimo atlikimo metu buvo 10, o kiti laikomi klasterių iniciatyvomis, tikintis vėlesnio jų siekimo gauti žymas. Šiuo atveju analizuojami klasteriai yra: iVita, LauGEA, Lietuvos plastikų klasteris, LITEK, Smart Food Cluster, PrefabLT, VKK, FETEK, LitCare, NaMŪK.

Klasteriai analizuojami keliais aspektais. Pirmiausia pateikiamas klasterio aprašymas, įkūrimo metai, koordinatorius ir miestas, kuriame registruotas koordinatorius, organizacijos tipas ir 3.21 pav.

klasterio narių skaičius pagal KlasterLT svetainėje pateiktą informaciją. Tuomet apžvelgiama kiekvieno klasterio nario ekonominė veikla pagal Ekonominės veiklos rūšių klasifikatorių (EVRK), kurį galima rasti Oficialios statistikos portale ("Classification of Economic Activities (EVRK) – Oficialiosios statistikos portalas," n.d.). Vėliau sudaromas žemėlapis, kuriame pateikiami kiekvieno klasterio nariai pagal geografinę vietą, įmonės tipą, darbuotojų skaičių ir apyvartą. Ši informacija oficialiai prieinama rekvizitai.lt ir sodra.lt svetainėse.

Remiantis rekvizitai.lt pateikta informacija, klasterių įmonių apyvarta gali svyruoti nuo 0–5000 EUR iki daugiau nei 100 000 000 EUR. Pagal Europos Komisijos pateiktą MVĮ apibrėžimą (Directorate–General for Internal Market, Industry, 2017), subjektas turi užsiimti ekonomine veikla, darbuotojų skaičius mažesnis nei 250, o metinė apyvarta neviršyti 50 000 EUR arba metinė balanso suma neviršyti 43 000 EUR. Įmonės dydžiui nusakyti šiame darbe imamas darbuotojų skaičius ir metinė apyvarta.

Klasteriai Lietuvoje skiriasi daugeliu aspektų. Lietuvos klasterizacijos studijoje (Vaiginienė, 2019) įvardinami 57 klasteriai, kuriems iš viso priklauso 777 nariai. Ilgiausiai dirbantis klasteris skaičiuoja 25 metus, o daugumos klasterių amžius yra apie ketverius metus. Kai kurie iš jų vis dar yra pradinio formavimosi etape arba jį sudaro įmonių grupė, susitelkusi siekdama ES struktūrinės paramos. Yra vienas klasteris, kuriam priklauso tik vienas narys, o didžiausias narių skaičius klasteryje yra 69. Kai kurie klasteriai turi tą pačią specializaciją, kas rodo, kad klasterių nariai turėtų vienytis ne kurdami naujus, o papildydami esamus klasterius. Taip būtų stiprinami esami klasteriai, papildant juos naujais nariais, skatinamas bendradarbiavimas ir plėtra.

Darbe pateiktas klasterių veiklos vertinimo pereinant prie ŽE modelio praktinis pritaikomumas yra išbandytas Lietuvos klasterių atveju. Empiriniai tyrimai atliekami analizuojant septynis Lietuvos klasterius.

Duomenims rinkti buvo naudojamos statistinių duomenų bazės ir klasterių koordinatorių anketinės apklausos. Atvejų analizei buvo atrinkta dešimt klasterių, tačiau tik septyni atsakė į apklausą. Kiti reikalingi statistiniai duomenys buvo paimti iš oficialių šaltinių: Sodra, AAA, KlasterLT.

Klasterių veiklos atsižvelgiant į perėjimą prie ŽE vertinamas atliktas taikant antrame skyriuje aprašytą metodiką. Rezultatams apskaičiuoti buvo taikomi daugiakriteriniai vertinimo metodai ir tiesinė regresinė analizė, kuri parodo ar egzistuoja ryšys tarp klasterių veiklos ir perėjimo prie ŽE. Skaičiavimai atliekami pagal suformuotą hierarchinę rodiklių sistemą.

Rodiklių sistema buvo sukurta atsižvelgiant į mokslinės literatūros analizę ir tarptautines bei nacionalines stebėjimus rengiančias agentūras: ESCA ir MITA. Rodiklių sistema buvo suformuota įtraukiant labiausiai informatyvius rodiklius. Klasterių veiklos vertinimas apima 25 rodiklius, kurie yra suskirstyti į keturis komponentus: tarpusavio komunikacija su šešiais rodikliais, marketingo veikla su šešiais rodikliais, žmogiškieji ištekliai su septyniais rodikliais ir finansiniai ištekliai su šešiais rodikliais. Perėjimo prie ŽE vertinimas apima 10 rodiklių, kurie smulkiau neskaidomi.

