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How Far Away Are World Economies from Circularity: Assessing the Capacity of Circular Economy Policy Packages in the Operation of Raw Materials and Industrial Wastes

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Abstract: Nowadays, circular economy (CE) is on the agenda, however, this concept of closed supply chains originated in the 1960s. The current growing quantity of studies in this area accounts for different discourses except the holistic one, which mixes both approaches—contextual and operating (contextual approach utilizes the thorough examination of the CE theory, stricture of the policy, etc.; the operating one uses any kind of statistical data)—to assess the capacity of circular economy regulatory policy packages (CERPP) in operating raw materials and industrial wastes. This article demonstrates new guidelines for assessing the degree level of capacity (DLC) of CERPPs in the operation of raw materials and industrial wastes by utilizing the apparatus of the fuzzy set theory. It scrupulously surveys current CERPPs in three regions: the EU overall, Finland and Russia; and assesses for eight regions—the EU overall, Finland, Russia, China, Greece, France, the Netherlands and South Korea—the DLC of CERPPs in operating raw materials and industrial wastes. The results show that EU is the best in CE policy and its CERPP is 3R. The following are South Korea and China with the same type of CERPP. Finland, France and the Netherlands have worse results than EU with the type of CERPP called "integrated waste management" because of the absence of a waste hierarchy (reduce, recover, recycle). Russia closes the list with the type of CERPP "basic waste management".

Keywords: circular economy (CE); circular economy regulatory policy packages (CERPP); raw materials (RM); wastes; human-made mineral deposits (artificial deposits); industrial wastes; guidelines; capacity; fuzzy set theory

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1. Introduction

The waste problem is not something new for all countries. In the 1960s, according to the expert estimates, the mass of solid waste on the Earth's surface increased by 40 billion tons annually, excluding wastewater [1]. Today, the numbers of the solid waste (both industrial and municipal solid waste) are much higher, for example, Russia alone has accumulated 80 billion tons of industrial and municipal solid waste on the Earth's surface [2]. Recently, scientists quantified the human-made mass, and compared it to the overall living biomass on Earth, which currently equals approximately 1.1 teratonnes, and they found that Earth is exactly at the crossover point in the year 2020 (±6) [3], which means that in the year 2020 (±6), the anthropogenic mass, which has recently doubled roughly every 20 years, will surpass all global living biomass. However, the certain quantity of the world's mass of all solid waste, including industrial waste in particular, is still unknown.

Nowadays, the industrial waste problem has been on the agenda because of two main reasons. The first is the exhaustion of natural mineral deposit reserves located

in the regions with well-developed infrastructure [4–8]. The second is the fact that the demand for the raw materials exceed the supply/extraction of them. This problem has triggered the objective need to supplement the mineral resource base with the human-made mineral deposits (artificial deposits), that are full of useful components in which the amount of these components corresponds to or even exceeds that in the ores of natural mineral deposits [9–11]. Moreover, to extract raw materials from the human-made mineral deposits is much cheaper than to do so from the natural mineral deposits; there are no costs for the construction of mining and for delivery of ore from the deep below the Earth's crust, etc. Thus, when the ecological aspect—that the industrial waste is the reason for ecological problems in nearby ecosystems—has been supplemented by the economic one [12], the problem of waste has become a priority, as evidenced by the targets of a number of legislative documents in many countries [13–17] and broad support for the concept of closed supply chains (circular economy (CE)) [18–25], which originated in the 1960s [26,27].

Nowadays, that there is a big buzz around the concept of the circular economy (CE). The growing quantity of the studies include different discourses, such as the concept of CE and main principles [23,28]; the regulatory policy packages [29] and their optimality [30,31], strategies [32–34] and some practical applications, including policy instruments, flows of resources and materials, and technological innovations [35,36]; even how to teach CE concepts [28], etc. It is argued that the CE cannot be achieved by utilizing isolated measures. The holistic approach for the development of the CE regulatory policy should be used in these circumstances [37], in agreement with the authors of this paper. However, what are the indicators of the efficiency of the policy design from the "holistic" point of view? Many separate indicators of CE policy have been proposed by different researchers [38]. However, no consensus has been reached so far [39]. The holistic one is proposed in the European Circular Economy Action Plan for monitoring targets with the purpose of assessing "interlinkages between circularity, climate neutrality and zero-pollution ambition" [19,40], but without any instruments and guidelines. The research in [40] demonstrates the scientometrics approach for the assessment of the CE's initiatives in the waste management policies in Italy. The research in [29] investigates and assesses the nature of the optimality of a circular economy regulatory policy package (CERPP). The article [41] shows the statistical approach to the evaluation of the CE indicator. Thus, a few studies are interested in the assessment of the degree level of capacity of circular economy regulatory policy package (DLC CERPP). All of them are based on the two main approaches: contextual and operating. The contextual approach utilizes the thorough examination of the CE theory, stricture of the policy, etc. [29,40,42]. The operating one uses any kind of statistical data [19,41]. Therefore, in this paper, we decided to mix approaches to assess the DLC CERPP by utilizing the apparatus of the fuzzy set theory. The choice of this theory is due to the socio-technical nature of the circular economy, where we should operate the quality and quantity characteristics of CERPP.

