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Circular economy in clusters' performance evaluation

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Abstract
Research background: The value of clusters in developing advanced technology products and services as well as promoting regional growth is acknowledged by many policymakers and researchers (Lee *et al*., 2012). Hence, clusters are identified as enablers of the circular economy and resource efficiency in this study. Companies aim to enhance competencies and create competitive advantages in global competition and this can be achieved through pulling from a common and accessible pool of resources, information and demand for innovation which means that companies can profit from belonging to a cluster.
Purpose of the article: The main aim of the article is to overview the scientific literature that addresses the circular economy, identify clusters and their role in the circular economy and suggest how small and medium enterprises could engage in a circular economy through clusters' performance development.
Methods: Bibliometric literature analysis enables identifying the latest trends in scientific articles regarding a circular economy and clusters. The analytical hierarchy process (AHP) allows for composing the scheme of the cluster's competitive advantage within circular economy.
Findings & Value added: The findings suggest that resource efficiency is considered to be one of the most important ambitions and clusters can work as enablers of a circular economy for small and medium enterprises (SMEs), gaining a competitive advantage at the same time. Clusters can encourage and provide conditions in which SMEs would turn to a circular economy. The scheme of Cluster's competitive advantage proposed by the author can help cluster's coordinators, policymakers and all the concerned parties to verify the importance of clusters' involvement in the circular economy.

Introduction

Human development determined the use of natural resources rapid growth during the last century. The extraction of global resources increases due to economic development in all the parts of the world, making people think of reusing benefits and turning to a circular economy (Fomina *et al.*, 2018; Mishenin *et al*., 2018; Tetsman *et al.*, 2017; Yevhen *et al*., 2018). Resource efficiency is viewed as one of the elements that can help to control resource extraction and economic growth (Blomsma & Brennan, 2017). The transition to the circular economy is a complex task that should be planned and encouraged by governments for long term implementation. The European Commission (European Commission, 2018) has introduced a new ambitious Circular Economy Package to encourage shifting from a linear economy to a more circular to ensure sustainable use of resources. Recycling and re-use are promoted to bring benefits for the environment and the economy through proposed actions.

The circular economy is viewed as an industrial system designed to be restorative and regenerative by its definition (Haas *et al.*, 2015b). It started being promoted and encouraged by Global corporations, NGOs, scholars long before the European Commission with its action plan for the circular economy. Even though global corporations can implement these actions and promote sustainability, it is not so easy to achieve for small and medium enterprises (SMEs), for they lack many components that bigger companies have (Ghenţa & Matei, 2018).

Clusters as a unit involve different organizations, SMEs, educational institutions, research institutes, companies (Amraoui *et al.*, 2019; Eddelani *et al.*, 2019; Havierniková & Kordoš, 2019). Belonging to a cluster gives many advantages through increased competitiveness because of a common pool of resources, innovations, research and development (R&D) and other common cluster activities (Raudeliūnienė *et al*., 2018; Žižka *et al*., 2018). Clusters naturally form in geographical areas or can be structured by the companies in different regions, adding to regional development through their activity (Bezpalov *et al.*, 2019; Havierniková & Kordoš, 2019; Monni *et al*., 2017; Yang & Černevičiūtė, 2017; Žižka *et al*., 2018).

The purpose of this study is to review scientific literature in a circular economy, to identify the latest trends and find out if the interest in this area is growing, define clusters and how they work in circular economy, provide clusters' performance development scheme which would enable SMEs detecting their role in circular economy through belonging to a cluster. SMEs have limited abilities to be involved in circular economy activities in most of the cases for they lack knowledge, resources, capabilities. Here clusters

can play a huge role by connecting all the interested parties and linking to necessary resources. Gaining competitive advantage is highlighted in this study and a scheme of clusters' competitive advantage is suggested, involving elements of a circular economy and clusters performance. Bibliometric analysis technique was applied in literature analysis and the analytical hierarchy process (AHP) method was used to compose the scheme finally proposed by the author.

