Knowledge of the Business Ecosystem and the Implementation of a Circular Economy

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Abstract: Part of the European Green Deal is the Circular Economy Action Plan. Among other things, this plan formulates priorities for the design of products and production processes so that they are climate-neutral, correspond to a resource-efficient and circular economy (CE) and lead to a reduction of waste. These actions require companies not only to make changes to their organisational and management systems, but also to make investments. For this reason, these changes do not encourage companies to introduce the principles of the circular economy. Such encouragement can come from the business ecosystem. The aim of this article is to answer the question of whether companies gain such knowledge about the ecosystem in which they operate that encourages them to replace harmful technologies with friendly ones, to use their waste in their own production processes and those of other companies, and to neutralise their waste. This includes knowledge relating to the regulatory, economic, social, environmental and technological segments, as well as knowledge gained from buyers, suppliers and also competitors. The research hypothesis of the paper is that the greater this knowledge is, the more companies engage in the introduction of CE principles. In order to verify this hypothesis, an empirical study was conducted in 150 medium and large-sized companies belonging to 19 industrial sectors. Data were obtained using an interview questionnaire and were processed using a Kruskal-Wallis ANOVA and post hoc test. The results obtained allow us to conclude that knowledge of changes occurring in macro-environmental segments is more influential than knowledge obtained from buyers, suppliers and competitors. Companies that have knowledge of the changes taking place in the ecosystem perceive and exploit these changes and actions towards a circular economy as business opportunities. The research results obtained are useful for indicating the practical steps that leaders in the introduction of circular economy principles are taking in order to acquire the necessary knowledge about the ecosystem. They can also provide some contribution to the development of a sustainable product policy legislative initiative by the European Commission using the performance of these leaders.

Keywords: Knowledge obtaining, Circular economy, Business ecosystem, Designing sustainable products and processes

1. Introduction

Enterprises and organizations, interconnected by cooperation, collaboration, and also competition, together with the conditions created by the macro-environment in which they operate, form an ecosystem. It is not an institution, but a natural creation within which enterprises modify their activities and benefit from participation in it. Its boundaries are not defined and the number of participants that make up the ecosystem changes as companies develop their potential, products, technologies, and their own networks. In the ecosystem, knowledge is created, collected, and distributed. This is, however, a natural process and not one that is controlled by some central hub, even though the development of the ecosystem is usually influenced by companies that are leaders in their sector in some respect. Such a hallmark could be the implementation of solutions specific to the circular economy (CE). The decision to transform into a CE has a political character in the European Union and is triggered by the need for environmental transition.

The aim of this article is to answer the question of whether companies gain such knowledge from the ecosystem in which they operate that encourages them to replace harmful technologies with friendly ones, to use their waste in their own production processes and those of other companies, and to neutralize their waste. The knowledge that encourages or even impels the implementation of a CE can come from buyers who expect green products, from suppliers and subcontractors who offer materials and technologies that minimize waste and energy consumption, and from segments of the business macro-environment. The latter includes, in particular, the political-legal segment that regulates green activities and the circular economy, as well as the economic, socio-demographic, environmental, and technological segments. The acquisition of knowledge from these segments and also from segments of the industrial micro-environment is carried out by scanning them. These segments, especially the regulatory and technological ones, are the hypothetical drivers of the circular economy (CE). In this article, we pose and verify the hypothesis that the greater this knowledge is, the more companies engage in the implementation of CE principles.

To verify this hypothesis, we carried out empirical research on medium-sized and large companies operating in Poland. The research was aimed at determining whether there is a relationship between sourcing knowledge from the ecosystem and implementing a circular economy.

2. Literature Review

The ecosystem concept dates back to 1930. Initially applicable to sciences such as ecology or social science, it was introduced to management in the early 1990s by Moore (1996) and provided a bridge between systems thinking and evolutionary economics. An economic ecosystem is understood as "an economic community supported by a foundation of interacting organizations and individuals - organisms of the business world that produce goods and services of value to customers who are themselves members of the ecosystem" (Karhiniemi, 2009). Therefore, managers should consider companies as elements of the ecosystem (Eriksson & Vidén, 2018).