Initially, we should mention that the research in [29] provided a valuable perspective that helped us to compose the current manuscript, for which we want to thank the authors Fitch-Roy O., Benson D. and Monciardini D. Like authors from this study, we also choose the CERPP as the focus of our research object, and argue that a CERPP is a dynamic thing, which in real time arises during the "coevolutionary processes by which mixes of policy instruments emerge, develop and interact within their political and technological context" [29]. We also support the ideas of the measurable effectiveness of single instruments and the immeasurable (with the obtaining of the certain numbers) optimality of CERPP. However, we argue that the capacity—the state of CERPP, which forms "the ability to perform functions, solve problems, and set and achieve goals" [43]—is absolutely and quite easily measurable by utilizing our guidelines for assessing the degree level of capacity of CERPP (DLC CERPP), that are presented in the section "Method".

Thus, the aim of this paper is to assess and compare different DLCs CERPP in the operation of raw materials (RM) and industrial wastes by utilizing the apparatus of the

fuzzy set theory, on which the authors' guidelines for assessing DLC CERPP have been based. It should be highlighted that the RM extraction stage plays a key role in the transformation towards CE and sustainable development because it is at the beginning of production value chains [32].

For approbation targets, the sample from eight regions (the EU overall, Finland, Russia, China, Greece, France, the Netherlands and South Korea) [44–50] has been determined. According to the authors' guidelines for assessing DLC CERPP, this article fully represents the calculation (1) for one of the leaders in the integration of CE policy according to many articles and statistical data—Finland—because of its innovative policy, however, it still does not have the waste hierarchy (reduce, recover, recycle) [29]; (2) for the whole of the EU—as the closest to the gold standard [32] and an active initiator in the policy transformation [42]; and (3) for Russia as a big industrial country.

2. Materials and Methods: The Guidelines for Assessing the Degree Level of Capacity of CERPP (DLC CERPP)

"Capacity" is a formative state of CERPP which provides "ability to perform functions, solve problems, set and achieve goals" [43].

Assessing the DLC CERPP is proposed on the basis of the attached authors' guidelines, which is also based on a theory of fuzzy sets. The main directions of capacity include:

- Legal capacity direction (X_1);
- Project capacity direction (including innovations) (X_2);
- Organizational capacity direction (X_3);
- Monetary and fiscal capacity direction (X_4);
- Educational capacity direction (X_5).

According to the guidelines, these directions act as factors (X_1 X_2 X_3 X_4 X_5) for assessing the DLC CERPP.

Complex formation of the capacity of CERPP is carried out on five levels of regulatory:

- International (I);
- National and alliance/union level (II);
- Intergovernmental (III);
- Regional (IV);
- Interregional (V).

The need for the assessment on an intergovernmental level appears when implementing close economic cooperation between the two countries, for example, when organizing a transport corridor. The same occurs at the interregional level, but in this case, the regions are considered as economic entities.

Step 1. At the first stage, a set of specific tools (X_{ai}) is identified for each of the levels of regulation (I–V) in the main areas of CERPP capacity. An example set is shown in Table 1. The content of each direction depends on the level of regulation. Therefore, for the legal direction on the international level, it is going to be agreements, conventions, etc.; on the national level—federal laws, government resolutions, presidential decrees, etc. At this stage, the virtual version of the most complete capacity is justified based on the available systematized material.

Step 2. Selection of the CERPP capacity's system of weights for the main directions.