The article is structured in the following way. The next part informs about the research methodology. The third part provides the research results where the scheme of clusters' competitive advantage is explained in detail. The last part presents the conclusions that summarize the whole research.

Research methodology

The material was selected from the Web of Science platform which suggests providing world-class research literature. This platform allows selecting Web of Science Core Collection the main advantages of which are the fully indexed and searchable publications, search across all authors and all author affiliations, Citation alerts which allow for citation tracking, Citation report enables the graphical representation of citation activity and trends, trends and publication patterns can be identified.

The basic search was initiated with the keywords *circular economy* for search by topic. This gave 3370 results with publications starting since 1991 the number of which during the last 5 years doubles almost every year since 2014 reaching 1006 in 2018 (Figure 1). The growth of interest in a circular economy is evident as the total number of publications reaches 3100, one-third of which is published during the last year.

Further steps included refining search results according to Web of Science categories: environmental sciences, green sustainable science technology, engineering environmental, environmental studies, engineering industrial, engineering manufacturing, engineering mechanical, economics, agricultural economics policy, business. This research includes 50 articles published in the last 5 years selected (Figure 2) using these criteria of search by keywords, Web of Science categories and publication years.

The traditional bibliographic analysis was chosen, for it enables tracking the latest trends in the scientific literature regarding the circular economy. In this case, a limited number of articles were selected disregarding the articles which were highly cited, but did not fall into one of the Web of Science categories selected in this research. From this perspective, the research method can be applied in further analysis, taking into account differ-

ent Web of Science categories or varying between the number of selected articles.

The multi-criteria decision-making methods are applied when researchers face complex situations, usually including qualitative and quantitative criteria in the decision-making process (Boutkhoum *et al.*, 2016). One of the methods of the unique approach of synthesis is AHP. This method allows for hierarchically structuring a multi-period and multi-criteria problem to facilitate the solutions. Here, AHP is used to make a hierarchical structure to organize criteria in clusters' competitive advantage scheme.

Literature review: the trends in circular economy literature research

The circular economy literature concentrates on different approaches, trying to motivate those policies, consumers and producers to move towards a more circular way of materials application. Several authors mention a linear take-make-consume-dispose way of economy (Broadbent, 2016; Mendoza *et al.*, 2017; Muranko *et al.*, 2017; Rivera, 2018; Zwirner *et al.*, 2017) which seems to be wrong, as resources are limited and may endanger future generations. Waste is considered as a resource or product by Iacovidou *et al.* (2019); Iuga (2016); Van Ewijk *et al*. (2018); Velenturf *et al.* (2018); Wilts *et al.* (2016); Zwirner *et al.* (2017), reduce-reuse-recycle are viewed as one of the components in circular economy by Cooper *et al.* (2017); Ghenţa and Matei (2018); Heyes *et al.*, (2018); Moreau *et al.* (2017); Nakamura and Kondo (2018); Vanegas *et al.* (2018); Wuttke *et al.* (2017), closing the loop as a way towards circular economy is considered by Braun *et al.* (2018); Bressanelli *et al.* (2018); Cerdas *et al.* (2015); Cole *et al.* (2018); Haupt *et al.* (2017); Hobson *et al.* (2017); Niero *et al.* (2017); Niero and Olsen (2016); Stewart *et al.* (2018); Witjes and Lozano (2016). Life cycle assessment is highlighted by scholars Boutkhoum *et al.* (2016); Junnila *et al.* (2018); Niero and Kalbar (2019); Van der Voet *et al.* (2018). Hence, resource efficiency (Huang *et al.*, 2017; Iuga, 2016; Lozano *et al*., 2018; Michelini *et al.*, 2017; Milios, 2017; Muranko *et al*., 2017; Nußholz, 2017; Pan & Li, 2016; Popa & Popa, 2016; Reuter, 2016; Smol *et al.*, 2017; Walker *et al.*, 2018; Wilts *et al*., 2016) or eco-efficiency (Blomsma & Brennan, 2017; D'Amato *et al*., 2017; Gregorio *et al.*, 2018; Guo *et al*., 2016; Kalmykova *et al*., 2016; Liu *et al*., 2018; Rizos *et al*., 2016) are considered to be one of the most important components of circular economy.