The essence of this concept is the self-organization of entities, differing in size and scope of activities, around the idea of creating and serving markets in a way that could not be achieved by a single organization alone (Valkokari, 2015). The ecosystem is made up of leading manufacturers, suppliers, distribution channels, companies selling complementary products, and customers, but also other stakeholders (e.g. shareholders, investors, government agencies, industry associations) delivering value to customers. Their capabilities and roles evolve over time, adapting to the development of the ecosystem, which is often governed by a vision created by leading companies (Karhiniemi, 2009). By combining the multiple skills, knowledge, and resources available in such ecosystems, innovative solutions can be more effectively co-created to meet basic human needs and face emerging challenges. A key aspect of the long-term success of an ecosystem is the diversity of the actors involved and the synergies arising from their collective ability to learn, adapt and innovate (Kelly, 2015).

Ecosystems are influenced by factors from the following segments of the macro-environment: political (like political stability, acute crises, monetary policy, fiscal policy, economic situation), regional (availability of materials and labour, physical distances, norms, and values), and regulatory (changes in regulations creating opportunities or threats) (Karhiniemi, 2009).

In the ecosystem, knowledge is exchanged and cooperation between its actors takes place, which makes it possible to address jointly important societal challenges. Knowledge as an intangible resource is of great importance in creating the organisation's value (Krawczyk, 2022). One such challenge is to prevent the pollution of the environment, to which also companies contribute. In this article, we focus mainly on activities related to the CE, as one of the approaches to tackle this problem, which aims to address it through fostering more responsible use of resources, reducing the consumption of materials, and generation of waste by industrial companies.

One source of environmental problems, such as emissions of carbon dioxide and other greenhouse gases, loss of biodiversity, and water scarcity (EEA, 2019), is the mismanagement of materials and products made from them. Due to socio-economic and technological changes, global material consumption is projected to increase by 1.5% per year until 2060, almost doubling from 2017 (from 33 kg in 2017 to 45 kg in 2060). Waste generation could increase by up to 70%. The environmental impact is projected to double, with the largest impacts expected for the use of iron, copper, concrete and aluminium (OECD, 2021).

Clothing, footwear and home textiles are also among the product categories that consume the most primary raw materials, water, land and emit greenhouse gases in the EU and globally. It is estimated that the clothing and footwear industry is responsible for 8% of global greenhouse gas emissions. Only a small share of end-of-life textiles are currently recycled, while the majority is landfilled, incinerated or potentially recycled, but for less valuable uses (the so-called downcycling) (OECD, 2021).

Improving the situation is possible by moving towards a closed-loop (i.e. circular) economy, a flagship initiative of the European Commission. The circular economy (CE) is a production and consumption model that involves sharing, borrowing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as feasible and reasonable. This extends the life cycle of products and reduces waste generation. When a useful product's life cycle comes to an end, the raw materials and waste resulting from it should be maintained in the economy through recovery and recycling. They can be successfully reused, thus creating additional value (European Union, 2020).

Environmental impact is mainly determined at the product design stage (Visotskya et al., 2017). A number of closed-loop business models, through which companies can close their production cycles, slim down resource flows and decouple resource use from production, are available. Sustainable product design and Design for

Environment (DfE) are key concepts applied in the following models (OECD, 2021): Closed-loop supply models, Resource recovery models, Life extension models, Unused capacity or sharing models, Product as service models.

In line with the recent EU initiatives linked to the Green Deal and its relevant environmental legislation, products should be designed to meet the requirements of the CE and climate neutrality. Established sustainability principles regulate various aspects such as improving product durability, reusability, repairability, and energy efficiency while reducing the use of hazardous compounds and increasing recycled content (European Union, 2020). Implementing a circular economy involves applying the 3Rs principle, i.e. reduce, reuse, recycle.