The identification of this system of weights depends on the need to assign them different values. If such a need exists, then the weights should be determined according to Fishburn's rule (Formulas (1) and (2)):

$$r_a = \frac{2(N - a + 1)}{(N + 1)N} \quad (1)$$

r_a—the weight of the CERPP capacity of the a-th direction; N—number of CERPP capacity directions; a—CERPP capacity directions.

If all directions of CERPP capacity have equal value, then:

$$r_a = 1/N \quad (2)$$

Step 3. The creation of the classifier for scoring the CERPP capacity tools in comparison with the virtual version of the most complete capacity. An example of the classifier is shown in Table 2.

Table 1. Circular economy regulatory policy packages (CERPP) capacity tools by directions and levels of regulation (X_{ai}).

Levels of Regulation (i)	Specific CERPP Capacity Tools (X_{ai})				
	Legal Capacity Direction (X_1)	**Project Capacity Direction (X_2)**	**Organizational Capacity Direction (X_3)**	**Monetary and Fiscal Capacity Direction (X_4)**	**Educational Capacity Direction (X_5)**
international (I)	X_{11}	X_{21}	X_{31}	X_{41}	X_{51}
national (II)	X_{12}	X_{22}	X_{32}	X_{42}	X_{52}
intergovernmental (III)	X_{13}	X_{23}	X_{33}	X_{43}	X_{53}
regional (IV)	X_{14}	X_{24}	X_{34}	X_{44}	X_{54}
interregional (V)	X_{15}	X_{25}	X_{35}	X_{45}	X_{55}

Note: X_{ai}—specific CERPP capacity tools at a-th direction on i-th level of regulation; a—directions of CERPP capacity (a = 1 . . . 5), i—levels of CERPP regulation (i = 1 . . . 5).

Table 2. The classifier for scoring the CERPP capacity tools.

Indicators	The Criterion for Division (j)				
	Low (j = 5)	**Below Average (j = 4)**	**Average (j = 3)**	**Above Average (j = 2)**	**High (j = 1)**
Score	1–2	3–4	5–6	7–8	9–10

Step 4. A scoring-based determination of the CERPP capacity tools in comparison with the virtual version of the most complete capacity. The scoring-based determination is based on the experience and knowledge of experts including the statistical data.

It is proposed to use the classifier for scoring the CERPP capacity tools (Table 2) when assessing the capacity of CERPP for each directions and levels of regulation.

In case of insufficient information about the tool, it is possible to use "n/a" (not applicable), which means that there is a lack of data for assessing a particular CERPP capacity tool. It is recommended to recognize "n/a" as the "below average" level, because the lack of data usually indicates the lack of activity in the certain analyzed direction.

As a result, by calculating the arithmetic mean on the data of expert questionnaires, we get a table with capacity of CERPP estimated according to the classifier (Table 2); in other words, the level of its compliance with the virtual version of the most complete capacity.

Step 5. Mapping the degree of capacity of CERPP.

Such maps are built on a binary number system by making up a table, where the level of the direction of CERPP capacity takes the value "1" (if the expert has recognized the current level of the indicator in this way), and "0"—in all other cases.

Step 6. Determining the weight of the division criteria.

The weight levels are determined by the formula:

$$g_j = 0.9 - 0.2 \times (j - 1) \quad (3)$$

g_j—weight of the division criteria, interval is [0.1–0.9]; j –level of the criteria (j = 1 . . . 5), where max j = 5.

Step 7. The assessment of the degree level of the capacity of CERPP (DLC CERPP).

The assessment of the DLC CERPP is made by the method of double convolution of the maps' data, created on the fifth level, by employing the Formulas (3) and (4):

$$\text{DLC CERPP} = \sum_{j=1}^{5} g_j \sum_{i=1}^{N} r_a \lambda_{aj} \quad (4)$$

λ_{aj}—number of CERPP capacity directions, belonging to certain division criteria according to the degree levels of capacity; *j*—level of the criteria; *a*—directions of CERPP capacity; *i*—CERPP levels of regulation ($i = 1 \ldots 5$).

Thus, the higher the DLC CERPP, the higher the degree level of capacity of CERPP at a certain level of regulation. Moreover, based on the analysis of a sample of 8 regions (the EU overall, Finland, Russia, China, Greece, France, the Netherlands and South Korea), it has been determined that for the policy package type "basic waste management" the level of capacity matches the interval [0.1–0.3]; for "integrated waste management"—(0.3–0.5]; for "3R"—(0.5–0.7]; for "CE"—(0.7–0.9] (Table 3). The characteristics of CERPP are mentioned according to the research [29]. The interval of CERPP is [0.1–0.9] because something on waste management has been done in every country, however, the 100% scenario is an ideal package and situation, which cannot be real. Therefore, we have left 90% as a maximum.