During the last forty years, the extraction of global material has grown three times, Zwirner *et al.* (2017) state, which threatens our stock of finite materials, causes damage to our planet by filling it with waste, endanger

global economy and ecosystems. Relying on the evolution of resource recovery from waste and some sustainability principles, an approach was developed by the authors, helping to develop a dynamic, flexible, transparent valuation. This approach can help move closer to sustainability and make the basis for future methodologies of circular economy assessment.

Wilts *et al.* (2016) assume that resource-efficient circular economy must be taken in action considering that only 40% of municipal waste generated in the European Union was recycled in 2011, while other 37% was landfilled and 23% incinerated despite around 500 million tones could have been reused or recycled. 10 countries were selected for a case study regarding current national framework conditions. The approach addresses two pillars: the policy and institutional factors versus waste programs. The results of the study highlight that the transition from waste management to integrated resource management depends on context-sensitivity of incentive structures, policy mixes and coordination of policy instruments for transnational chains often lead to a generation of waste.

The amount of recycled waste materials reaches 4 gigatonnes (Gt/y) per year to compare with 62 Gt/y of processed materials and 41 Gt/y of outputs in 2005. Haas *et al.* (2015a) discusses the degree of circularity of the global economy regarding the qualification of different material flows through suggested schemes. Considering the materials that are discussed in the research — fossil energy carriers, biomass, metals, nonmetallic minerals — they are far from closing the material loop. The conclusions suggest that a circular economy cannot rely on recycling alone, so there must be other factors of materials consumption considered, such as materials accumulated as in-use stocks and many materials used for energy generation.

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

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

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

The results of implementing the Resource Recovery from Waste program (RRfW) 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 *et al.* (2019) in the later study state that reproduced MCPs 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 solutions in resource efficiency. The quality assessment typology is suggested in the study, which was presented in the single-use plastic bottle manufacturing process, although it can apply to any kind of 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, recycle. It is highlighted that following these principles may lead to lower energy intensity and higher labor intensity, the proportions of which highly depend on institutions. Territorial as well as economic policies can impact the profitability of CE through waste management, resource efficiency. The core of the economy is presented as labor which has a renewable nature and human work should be involved in remanufacturing and recycling.

Cooper *et al.* (2017) conduct a study which aims at analyzing the energy demand reduction that might be achieved through circular economy opportunities and identify the priority areas that should be changed to achieve

better results. The findings suggest that circular economy approaches are possibly able to reduce the 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 circular economy by closing the loops through recovery, changing the scheme from price per unit to value provided per service to ensure that technical, non-technical and socio-cultural specifications are included, as well as the responsibility of the product/service is shared. The collaboration between procurers and suppliers is considered enabling to reduce raw material utilization and waste generation.

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

Digital technologies are viewed not only as introducers of servitized business models, but also as supporters for circular economy models in the research by Bressanelli *et al.* (2018). A framework developed in this study investigates how eight identified functionalities enabled by 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 life cycle. A CLP manufacturing system differs from a cradle-to-cradle, which ensures that the producer realizes the amount of material to be recovered and preventing valuable resources to be disposed to the landfill, while 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* — intensively used products with outdated technology; *End of Life* — not functioning very old 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 their value. Industrial Symbiosis is described in the article as serving to create links between companies to exchange materials, energy, water, and by-products.

A Hybrid Manufacturing / Remanufacturing System satisfies product demand through the manufacturing of new products or remanufacturing of recovered products. Authors conclude by stating the need to create a production model that merges some elements of the SLP system into operation elements of a company and calls it Circulation Factories.