Companies that try to meet this challenge may face, however, a number of obstacles (Lamenta & Grzybowska, 2023). One of them is related to implementing the "zero waste" strategy, and the question of its real achievability. For many materials, their multiple reprocessing can lead to a decrease in quality (Golkaram at al., 2022) and the need to use higher shares of virgin materials again. Another issue links to costs, which in some cases can be higher for recycled materials than for virgin ones. Thus, reaching a one hundred percent recyclability rate is sometimes seen as counterproductive from the business' point of view (Lewandowski, 2016). Another aspect encountered problematic by businesses is the lack of a social dimension in the core framework of the CE that is mainly focused on technological, economic, and environmental dimensions of sustainability (Khalamayzer, 2017; Lewandowski, 2016). Further barriers encompass organisational aspects such as restructuring costs and the related risks, or the unwillingness of stakeholders who benefit from the linear business model (Oghazi & Mostaghel, 2018). Last but not least, the lack of clear guidelines and standardisation is an issue which makes the transition from a linear business model to a circular one more challenging for companies (Atiku, 2020).

To remove or reduce the barriers to a circular economy (CE), knowledge management can be applied in the ecosystem to incorporate the sustainability dimension (Weina & Yanling, 2022) and the principles of circular early into the product design. This involves the creation, organisation, accumulation and sharing of knowledge among multiple parties and involves actors from both the macro-environment and the interior of the ecosystem. Knowledge content may be derived from both inside and outside the organization, thus underlining the holistic nature of KM (Siuko at all., 2022). For this purpose, we used the research model presented in Figure 1.

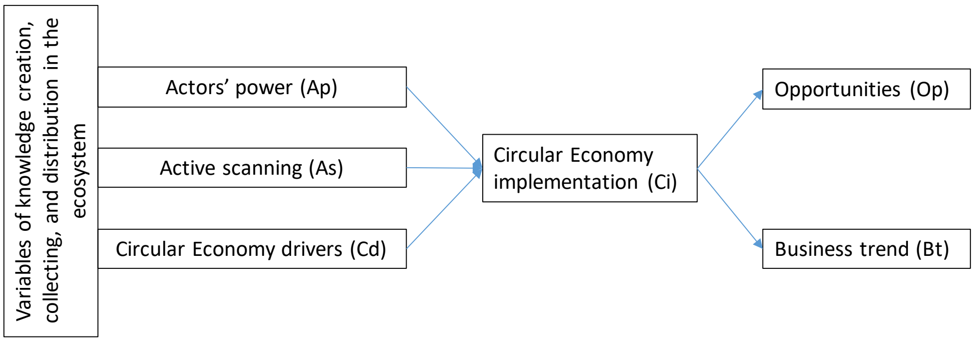

Figure 1: Research Model

3. Methodology

The empirical research was carried out in December 2022 in 150 enterprises located across Poland, 90 thereof medium-sized and 60 large ones. These companies were assigned to 19 industry sectors according to similarities in their businesses.

Data were collected by means of an interview questionnaire with closed questions, using the CAPI (Computer-Assisted Telephone Interviewing) method. All 150 surveys were positively returned. The respondents were: presidents/managing directors; technical directors and other employees with relevant competence and area of responsibility. Each of the surveyed companies answered 18 questions. The questionnaire questions were divided into seven groups of variables. The reliability of the variables was tested using the Cronbach alpha test.

The following group of dependent variables for the implementation of the circular economy (Ci) was adopted: Use of third-party waste materials (Ci1); Replacement of harmful with environmentally friendly technologies (Ci2); Use of our waste in other own processes (Ci3); Use of our waste in manufacturing processes of other companies (Ci4); Neutralisation of waste harmful to the environment (Ci5).

Whereas the remaining variables, referring to various aspects of knowledge acquisition, were divided into six groups:

Power of ecosystem actors (Ap) in terms of conditions to be met by products and technologies: Buyers' purchasing preferences (green products, energy-efficient products) (Ap1); Bargaining power of domestic buyers (Ap2); Bargaining power of foreign buyers (Ap3); Bargaining power of domestic suppliers (Ap4); Bargaining power of foreign suppliers (Ap5).

Active scanning regarding environmental issues (As): Scanning the regulatory segment of the environment (As1); Scanning the economic segment of the environment (As2); Scanning the social and demographical segment of the environment (As3); Scanning the natural environment segment (As4); Scanning the technological segment of the environment (As5); Scanning the customer segment of the environment (As6); Scanning the supplier segment of the environment (As7); Scanning the competitors' segment (As8); Research on customer needs (As9); Research on customer satisfaction (As10); The present market needs analysis (As11); New markets needs analysis (As12).