Table 3. The characteristics of CERPP.

CERPP	Characteristic of CERPP [29]	Interval of DLC CERPP
basic waste management	Basic provision for public service managing of wastes through landfilling or burning (no linkage between waste management and resource use)	[0.1–0.3]
integrated waste management	Collection and treatment of wastes, some limited usage of wastes (limited linkage between waste management and resource use)	(0.3–0.5]
3R (reduce, recover, recycle)	Implementation of the waste hierarchy (reduce, recover, recycle) in resource use and waste management (strong linkage between waste management and resource use)	(0.5–0.7]
CE	Reducing waste and pollution through design, maintaining materials in production and consumption cycles through reusing, recycling and recovering (complete integration of waste management and resource use)	(0.7–0.9]

Step 8. When analyzing the degree of capacity of CERPP, implemented within the framework of extensive territorial, legal, economic, social, and other types of spaces (I_{space}), the assessment of the DLC CERPP for such space is carried out employing the formula of arithmetic mean. However, it can be used in case of comparability of objects included in the analyzed space:

$$I_{space} = \left(\sum_{o=1}^{n} \text{DLC CERPP}_0\right)/n \quad (5)$$

where: *o*—objects/countries/regions, included in the analyzed space ($o = 1 \ldots n$); *n*—the number of objects/countries/regions.

3. Results

3.1. Case Studies: Comparison of the DLCs CERPP of Finland, EU and Russia at the National (Alliance/Union) Level

Step 1. According to the guidelines algorithm, at the first stage, we should identify a set of specific tools (X_{ai}) for each of the levels of regulation (I–V) in the main areas of

CERPP capacity. We have left all directions of CERPP capacity and one level of regulation as mentioned earlier, and the EU has been chosen as the closest to the gold standard.

Step 2. All directions of CERPP capacity have equal value (1/5).

Step 3. The classifier for the scoring the CERPP capacity tools is the same as demonstrated in Table 2.

Step 4. A scoring-based determination of the CERPP capacity tools in comparison with the virtual version of the most complete capacity is shown in Table 4.

Table 4. Scoring-based determination of the CERPP capacity tools for Finland, Russia and EU at the national (alliance/union) level.

Levels of Regulation (i)	Specific CERPP Capacity Tools (X_{ai})				
	Legal Capacity Direction (X_1)	**Project Capacity Direction (X_2)**	**Organizational Capacity Direction (X_3)**	**Monetary and Fiscal Capacity Direction (X_4)**	**Educational Capacity Direction (X_5)**
national and alliance/union level (II)	X_{11}	X_{21}	X_{31}	X_{41}	X_{51}
Finland	4	6	5	4	7
EU	8	5	8	5	7
Russia	3	1	2	1	5

Note: X_{ai}—specific CERPP capacity tools at a-th direction on i-th level of regulation; directions of CERPP capacity (a = 1 . . . 5), i—levels of CERPP regulation (i = 1).

Some additional information (the basis for the experts' assessments) about the direction capacity for Finland, Russia and EU is attached below.

Finland

Legal capacity: After some project initiatives in 2009 a "Natural Resource Strategy for Finland: using natural resources intelligently" was published. It was concentrated on materials efficiency (2013), real estate and construction (2012) and bio economy (2014). At last, in 2016, "Leading the cycle: Finnish Road Map to a Circular Economy 2016–2025" was published. However, it is still does not have the waste hierarchy and the strong linkage between waste management and resource use.

Project capacity: The history of CE integration in the Finish policy started in 2005 with the relies of "Getting More and Better from Less" policy for sustainable consumption and production, which was updated in 2012. In the 2015, Strategic Program of Prime Minister Sipila's Government was launched; it concentrated on reducing nutrient loss, increasing recycling and prohibiting landfill of waste. National Waste Management Plan "Towards a recycling society" was presented in 2016, alongside a National Waste Management Plan and Waste Prevention Program 2016–2030 in 2017.

Organizational capacity: Circular Economy Steering Group was established as an advisory body for the period 2017–2019, consisting of different stakeholders. In 2019, an updated version of the Road Map featured additional measures, giving the Circular Economy Steering Group long term official status.