Aluminum products are usually considered for one life cycle in life cycle assessment and several studies are conducted by different scholars (Niero *et al.*, 2017; Niero & Olsen, 2016; Stewart *et al*., 2018), although aluminum cans have a high potential for products in multiple loops. In the study by (Niero & Olsen, 2016) different scenarios were considered and the results show that after 30 loops of aluminum production and recycling the LCA option is more environmental 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 — maximization of benefits to ecological and economic systems — are combined to show what challenges occur while creating circular industrial systems. Life cycle assessment (LCA) and Cradle to Cradle (C2C) models were combined to develop a continuous loop packaging system to adopt for aluminum cans.

LCA adopts a tool-driven approach, which suggests that environmental performance should be evaluated of a product.

C2C adopts a goal-driven approach where the goal is to use a cyclical metabolism through upcycling the materials and using waste as a material, while the goals are in the first place and then tools and metrics needed to measure progress are developed.

Haupt *et al.* (2017) question whether currently used rates are suitable for the circular economy to be measured. The study shows that national statistics usually refer to the amount of material collected concerning the number of goods consumed. Such numbers reflect only the input into the recycling systems, despite the secondary material produced. Here, the official recycles rates are separated into a closed- and open-loop collection and recycling rates, and export rates. The authors conclude that the current system of indicators showing rates of the circular economy fails to describe how much material is kept within material cycles. Waste management could be improved by adding closed- and open-loop recycling rates.

Results: proposition of the new scheme of the cluster's competitive advantage within circular economy

The literature analysis revealed the importance of a circular economy in gaining competitive advantage, especially for SMEs. Clusters work as a unit consisting of different companies, organizations, educational research institutions. In most of the cases, SMEs form the basis of a cluster. Several issues encourage SMEs to join a cluster, such as a common pool of knowledge, innovations, participation in various events, the possibility to enter new markets, work as one unit in different situations. Competitive advantage is one of the advantages that are indicated in joining a cluster.

The suggested scheme of the cluster's competitive advantage (Figure 3) includes two groups of components: the first group consists of clusters' performance criteria and the second group of circular economy performance measures, respectively. The first group is unquestionably important to measure the cluster's performance and see how it links to competitive advantage as well as enables us to detect the areas that need to be developed for better performance of the cluster. The second group suggests measures of circular economy which may add to the competitiveness of the cluster, if they are implemented in cluster activities.

In the previous research (Razminienė *et al*., 2016) the importance of clusters' performance evaluation was emphasized and the possible methodology of clusters' performance evaluation suggested. The methodology includes clusters' performance evaluation criteria. AHP method was used to structure the criteria for further processing.

Clusters' performance includes three components: activities, processes, and resources. The first two components are further divided into communication activities, marketing activities (includes 10 indicators per each subcomponent), international processes (includes 8 indicators), human resources management processes (HRM) (includes 9 indicators). Resources include relatively few indicators (includes 7 indicators per component), which leaves this component undivided into smaller categories (Table 1).

Communication activities include indicators that can help cluster members to share their knowledge, create interpersonal relations, communicate through different channels. Regular meetings of cluster members can be arranged according to the need. In this case, it is very important to indicate how often the members should meet in-person to ensure that they are seeing each other often enough. These regular meetings can include personal visits of the cluster coordinator to the cluster member. There should be indicated if there are any cluster integration events and how often they take place. A common communication platform would enable fluent information

flow for all members and help easier access to the common pool of information. There can be different cluster publications released, such as booklets, newsletters, and others. Other important activities are co-operation while creating new products or technologies and while creating innovations. Innovations can be organizational, marketing and others. Cluster members can also participate in training, workshops, conferences, internships to uphold their interpersonal relations while raising qualifications. Smooth knowledge transfer can be ensured by a common database and informal sharing of knowledge and experience. Besides, technology transfer must be ensured in a cluster as well.