Circular economy drivers (Cd): Regulation on environmental protection (Cd1); Energy efficiency regulations (Cd2); Availability of funding for R&D (Cd3); Availability of licences and patents (Cd4); Offer of country R&D centres for products and technologies (Cd5); Offer of foreign countries R&D centres for products and technologies (Cd6); Patent protection (Cd7).

Opportunities (Op): opportunity recognition (Op1); Opportunity exploitation (Op2).

Business trend (Bt) – single variable.

The data collected in the interview questionnaire was processed using the following tests: Cronbach's alpha test - to check the reliability of measurement scales, Spearman's rank correlation test - in order to determine whether the variables related to the creation and use of knowledge are correlated with the implementation of the Circular Economy (CE) and whether the CE is an opportunity for enterprises implementing it; Kruskal-Wallis test - to determine whether the intensification of activities related to the creation and use of knowledge is statistically significant for the implementation of CE; Multiple comparison test - to determine what levels of intensity of these activities have different impact on the implementation of circular economy. The last three tests are non-parametric, as the variables were expressed on a rank scale.

4. Results and Discussion

4.1 Results of Descriptive Statistics

Based on the respondents' answers, it was found that:

Ci1: 21% of companies do not use or use other companies' waste materials to a very small extent, while 25% use them to a large or very large extent.

Ci2: 21% of companies do not replace environmentally harmful technologies with friendly technologies or replace them to a very small extent, while 36% of companies do so to a large or very large extent.

Ci3: 37% of companies do not use or use their own waste to a very small extent in their other processes, while 17% do so to a large extent. No company uses its waste to a very large extent.

Ci4: 41% of companies do not provide or provide a very small portion of their waste for use by other companies, while 21% provide a large or very large portion.

Ci5: 21% of companies do not neutralize or neutralize a very small share of their waste, while 43% neutralize a large or very large share of their waste.

For each variable, the number which is the complement of the sum of the given frequencies to 100% corresponds to the moderate involvement of the company.

4.2 Results of Correlation Analysis

Table 1 presents the correlation between variables, with Ci (Circular economy implementation) variables treated as dependent variables.

Table 1: Correlation of Circular Economy Implementation Variables With Knowledge Ecosystem Variables

Variable		Cronbach alpha	Circular economy implementation Cronbach alpha = 0,72				
			Ci1	Ci2	Ci3	Ci4	Ci5
Actors' power	Ap1	0,87	**0,738**	**0,238**	**0,285**	**0,209**	0,013
	Ap2		**0,417**	**0,345**	**0,287**	**0,233**	-0,061
	Ap3		**0,417**	**0,345**	**0,287**	**0,233**	-0,061
	Ap4		**0,417**	**0,345**	**0,287**	**0,233**	-0,061
	Ap5		**0,417**	**0,345**	**0,287**	**0,233**	-0,061
Active scanning	As1	0,94	**0,189**	**0,313**	**0,323**	**0,304**	0,098
	As2		0,138	**0,233**	**0,181**	**0,177**	0,055
	As3		0,136	**0,306**	**0,217**	**0,251**	0,068
	As4		0,066	**0,409**	**0,260**	**0,287**	0,016
	As5		0,090	**0,178**	0,078	0,072	0,075
	As6		-0,141	0,052	-0,068	-0,011	0,152
	As7		0,066	0,025	-0,052	-0,019	**0,178**
	As8		0,036	**0,222**	0,021	0,101	0,094
	As9		**0,178**	**0,313**	**0,188**	**0,219**	**0,229**
	As10		0,104	**0,205**	0,143	**0,199**	**0,276**
	As11		-0,040	0,135	-0,022	0,059	0,142
	As12		0,142	**0,296**	0,136	**0,187**	0,160
Circular Economy drivers	Cd1	0,97	1,000	**0,199**	**0,182**	0,153	-0,040
	Cd2		1,000	**0,199**	**0,182**	0,153	-0,040
	Cd3		**0,634**	0,079	0,087	0,037	0,145
	Cd4		**0,634**	0,079	0,087	0,037	0,145
	Cd5		**0,634**	0,079	0,087	0,037	0,145
	Cd6		**0,634**	0,079	0,087	0,037	0,145
	Cd7		**0,634**	0,079	0,087	0,037	0,145
Opportunities	Op1	0,85	**0,493**	**0,171**	0,114	0,063	0,070
	Op2		**0,499**	**0,166**	**0,174**	0,144	**0,161**
Business trend	Bt	-	**0,316**	0,138	-0,006	-0,043	**0,252**