Monetary and fiscal capacity: Within the Action Plan for a Circular Economy (2017) there are three main types of instrument: public procurement; new products and service innovations; and platforms for CE experimentation. "A key instrument for innovation is reducing regulatory barriers to the CE through a 'one-stop-shop' for business licensing and 'voluntary contractual models' for materials and energy efficiency. Another instrument listed is public procurement, with new financial instruments for central and municipal governments (ibid.). The Action Plan also identifies promotion of new business models such as digitalisation and urban CE initiatives, along with a business network for CE support" [29].

Educational capacity: The Action Plan of 2017 also identifies educational instruments for CE skills creation and citizen information provision. The study of CE is integrated into a holistic system covering all groups of the population, regardless of age and social status.

Since the adoption of the SDGs, a huge number of educational programs dedicated to the specifics of running CE have appeared in Finland. CE is taught here in universities, schools, and is actively being introduced into the corporate culture of Finnish companies. A study by The Finnish Innovation Fund Sitra shows that a CE could boost Finland's economy by EUR 3 billion by 2030 [44].

European Union

Legal capacity: The end of the 2019 is marked with the adoption of a new strategy, called European Green Deal. The main ideas of it are: (1) within the economic dimension, to "build more competitive Europe in co-creation with economic actors, consumers, citizens and civil society organizations"; within the environmental dimension, to "build a cleaner and climate-neutral Europe in co-creation with economic actors, consumers, citizens and civil society organizations"; and within the social dimension, to "build a fair and prosperous society" [32]. Special attention is paid to the management of mineral resources because the new strategy refers to the economic growth, that is decoupled from resource usage.

Based on the literature [42] there are main regulatory documents which indicate the key CE directions in operating raw materials (RM) and industrial and municipal wastes and for EU (Table 5).

Table 5. EU's main regulatory documents in circular economy (CE) of raw materials (RM).

Regulatory Documents	Comments
Directive 2018/849	amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment
Directive 2018/850	amending Directive 1999/31/EC on the landfill of waste
Directive 2018/851	amending Directive 2008/98/EC on waste
Directive 2018/852	amending Directive 94/62/EC on packaging and packaging waste
Directive 2019/883 of 17 April 2019	on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC
Directive 2019/904 of 5 June 2019	on the reduction of the impact of certain plastic products on the environment
Directive 2019/771 of 20 May 2019	on certain aspects concerning contracts for the sale of goods, amending Regulation 2017/2394 and Directive 2009/22/EC, and repealing Directive 1999/44/EC
Regulation 2019/1009 of 5 June 2019	laying down rules on the making available on the market of EU fertilizing products and amending Regulations No 1069/2009 and No 1107/2009 and repealing Regulation No 2003/2003
Regulation 2019/424 of 15 March 2019	laying down ecodesign requirements for servers and data storage products pursuant to Directive 2009/125/EC of the European Parliament and of the Council and amending Commission Regulation No 617/2013

Table 5. *Cont.*

Regulatory Documents	Comments
Regulation (EU) 2019/1784 of 1 October 2019	laying down ecodesign requirements for welding equipment pursuant to Directive 2009/125/EC of the European Parliament and of the Council
Regulation (EU) 2019/2021	laying down ecodesign requirements for electronic displays pursuant to Directive 2009/125/EC, amending Regulation No 1275/2008 and repealing Regulation 642/2009
Regulation (EU) 2019/2023	laying down ecodesign requirements for household washing machines and household washer-dryers pursuant to Directive 2009/125/EC, amending Regulation (EC) No 1275/2008 and repealing Regulation (EU) No 1015/2010
Regulation 2019/2019	laying down ecodesign requirements for refrigerating appliances pursuant to Directive 2009/125/EC and repealing Regulation (EC) No 643/2009
Regulation 2019/2024	laying down ecodesign requirements for refrigerating appliances with a direct sales function pursuant to Directive 2009/125/EC
Regulation 2019/2022	laying down ecodesign requirements for household dishwashers pursuant to Directive 2009/125/EC amending Regulation (EC) No 1275/2008 and repealing Regulation No 1016/2010

In addition, EU states have implemented waste hierarchy principles through Community waste legislation, primarily the Waste Framework Directive (Directive 2008/98/EC).

Project capacity: Based on the research [32,42] there are main documents and projects which indicate the key CE directions in operating of the raw materials (RM) and industrial and municipal wastes and for EU (Table 6).