Marketing activities include indicators that enable the promotion of the cluster in the society. This can be achieved through common supply and ordering schemes, as well as distribution channels. External clients can be reached through tenders which are made up of cluster members. Common market information should be exchanged between cluster members to help identifying companies as belonging to the same unit. Leaflets, media and other means of communication should be used for cluster advertisement. Exhibitions and fairs can work as a suitable means for cluster promotion with the participation of cluster members as representatives. Lobbying as a seek to influence a cluster by a politician or public official may help to identify cluster activities. The common internet site can help in informing the public about the cluster and promoting visibility. A common logo or brand as visual identification means helps cluster to be easily recognizable in any context. Advertising can work on different channels, although the image in mass media should be highlighted and contacts maintained.

International processes indicate how active the cluster is in the market regarding financial records. These processes include products or goods sold in both, the internal and external markets by a cluster. It is very important if new members have joined a cluster to see if it is attractive and available for further expansion. Start-ups should be indicated if any of them were initiated in a cluster. The number of foreign markets where members of cluster work can help to measure the possible extent to foreign markets. The part of export in the total cluster sales characterizes how international a cluster is. Official co-operation agreements, if they are signed with foreign entities, are valuable in the internationalization of a cluster. International exhibitions and sales offices should be attended and the record during the last two years submitted for evaluation.

HRM processes indicate the qualification of personnel in a cluster, what kind of training they get, how the cluster is coordinated and other basic information. The indicators include the increase of employees in member companies during the last two years to indicate the growth, the number of

employees that participated in the internal cluster training during the same period, the number of training organized by the cluster in two years. It needs to be indicated how many employees have upgraded their qualifications in the last two years. The number of university graduates working at cluster companies helps to indicate the qualification of personnel. Was there an increase in direct employment in cluster innovative activities and how many employees work for R&D activities? The structure of cluster members should be clear, naming companies, R&D subjects, supporting organizations, educational institutions and the number of clusters coordinating members should be provided.

Resources are composed to include indicators that determine financial information about cluster initiatives. The number of common cluster projects should be indicated. Cluster initiatives co-financing is crucial in cluster development which asks to provide the number of such financed cluster projects in two years. External financing should be stated as cluster initiatives in the same period. The part of R&D expenses in the same period needs to be provided in common. Submitted and funded European Union Structural Funds (EU SF) projects need to be indicated as well as international Research and Development (R&D) projects prepared by cluster members having another foundation, except the EU SF. How many cluster members have invested in cluster initiatives in the last two years?

These cluster's performance criteria give information which can be evaluated using other methods. They can be supplemented or decreased according to the need, although the attention should be paid to the importance of every criterion in order not to deteriorate the quality of the survey.

An extensive literature analysis regarding the circular economy gave crucial results as well. Scientists emphasize the importance of a circular economy for SMEs, whereas, the circular economy criteria were selected according to their observations. Clusters are identified as enablers of SMEs in involving to a circular economy and turning to resource efficiency.

Circular economy criteria were organized using the AHP method as well. The circular economy includes four components which are further divided into criteria: environmental performance (includes 4 indicators), operational performance (includes 4 indicators), organizational performance (includes 4 indicators), economic/financial performance (includes 3 indicators) (Table 2). These components include relatively fewer criteria than the cluster's performance. The circular economy components are supplementary, adding to the cluster's competitiveness, while those of the cluster's performance are viewed as giving the main information about a cluster.

Environmental performance includes indicators that determine the statistical information on how the cluster is treating the environment. Usage of alternative energy sources questions if any companies in the cluster use alternative energy sources and how many. Solid waste, as well as liquid or water waste, should be submitted in percent to allow evaluating the soiling. Recycled or reused materials should be provided in percent as well. These indicators are used to gather basic information about the cluster's environmental performance.

Economic or financial performance criteria indicate the financial outcomes of turning to a circular economy. Labor cost per hour can be related to HRM processes from the cluster's performance indicators for it reflects these criteria. Moreover, it indicates circular economy performance as well. Green products give profit, which should be presented on average. Companies need to invest in green profits, which give the return, indicated on average.

Operational performance defines how the circular economy is incorporated into the production. The use of recyclable and recycled materials in production needs to be provided. Another important issue is customers and how companies cooperate with them for green production. Companies should indicate if life cycle assessment is present in their schedule.