4.3 Influence of Actor's Power (Ap)

Actor's power (Ap) was found to have the greatest influence on the implementation of activities represented by variables Ci1, Ci2, Ci3, and Ci4. The preferences of customers and the bargaining power of buyers and suppliers regarding product and technology conditions were identified as key factors. The Kruskal-Wallis test and multiple comparison test revealed qualitative differences in commitment to Ci1 and Ci3 activities when buyers strongly articulated their purchasing preferences (Ap1). Additionally, commitment to all Ci activities increased when the bargaining power of domestic and foreign buyers (Ap2 and Ap3) as well as domestic and foreign suppliers (Ap4 and Ap5) increased.

4.4 Impact of Active Scanning (As)

Active scanning of the macroenvironment (As1-As5) and industry environment (As6-As9) to gain knowledge about opportunities and threats, including those related to environmental activities, was found to have a significant impact on Ci implementation. Knowledge from the regulatory segment (As1) in the macroenvironment was particularly important for Ci1-Ci4 activities. Knowledge from the economic, social, demographic, and natural environment segments also played a significant role in Ci2-Ci4 activities. The intensity of macroenvironment scanning was found to be important for companies' commitment to implementing the circular economy.

4.5 Influence of Industrial Environment (As)

Among the variables in the industrial environment (As6-As12), knowledge acquisition through surveys of customer needs (As9), customer satisfaction (As10), and new markets' needs (As12) had the greatest impact on the implementation of the circular economy. Knowledge acquisition about competitors (As8) was significant for Ci2 (Replacement of harmful with environmentally friendly technologies). The intensity of these activities was found to qualitatively affect their impact on the implementation of the circular economy.

4.6 Circular Economy Drivers (Cd)

Circular Economy Drivers (Cd1, Cd2, Cd3, Cd4, Cd5, Cd6, Cd7) showed moderate significance in the implementation of the circular economy. Regulation on environmental protection (Cd1) and energy efficiency regulations (Cd2) were found to be statistically significant for Ci2 and Ci3. The other factors included in Circular Economy Drivers were statistically significant only for the implementation of Ci1 (Use of third-party waste materials). The perception of changes in the environment and the technological segment of the macro-environment played a role in the implementation of technologies for the use of third-party waste materials.

4.7 Opportunities (Op)

The implementation of the circular economy was seen as an opportunity for companies. Variables Op1 (Opportunity recognition) and Op2 (Opportunity exploitation) were positively and relatively strongly correlated with Ci1 and Ci2. The majority of companies recognized the use of third-party waste materials (Ci1) as a good or very good opportunity. However, a significant proportion of companies did not perceive it as an opportunity or found it completely unattractive. Similar findings were observed for Ci2.

4.8 Utilization of Own Waste and Neutralization (Ci3, Ci5)

Use of own waste in other processes (Ci3) and neutralization of waste harmful to the environment (Ci5) were also considered as opportunities (Op2), but the correlation between these variables, although statistically significant, was relatively weak. The utilization of own waste materials (Ci3) to a high or very high degree was observed in a significant percentage of companies. However, the lack or a small degree of neutralization raised concerns, and further research is needed to determine the reasons behind it.

These findings provide insights into the factors influencing the implementation of the circular economy and highlight the importance of actor's power, active scanning, industrial environment, circular economy drivers, and opportunities for companies in adopting circular practices.

5. Conclusions

5.1 Achievement of Objectives and verification of the Hypothesis

The results obtained allow us to conclude that the knowledge created, collected and distributed in the ecosystem has an impact on the implementation of the circular economy by companies. It has the greatest impact on the replacement of environmentally harmful technologies with friendly technologies (Ci2). It equally influences firms' use of waste materials from other companies (Ci1), the use of their own waste materials (Ci3), and the use of a company's waste materials by other companies (Ci4). In contrast, it has a marginal effect on the neutralization of environmentally harmful waste (Ci5). It seems that this obligation is widely known hence knowledge regarding this issue does not affect the activity of companies in this regard. In general, it can be concluded that we obtained positive answers to the research questions set forth in this work.