Table 6. EU's main documents and projects in CE of RM.

Documents and Projects	Comments
COM (communication) (2014) 398	Towards a circular economy: A zero waste program for Europe
COM (2015) 614	Closing the loop—An EU action plan for the Circular Economy
COM (2016) 773	Ecodesign Working Plan 2016–2019
COM (2017) 479	Investing in a smart, innovative and sustainable industry—A renewed EU Industrial Policy Strategy
COM (2017) 33	Final Report on the implementation of the Circular Economy Action Plan
COM (2018) 28	A European Strategy for Plastics in a Circular Economy
COM (2018) 29	On a monitoring framework for the circular economy

Table 6. *Cont.*

Documents and Projects	Comments
COM (2018) 32	Communication on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation
COM (2018) 35	Report on the impact of the use of oxo-degradable plastic, including oxo-degradable plastic carrier bags, on the environment
COM (2019) 22	Reflection Paper Towards a Sustainable Europe by 2030 COM (2019) 190 final Report on the implementation of the Circular Economy Action Plan
COM (2020) 98	A new Circular Economy Action Plan for a cleaner and more competitive Europe

In these communications, the European Commission (EC) clearly emphasizes the importance of sustainable RM management in the transformation process towards CE in Europe. The content of CE definitions also is linked to the RM, including mineral resources. In COM (2014) 398, the CE was defined as "system which keeps the added value in products for as long as possible and eliminates waste"; in COM (2015) 614 the CE was indicated as "economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized"; at last, in COM (2020) 98 it is defined as "a regenerative growth model that gives back to the planet more than it takes, advance towards keeping its resource consumption within planetary boundaries, and therefore strive to reduce its consumption footprint and double its circular material use rate in the coming decade".

Organizational capacity: There are no data about some special organizations for CE integration. However, to share best practices, strategies and knowledge to accelerate the transition to a circular economy, in 2017 the European Commission and the European Economic and Social Committee created a global platform that brings together corporations, governments and research organizations from different regions of the world.

Monetary and fiscal capacity: According to the report on the implementation of the Circular Economy Action Plan (2019) [45], made by the European Commission, The new regulation on the boosting the use of secondary raw materials was aimed to "substantially reduce significant market entry barriers for more sustainable and circular products; to include new limits on hazardous substances, including from virgin raw materials, lowering the risk of material cycles containing dangerous levels of certain toxic elements; to include end-of-waste criteria, thereby contributing to the smooth functioning of the interface between chemicals, products and waste legislation and giving investors more legal certainty" [45]. In addition, over the 2016–2020 period, the Commission has spent more than EUR 10 billion in public funding for the transition to CE. To stimulate further investments, the Circular Economy Finance Support Platform has been established. The platform will work with the European Investment Bank on providing financial assistance and exploiting synergies with the action plan on financing sustainable growth. The Commission's proposal for a new European Regional Development Fund and Cohesion Fund places the circular economy as a priority in EU's efforts to achieve a greener and smarter Europe and excludes investments in landfills and facilities for the treatment of residual waste.

Educational capacity: First of all, it should be mentioned that the EU's universities were the pioneers in the development of universities' sustainable development strategies [46]. There are many practices of how to teach CE [47]. For instance, in Sweden, researchers explore the educational practices' usage of serious games for teaching CE concepts in engineering degrees and, in particular the efficient use of critical materials [48]. In the

Netherlands, the CE concept is installed in the education process in schools and universities; moreover, with the employment of simulation and a problem-solving approach [49].

Russia

Legal capacity: Russia takes part in the SDG race and has prepared a number of laws and projects, such as the draft of the "Strategy for the long-term development of Russia with low greenhouse gas emissions until 2050", the Decree "On national goals and strategic objectives for the development of the Russian Federation for the period until 2024" and others. In 2020, the Voluntary National Review on the implementation of the SDGs until 2030 was presented. As far as the RM are concerned, two main laws exist: The Subsoil Law of the Russian Federation and the Law on Production and Consumption Waste of the Russian Federation. However, these still have many imperfections. The fundamental one, that stopped the process of transferring to CE in RM, is the need to allocate the legal status of the human-made mineral deposits (artificial deposits) with the certain mode of their use in the Subsoil Law of the Russian Federation. It would help to eliminate their equalization with natural mineral deposits (due to the specific conditions of occurrence, composition, properties of artificial deposits and, accordingly, processing technologies) and would simplify the procedure for artificial deposits' involvement in the economic activity. At the same time, artificial deposits should be removed from the regulation of the Law on Production and Consumption Waste of the Russian Federation.