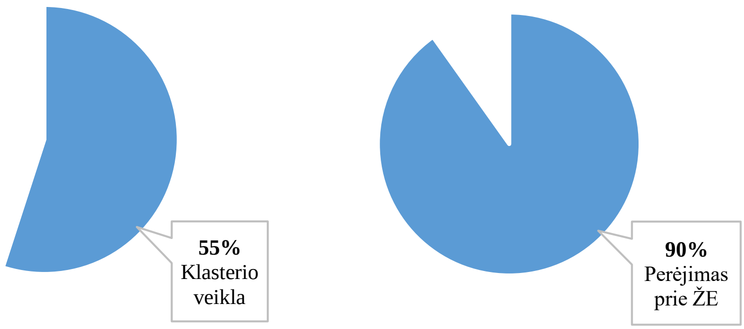
Ekspertų buvo paprašyta patvirtinti rodiklių tinkamumą juos vertinant ir suteikiant svorius. Klasterių veiklos vertinimas ir perėjimo prie ŽE vertinimas buvo pateikti kaip skirtingos rodiklių sistemos, kurias reikia vertinti atskirai. Klasterių veiklos vertinimas apima keturis komponentus smulkiau skaidomus į rodiklius, todėl šie taip pat buvo vertinti ekspertų.

Apdorojus rezultatus apskaičiuotas ekspertų vertinimo nuoseklumas. Vertinimas buvo atliktas reitinguojant rodiklius. Ekspertų skaičius yra septyni. Kiekvienam sprendimo etapui buvo apskaičiuotas konkordacijos koeficientas W, kriterijus χ^2 siekiant patikrinti suderinamumą. Suderinamumo koeficiento W reikšmės svyruoja nuo 0,52 iki 0,86. Ekspertų nuomonių suderinamumas patvirtintas, nes visos reikšmės χ^2 yra didesnės nei χ^2_{kr}.

Pasiekus rezultatų skaičiavimo etapą taikant SAW ir TOPSIS metodus, iškyla duomenų trūkumo problema. Kadangi klasteriai vis dar nesulaukia pakankamai dėmesio, nėra privaloma rinkti ir sisteminti duomenų, kurie leistų vertinti klasterių veiklą. Tai lemia, kad kai kurie duomenys nėra pateikti.

Taikant metodus ir nepaisant duomenų trūkumo, rezultatai gali būti iškraipyti. Dėl šios priežasties buvo pritaikytas nestandartinis matematinio skaičiavimo metodas. Jis pritaikytas kiekvienam klasteriui, pašalinant rodiklius, kuriems nepateikti duomenys ir atitinkamai perskaičiuojami svoriai. Toks perskaičiavimas leidžia tinkamai taikyti daugiakriterius vertinimo metodus ir pritaikyti siūlomą modelį. Vienas iš analizuojamų klasterių pateikė visus prašomus duomenis per pakankamai trumpą laiką, kas įrodo, kad rodikliai yra tinkami ir gali būti vertinami.

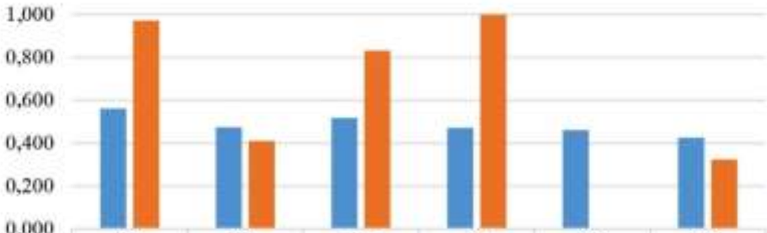
Klasteriai vertinti pritaikius du skirtingus daugiakriterinio vertinimo metodus. Rezultatai gauti SAW metodu pateikti skritulinėje diagramoje skaitines vertes pavertus procentais link idealios alternatyvos. SAW metodu apskaičiuotos reikšmės gali būti viena nuo kitos nutolusios skaitine verte, todėl jas vaizdžiau vertinti pavertus procentais link idealios alternatyvos. Reikšmių pateikimas procentais leidžia vertinti vieno klasterio rezultatų priartėjimą prie imtyje esančios geriausios vertės. Toks rezultatų pateikimas leidžia klasterio koordinatoriams palyginti klasterio rezultatus su bendru imtyje esančiu geriausiu rezultatu. S3.1 paveiksle pateiktas klasterio veiklos vertinimas rodo, kad klasterio veikla atitinka 54,83 procento, kai vertinamas priartėjimas prie idealios alternatyvos. Vadinasi, klasterio veiklos bendras rezultatas yra artimesnis geriausiai alternatyvai esančiai imtyje. Klasterio perėjimas prie žiedinės ekonomikos atitinka 90,15 procento, kai vertinamas priartėjimas prie idealios alternatyvos. Tai rodo, kad vertinamo klasterio perėjimo prie ŽE rezultatas yra labai artimas geriausiai vertei esančiai imtyje.