Between the variables treated as independent (Ap - Actors power; As - Active scanning; Cd - Circular economy drivers) and the dependent variables (Ci - Circular economy implementation) there are 55 statistically significant and positive correlations out of 120 possible. This implies that our research hypothesis has been positively verified. The greatest influence on the implementation of CE has the knowledge obtained from the actors of the ecosystem (Ap), that is, buyers and suppliers. Through their bargaining position or good example, they force the involvement of enterprises in the implementation of CE. The second most important group of drivers is Active scanning (As) with a greater importance given to knowledge extracted from the business macro-environment than from the industrial environment. In the Circular economy drivers group (Cd), knowledge about changes taking place in the natural environment has a greater influence on CE than knowledge about changes in technological segment of the macro-environment.

It is positive to see that managers perceive the implementation of the circular economy as an opportunity and are exploiting that opportunity. Presumably, this is not just a question of business benefits but also an issue of a company's reputation for being seen as environmentally friendly, modernizing its manufacturing capacity or organizational development. Our research shows that this attitude to the transformation to the circular economy has a positive impact on the business development trend. Despite the turbulence in the macro-environment caused by the Covid pandemic, the war in Ukraine, and very high inflation, as many as 58% of companies rate this trend as favorable or very favorable, of which 57% are medium-sized companies. Only 13% of companies rate the trend as strongly negative or unfavorable, of which 84% are also medium-sized companies.

5.2 Research Implication

In order to make significant progress in implementing the circular economy, managers ought to gain knowledge and draw motivation from a variety of sources. It seems that relatively the fastest progress can be made in replacing environmentally harmful technologies with friendly ones (Ci2). Our research shows that this effect is supported by the largest number of activities belonging to the Ap, As, Cd groups. There is relatively equal support for the use of third-party waste materials (Ci1), the use of our waste in our other processes (Ci3) as well as the use of own waste in manufacturing processes of other companies (Ci4). In all of these cases, critical is listening to the opinion of buyers and suppliers and also acquiring knowledge from the segments of the business macro environment (regulatory, economic, socio-demographic, environmental).

Although the correlations between Ap, As, Cd and Ci are positive, the results of the Kruskal-Wallis test and the multiple comparison test showed that there are differences in the impact on Ci of activities of different intensities measured on the Likert scale. For example, there is no difference between the impact of scanning the socio-demographic environment (As3) when its intensity on the Likert scale is 1 (no scanning) and when it is 2 (very small intensity) but there is a difference when it is 3 (moderate intensity), 4 (high intensity) or 5 (very high intensity). This implies that managers need to engage in different activities with the appropriate intensity to achieve a satisfactory level of implementation of the circular economy. This appears to be the direction of the incentives aimed at companies by European Comission (2020, p.7), which has established rewarding products based on their improved sustainability performance.

5.3 Research Limitation

The research results we present are part of a broader study that we conducted on the same population of enterprises, regarding the agility of these companies and the implementation of Industry 4.0. These issues introduced a certain analytical context for the respondents, which could be transferred to answering questions about the implementation of CE. Although we do not believe that such disruption of the semantic context has a significant impact on our results, we cannot rule it out. If it did, it could limit the representativeness of the obtained results.

Another limitation results from the methodology of obtaining answers to questions from the interview questionnaire. The answers were given on an ordinal Likert scale and although qualitative measures were assigned to the numerical ratings, this allows for arbitrariness in the respondent's answers. Some justification, however, is that this methodology is widely accepted and used in the social sciences. Nevertheless, in the future we intend to obtain at least some of the data expressed on a quotient scale.

References

Atiku, S.O. (2020) Knowledge Management for the Circular Economy, Handbook of Research on Entrepreneurship Development and Opportunities in Circular Economy Publisher: IGI-Global, pp 520-537.