Project capacity: There are limited state programs in CE's development and projects. The lack of effective incentive programs for enterprises that support the technologies of a closed production cycle is observed. However, in the past, the Sverdlovsk Region of Russia has already had a positive experience of interaction between the state and business in solving the problem of waste processing. In 1996, the regional government approved the federal program "Processing of the artificial deposits in the Sverdlovsk region", and at the end of the same year formed and approved the regional program with the same name. In order to coordinate the work under the program, a Coordinating and Authorized Body was created—LLC Ural Institute of Metals. During the program realization, new and advanced waste processing facilities were developed. It processed 20.1 million tons of waste from the mining and metallurgical complex; 35 thousand tons of copper and copper concentrate; 2 thousand tons of zinc; about 1 million tons of metallic iron and magnetic product; 7 thousand tons of ferrochrome; 7.5 million tons of building materials; and 81.0 thousand tons of asbestos were produced. Unfortunately, due to changes in the federal budget and tax legislation in early 2000, the program was curtailed due to the elimination of funding, although the results of its implementation turned out to be very positive: new technologies were developed; the volume of waste recycling almost doubled; state support was provided to a number of enterprises.

Organizational capacity: Russia has no specific organization responsible for the transition to CE.

Monetary and fiscal capacity: Russia has no specific funds or financial programs for the transition to CE [50]. Although, some of them maintained the ecological projects and innovations.

Educational capacity: There is a lack of a holistic educational system covering all groups of the population, regardless of age and social status. The first was the universities, that developed some CE's disciplines. However, the practices are quite fragmented. Schools and colleges are in the initial stage of introducing CE skills in educational programs. The consequence is the lack of corporate culture of enterprises aimed at the development of CE.

Step 5. Mapping the degree of capacity of CERPP for Finland, Russia and EU (Tables 7–9).

Table 7. Finland's map of the degree of capacity of CERPP at the national level.

CERPP Capacity Tools	The Criterion for Division (j)				
	Low (j = 5)	Below Average (j = 4)	Average (j = 3)	Above Average (j = 2)	High (j = 1)
X_1		1			
X_2			1		
X_3			1		
X_4		1			
X_5				1	

Table 8. EU's map of the degree of capacity of CERPP at the union level.

CERPP Capacity Tools	The Criterion for Division (j)				
	Low (j = 5)	Below Average (j = 4)	Average (j = 3)	Above Average (j = 2)	High (j = 1)
X_1				1	
X_2			1		
X_3				1	
X_4			1		
X_5				1	

Table 9. Russia's map of the degree of capacity of CERPP at the national level.

CERPP Capacity Tools	The Criterion for Division (j)				
	Low (j = 5)	Below Average (j = 4)	Average (j = 3)	Above Average (j = 2)	High (j = 1)
X_1		1			
X_2	1				
X_3	1				
X_4	1				
X_5			1		

Steps 6–7. Determining the weight of the division criteria and the assessment of the DLCs CERPP.

Therefore, the results are:

1. For Finland DLC CERPP $= \left(0.1 \times \frac{0}{5} + 0.3 \times \frac{2}{5} + 0.5 \times \frac{2}{5} + 0.7 \times \frac{1}{5} + 0.9 \times \frac{0}{5}\right) = 0.46$;
2. For EU DLC CERPP $= \left(0.1 \times \frac{0}{5} + 0.3 \times \frac{0}{5} + 0.5 \times \frac{2}{5} + 0.7 \times \frac{3}{5} + 0.9 \times \frac{0}{5}\right) = 0.62$;
3. For Russia DLC CERRP $= \left(0.1 \times \frac{3}{5} + 0.3 \times \frac{1}{5} + 0.5 \times \frac{1}{5} + 0.7 \times \frac{0}{5} + 0.9 \times \frac{0}{5}\right) = 0.22$.

The obtained numbers mean that the level of CERPP compliance with the virtual version of the most complete capacity is as follows:

- For Finland it is equal to 46 %, which is indicative of the "integrated waste management" type of CERPP;
- For the EU it is 62% (3R type of CERPP);
- For Russia it is 22% (basic waste management).