Organizational performance includes sharing information about the circular economy. Green initiatives and eco-service need to be assessed. The common website is one of the marketing activities which should be supplemented and updated on environmental issues to turn to a circular economy. More than that, trading partners should be sharing information promptly and accurately on these issues. After-sales service performance needs to be provided by companies in a cluster that works on production.

The information for circular economy indicators is complicated to collect and measure. A cluster is composed of several components, such as companies, organizations, educational or research centers and others. They can be enrolled in circular economy activities on different degrees and through various activities. Hence, the numbers would vary depending on the activities that companies are engaged in. Needless to say, the engagement in a circular economy is highly dependent on the sector in which a cluster operates.

Composing these two groups of components — cluster’s performance criteria and circular economy criteria — would enable to gain cluster’s competitive advantage.

Conclusions

Circular economy is viewed by scholars as a priority for better performance. It is viewed from different perspectives: resource efficiency, eco-efficiency, waste is considered as a resource, closing the loop and reduce-reuse-recycle approaches are presented, life cycle assessment is taken into account.

Clusters are gaining interest through the last century for they provide access to foreign markets, global knowledge networks, a common pool of resources, access to shared knowledge, innovations. SMEs usually aim at these advantages when decide to be connected with other companies in one unit to gain a competitive advantage. Clusters are a complex form of organization where a co-operative, as well as competitive density, is formed by social ties, productive networks of local companies and institutions. Clusters are characteristic in local environments, although their function is to create a competitive advantage for cluster members on a larger scale — nationally and internationally.

Clusters are identified as enablers of a circular economy in this research for SMEs can use up the advantages of being members of clusters through provided conditions of a unit. Clusters can encourage SMEs to turn to a circular economy. Involvement in the circular economy adds to clusters' competitive advantage complementing the clusters' performance criteria. The proposed scheme of cluster's competitive advantage can help cluster's coordinators, policymakers and all the concerned parties to verify the importance of clusters' involvement in the circular economy.

Clusters are composed of companies that differ in size, specialization, degree of involvement into common activities. This is a clear limitation when the collection of data is considered. Most of information required in this research is considered as confidential at the company level, although it should be available when cluster as a unit is viewed. Further research would require a case analysis where the indicators characterized in the paper should be tested in a cluster.

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Annex

Table 1. Indicators of clusters' efficiency

Communication activities	Regular meetings of cluster members	International processes	Products/goods of cluster, sold in internal market
	Cluster integration events		Products/goods of cluster, sold in external market
	Common communication platform		New cluster members in two years
	Common cluster publications (bucklets, newsletters, etc.)		Start-up in cluster
	Co-operation while creating new products or technologies		Foreign markets where members of cluster works
	Co-operation while creating innovations (organizational, marketing, etc.)		Part of export in total cluster sales
	Common training, workshops, conferences, internships		Number of official co-operation agreements with foreign entities
	Common data base		Participation in international exhibitions and sales offices in two years
	Informal sharing of knowledge and experience	HRM processes	Increase of cluster members' employees in two years
	Transference of technologies		Number of internal cluster training participants in two years
Marketing activities	Common supply and order scheme		Number of cluster organized common training in two years
	Common distribution channels		Number of qualification upgraded employees in two years
	Common cluster members' tenders for external clients		University graduates working at cluster companies
	Exchange of common market information between cluster members		Increase of direct employment in cluster innovative activities
	Cluster advertisement (leaflets, media)		Number of R&D personnel
	Common participation in exhibitions and fairs		Number of cluster members - companies, R&D subjects, supporting organizations
	Lobbying		Number of cluster coordinating members
	Common internet site	Resources	Common cluster projects in two years
	Visual identification (common logo, brand)		Financed common cluster projects in two years with cluster initiatives co-financing
	Contacts and image of cluster in mass media		External financing for cluster initiatives in two years
			Number of common submitted/funded EU SF projects in two years
			Number of common submitted/funded EU SF projects in two years
			Number of common international R&D projects, funded not from EU SF, in two years
			Total sum of cluster members' investments for cluster initiatives in two years