S3.1 pav. Klasterio veiklos ir perėjimo prie žiedinės ekonomikos vertinimas SAW metodu procentais link idealios alternatyvos (sudaryta autorės)

TOPSIS metodu gautų rezultatų palyginimas gali būti pateiktas sprendimų priėmėjams, kurie apžvelgia klasterių rezultatus lygindami juos. S3.2 paveiksle TOPSIS rezultatai pateikti skaitinėmis reikšmėmis intervale nuo 0 iki 1 leidžia palyginti klasterius tarpusavyje arba to paties klasterio rezultatų pokytį skirtingu laikotarpiu, vertinti jų pasiskirstymą pagal tai, kurioje srityje klasteris išsiskiria. Grafike matyti, kad klasterių veiklos rezultatai pasiskirstę ties vidurkiu, svyruoja nuo 0,425 iki 0,561. Tuo tarpu perėjimo prie ŽE rezultatai labiau išsisklaidę, svyruoja visame intervale. Toks pasiskirstymas galimas dėl klasterių priklausymo skirtingiems sektoriems, todėl priimant sprendimus būtina atkreipti dėmesį į klasterio specifiką.

Tiesinė regresinė analizė buvo atlikta siekiant patikrinti ar egzistuoja ryšys tarp klasterių veiklos ir perėjimo prie ŽE vertinant šešių klasterių rezultatus. Paimti statistiniai kintamieji *x* ir *y*, kai *x* rodo perėjimą prie ŽE, o *y* – klasterių veiklą skaitinėmis vertėmis, gautomis pritaikius SAW ir TOPSIS metodus. Pritaikius TOPSIS rezultatus, gauta lygtis: $y = 5{,}6307x - 2{,}1391$. Nustatyta, kad kintamasis y koreliuoja su regresoriumi ir rodo tikėtiną tiesinę priklausomybę. Šie du kintamieji turi teigiamą tiesinį ryšį – kai vienas kintamasis juda tam tikra kryptimi, kitas linkęs judėti ta pačia kryptimi. SAW metodu gauti rezultatai yra susiję tokiu ryšiu: $y = 0{,}868x + 16{,}617$. Gautos tiesinės regresijos lygtys leidžia vertinti klasterio veiklos ir perėjimo prie ŽE tarpusavio ryšį.



	K1	K2	K3	K4	K5	K6
Klasterio veikla	0,561	0,474	0,517	0,471	0,460	0,425
Perėjimas prie ŽE	0,971	0,410	0,831	0,999	0,000	0,324

S3.2 pav. Klasterių veiklos ir perėjimo prie žiedinės ekonomikos vertinimas TOPSIS metodu intervale nuo 0 iki 1 (sudaryta autorės)

Nustatytas determinacijos koeficientas R^2. Kuo koeficiento vertė yra arčiau 1, tuo stipresnis ryšys. Determinacijos koeficientas R^2 yra lygus 0,66 kai taikyti TOPSIS rezultatai ir 0,51, kai taikyti SAW rezultatai rodo statistiškai reikšmingą ryšį. Galima sakyti, kad egzistuoja preliminarus priežastinis ryšys – klasterių veikla gali prisidėti prie perėjimo prie ŽE.

Rezultatai rodo, kad kai kuriais atvejais tyrimams reikalingi duomenys yra nepasiekiami dėl reguliarios klasterių stebėsenos trūkumo arba ribotos prieigos, lemiamos duomenų apsaugos įmonės lygmeniu. Siūlomas modelis pritaikytas veikiančiuose klasteriuose Lietuvoje. Galutinis rezultatas rodo, kad tarp klasterių veiklos ir perėjimo prie ŽE yra preliminarus ryšys.