3.2. Case Studies: Comparison of the DLCs CERPP of the All Sample, which Consists of 8 Regions (the EU in Total, Finland, Russia, China, Greece, France, The Netherlands and South Korea)

All results for the analyzed sample are demonstrated in Table 10. It reflects the current state of the development of CE policies in each country and in the EU as a whole.

Table 10. The assessment of the samples' DCLs CERPP at the national (including alliance/union level).

Country/Union	DCL CERPP, %	Type of CERPP
EU in total	62	3R
Finland	46	integrated waste management
Russia	22	basic waste management
China	57	3R
Greece	51	3R
France	40	integrated waste management
the Netherlands	44	integrated waste management
South Korea	59	3R

4. Discussion

The obtained calculation in Table 8 demonstrates that no one from the analyzed regions can achieve the CERPP "circular economy", which is characterized by reducing waste and pollution through design, as well as maintaining materials in production and consumption cycles through reusing, recycling and recovering (complete integration of waste management and resource use). The closest areas to achieving a CE are the European union, South Korea, China and Greece with a type of CERPP called 3R (Table 3). In spite of the innovative policy in CE, Finland has a worse result than the EU because it still does not have the waste hierarchy (reduce, recover, recycle) [29]. For the same reason, France and the Netherlands have the type of CERPP "integrated waste management". Russia closes the list with the type of CERPP "basic waste management".

Nowadays studies include different discourses except the holistic one, which mixes both approaches—contextual and operating (contextual approach utilizes the thorough examination of the CE theory, stricture of the policy, etc.; the operating one uses any kind of statistical data)—to assess the capacity of circular economy regulatory policy packages in operating raw materials and industrial wastes. This paper demonstrates new guidelines for assessing the degree level of capacity of circular economy regulatory policy packages in operating raw materials and industrial wastes. It presents a deep analysis for three regions such as Finland as one of the leaders of the integration of CE policy due to many articles and statistical data; the whole EU—as the closest to the gold standard [32] and an active initiator in the policy transformation [42]; and Russia as a big industrial country. The CE policies of the remaining countries—China, Greece, France, the Netherlands and South Korea—are carefully described in the research [29] and other sources [14–16,32–35,42]. Thus, this study presents the calculated results of the degree levels of capacity of circular economy regulatory policy packages in the operation of raw materials and industrial wastes for the rest of the countries of the sample.

Interestingly, by combining studies about circular economy regulatory policy packages [19,29,30,40–42], the authors of this paper can identify the link between the CERPP the policy package type and the level of capacity. Therefore, for the "basic waste management" the level of capacity matches the interval [0.1–0.3]; for "integrated waste management"—(0.3–0.5]; for "3R"—(0.5–0.7]; for "CE"—(0.7–0.9]. The characteristics of CERPP are mentioned according to the research [29] and could help to monitor the dynamics of the transformation to CE at all levels of regulation for any region.

To the knowledge of the authors, the evaluation data of the CE policy in Table 10 are the first of their kind. However, the paper has one limitation: the calculation can vary a bit based on the experts' knowledge about the CE policy at the certain region. Therefore, to get the proper results, the expert panel should be identified properly. Moreover, the bigger the quantity of the specialized experts would be, the better (more accurate) the results that could be obtained.

5. Conclusions and Future Perspectives

This paper achieves its aim, which is to assess and compare different DLCs of CERPP in the operation of raw materials (RM) and industrial wastes by utilizing the apparatus of the fuzzy set theory, on the basis of the new authors' guidelines for assessing DLC CERPP. The main contribution of this research is the authors' guidelines that have been created via the synthesis of both approaches to assess the DLC CERPP: contextual and operating (contextual approach utilizes the thorough examination of the CE theory, stricture of the policy, etc.; the operating one uses any kind of statistical data). These guidelines could serve as a complex monitoring tool for the dynamics of transformation to CE at all levels of regulation.

The resulting numbers show that the transformation path to the achievement of CE and SDGs appears to be a difficult one for some countries (Russia), while Europe and a couple of Eastern countries have achieved a lot. Therefore, there is a long way to go for the whole world to reach the desired state of wellbeing according to the sustainable development paradigm. However, if we want to save our planet, the achievement of the CE is necessary for all humanity.

Future work is planned to develop a dynamic digital map of the evaluated degree levels of capacity of circular economy regulatory policy packages for countries located in Europe and Asia.

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