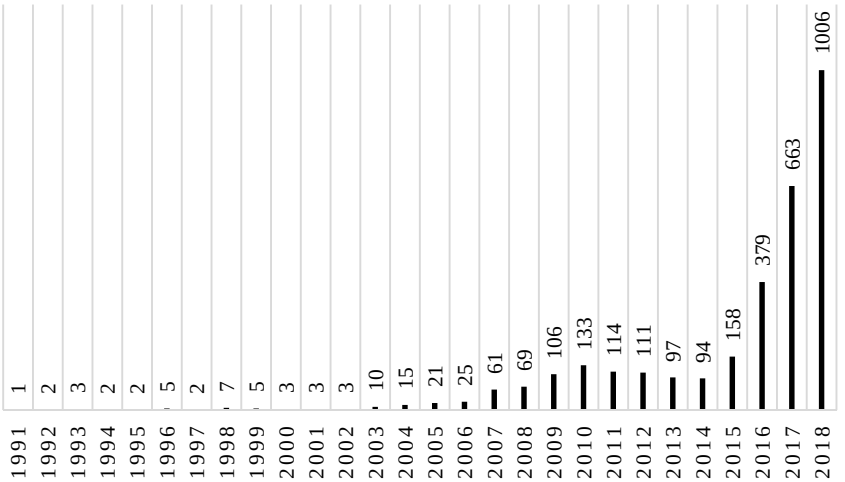
Source: author's compilation based on Razminienė *et al.* (2016).

Table 2. Indicators of circular economy

Environmental performance	Usage of Alternative Energy Sources Solid Waste Liquid/Water Waste Percent of Materials Recycled or Reused
Economic/financial performance	Labor Cost per Hour Average Profit from Green Products Average Return on Investment from Green Products
Operational performance	Use of Recyclable Materials in Production Use of Recycled Materials in Production Cooperation with Customers for Green Production Life Cycle Assessment
Organizational performance	Green initiatives and eco-service Keeping the website updated on environmental issues Accurate and prompt information exchange between trading partners After sales service performance

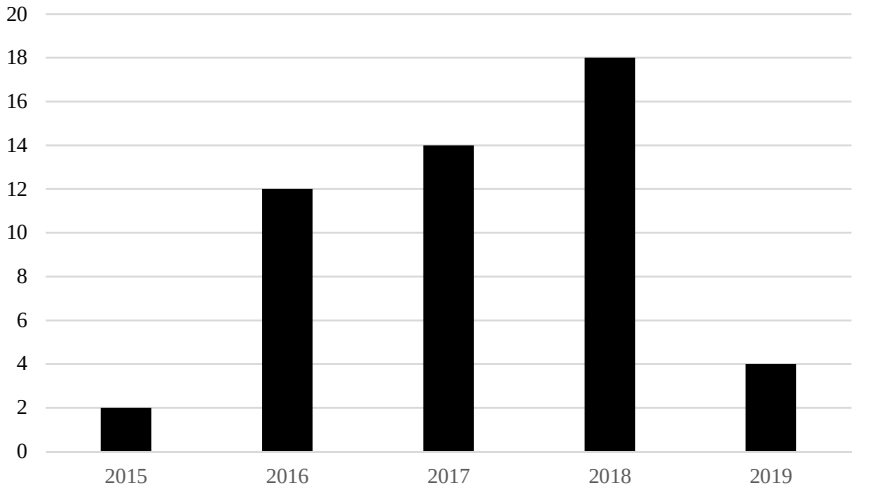
Source: Razminiene and Tvaronavičiene (2018).

Figure 1. Search results for a topic *circular economy* by publication years from 1991 to 2018



Source: author's compilation based on Thomson Reuters (2018).

Figure 2. Number of articles selected by years from 2015 to 2019



Source: author's compilation based on Thomson Reuters (2018).

Figure 3. The scheme of the cluster's competitive advantage