Eriksson, S. and Vidén, E. (2018) Thriving in a Business Ecosystem. A study of role and capability alignment, Industrial and Management Engineering, master's level, Luleå University of Technology, Department of Business Administration, Technology and Social Sciences, Lulea.

European Parliament (2015) Circular economy: definition, importance and benefits, website release, Ref.: 20151201STO05603, [online], https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits?at_campaign=20234-Economy&at_medium=Google_Ads&at_platform=Search&at_creation=DSA&at_goal=TR_G&at_audience=&at_topic

=Circular_Economy&gclid=Cj0KCQjwgLOiBhC7ARIsAIeetVDqVfZ66KbiFVpZha8d82t3tUtz78EBQbOJF8u53eHZNPkcqzerfg4aAu0PEALw_wcB.

European Union (2020) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A new Circular Economy Action Plan. For a cleaner and more competitive Europe, COM(2020) 98 final, [online], https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0098.

EEA (European Environment Agency) (2019), The European environment - state and outlook 2020, Executive summary, [online]. https://www.eea.europa.eu/publications/soer-2020-executive-summary.

Golkaram, M., Mehta, R., Taveau, M., Schwarz, A., Gankema, H., Harm Urbanus, J., De Simon, L., Cakir-Benthem, S., van Harmelen, T. (2022) "Quality model for recycled plastics (QMRP): An indicator for holistic and consistent quality assessment of recycled plastics using product functionality and material properties", Journal of Cleaner Production, Vol 362. https://doi.org/10.1016/j.jclepro.2022.132311.

Karhiniemi, M. (2009) Creating and Sustaining Successful Business Ecosystems*,* Information Systems Science, Master's thesis, Department of Business Technology, Helsinki school of economics, Helsinki.

Kelly, E. (2015) Business ecosystems come of age, Part of the Business Trends series, Deloitte University Press.

Khalamayzer, A. (2017) "Five challenges to scaling the circular economy", [online], https://www.greenbiz.com/article/5-challenges-scaling-circular-economy.

Krawczyk, P. (2022), Knowledge Management and Corporate Social Responsibility Interactions in Theory and Practice, Proceedings of the *23rd European Conference on Knowledge Management*, ECKM 2022, Vol. 23 No. 1, p.665

Lamenta, Z., Grzybowska, K. (2023), "Impact of the European Green Deal on Business Operations—Preliminary Benchmarking", Sustainability, Vol. 15(10), 7780. https://doi.org/10.3390/su15107780.

Lewandowski, M. (2016) "Designing the business models for circular economy—Towards the conceptualframework", *Sustainability*, Vol 8(1), 43. doi:10.3390u8010043.

OECD (2021) Towards a more resource-efficient and circular economy, The role of the G20, A background report prepared for the 2021 G20 Presidency of Italy, [online]. at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjXv-XO-uj-AhUfiv0HHYGvC38QFnoECBYQAQ&url=https%3A%2F%2Fwww.oecd.org%2Fenvironment%2Fwaste%2FOECD-G20-Towards-a-more-Resource-Efficient-and-Circular-Economy.pdf&usg=AOvVaw0Y1qC2fmIg9QghdUhda-dz.

Oghazi, P. and Mostaghel, R. (2018) "Circular business model challenges and lessons learned—An industrial perspective", *Sustainability*, Vol 10(3), 739. doi:10.3390u10030739.

Siuko, V., Myllärniemi, J. and Hellsten, P. (2022), Knowledge-Based Management Challenges in the Asset Life Cycle, Vol. 23 No. 2 : Proceedings of the 23rd European Conference on Knowledge Management, p.1080.

Valkokari, K. (2015) "Business, Innovation, and Knowledge Ecosystems: How They Differ and How to Survive and Thrive within Them", *Technology Innovation Management Review*, Vol 5, Issue 8, pp 17-24.

Visotskya, D., Patela, A., Summersa, J. (2017), "Using Design Requirements for Environmental Assessment of Products: A Historical Based Method", *Procedia CIRP,* Vol 61, pp 69 – 74.

Weina, A., Yanling, Y. (2022) "Role of Knowledge Management on the Sustainable Environment: Assessing the Moderating Effect of Innovative Culture", Frontiers Psychology, Vol 13, 861813. doi: 10.3389/fpsyg.2022.861813.