Bendrosios išvados

Apibendrinus literatūros analizės ir tyrimo rezultatus, galima teigti, kad:

1. Teorinė analizė atskleidė sąvokų daugiareikšmiškumą. Tolesnei klasterių ir ŽE analizei atlikti reikėjo jas tiksliai apibrėžti. Mokslinė literatūra padėjo nustatyti, kad klasteriai yra suinteresuoti išteklių efektyvumu, energijos, medžiagų ir vandens sąnaudų mažinimu. Tai parodo klasterių svarbą, kai siekiama paskatinti MVĮ pereiti prie ŽE. Viena iš dažniausiai aptinkamų klasterių ypatybių yra konkurencinis pranašumas, kurį MVĮ įgyja dėl klasterio narių artumo. ŽE gali prie to prisidėti, nes klasteriai turi galimybes įtraukti narius į efektyvų išteklių naudojimą, perdirbimą, pakartotinį medžiagų naudojimą ir kitą bendrą veiklą.

2. Remiantis literatūros analize nustatyti dažniausiai mokslininkų klasterių tyrimuose naudojami rodikliai. Papildomai atsižvelgta į Lietuvos vyriausybinėse institucijose ir Europos klasterių analizės sekretoriato siūlomas vertinimo priemones. Remiantis šiais šaltiniais buvo sudarytos keturios klasterių veiklą leidžiančios vertinti rodiklių grupės: tarpusavio komunikacija, finansiniai ištekliai, žmogiškieji ištekliai ir marketingo veiklos.
3. Rodikliai, parodantys perėjimą prie ŽE, buvo atrinkti remiantis literatūra ir Europos Komisijos siūloma pažangos stebėjimo sistema. Klasterių perėjimo prie ŽE vertinimui naudoti dešimt rodiklių, apimantys komunalinių ir kitų atliekų susidarymą ir prekybą perdirbamomis ar tinkamomis pakartotiniam naudojimui žaliavomis jas importuojant, eksportuojant ar vykstant prekybai tarp klasterio narių.
4. Disertacinio darbo mokslinį naujumą parodo dviejų siūlomų naujų rodiklių vertinimo sistemų sujungimas į vieną modelį: klasterių veiklos ir klasterių perėjimo prie ŽE vertinimo modelį. Šis modelis skirtas naudoti Lietuvos klasteriuose, tačiau gali būti pritaikomas kitose šalyse. Vertinimo modelis apimantis dvi rodiklių sistemas leidžia stebėti klasterių vystymąsi, atsižvelgiant į jų veiklas ir perėjimą prie ŽE. Jį gali naudoti klasterių valdytojai, koordinatoriai ir valdžios institucijos siekiant pagrįsti klasterių plėtros finansavimo poreikį.
5. Atlikta veikiančių klasterių atvejo analizė parodė, kad klasteriai Lietuvoje yra nepakankamai įvertinti. Duomenys apie klasterių rezultatyvumą turėtų būti renkami ir reguliariai vertinami siekiant stebėti klasterių vystymąsi. Atvejo analizei buvo atrinkti klasteriai, veikiantys skirtinguose sektoriuose, leidę įvertinti septynių klasterių veiklą ir šešių klasterių perėjimą prie ŽE taikant daugiakriterinius vertinimo metodus (SAW, TOPSIS).
6. Surinkti duomenys leido inicijuoti duomenų bazės sudarymą pagal siūlomas rodiklių sistemas. Pritaikius klasterių veiklos vertinimo pereinant prie ŽE modelį matome, kad egzistuoja ryšys tarp klasterių veiklos rezultatų ir perėjimo prie ŽE. Tai rodo, kad klasteriai gali būti identifikuojami kaip ŽE ir efektyvaus išteklių naudojimo skatintojai siekiant MVĮ įsitraukimo.

Annexes[1]

Annex A. The Process of TOPSIS Application

Annex B. Map Legend

Annex C. Questionnaire for Cluster Coordinators

Annex D. Questionnaire for Experts

Annex E. Declaration of Academic Integrity

Annex F. The Co-authors' Agreements to Present Publications Material in the Dissertation

Annex G. Copies of Scientific Publications by the Author on the Topic of the Dissertation

[1]The annexes are supplied in the enclosed compact disc