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Circular Economy: a review

Economia Circular: uma revisão

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ABSTRACT: Global stability is at risk due to the present extreme climatic events, social problems, and profound crisis on economic pillars. Aiming to promote well-being and justice, the academia proposes diverse actions and alternatives which can mitigate present and future problems. One of this alternatives is the substitution of the current linear economic model for a circular one, exchanging the loss of resources for the maximum exploitation of them. To absorb and conduct a better perception about this new concept, this paper proposes a brief literature review which can serve as a base for future studies, and that way help in the comprehension and better absorption of the opportunities circular economy can propose. In the same way this article shows the obstacles and challenges for the implementation of the concept, as well as solutions for future problems.

Key-words: Circular Economy. Sustainable Development. Strategic Management of Resources

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RESUMO: A estabilidade global encontra-se em risco devido aos eventos climáticos extremos, problemas sociais e profundas crises nos pilares econômicos. Com objetivo de promover o bem-estar e a justiça, a academia propõe diversas ações e alternativas que podem mitigar estes problemas atuais e futuro. Uma das alternativas proposta é a substituição do modelo linear econômico, pelo modelo de economia circular, substituindo o desperdício de recursos pelo máximo aproveitamento do mesmo. Para absorver e conduzir uma melhor percepção sobre esse novo conceito, esse trabalho se propôs a realizar uma breve revisão de literatura para que possa servir de base para futuros estudos, e assim auxiliar na compreensão e melhor absorção das oportunidades que a economia circular pode ocasionar. Do mesmo modo este trabalho propõe os obstáculos e desafios na sua implementação, bem como soluções para esses futuros problemas.

Palavras-chave: Economia Circular. Desenvolvimento Sustentável. Gerenciamento Estratégico de Recursos

1 INTRODUCTION

Present trends on population increase, growth in the search and consequent pressure on natural resources have as an outcome modern society needs to advance to a more sustainable paradigm, a greener economy which assures economic development, better quality of life and employment, as well as the regeneration of the environment.

The current linear productive process is unsustainable, being necessary to create new patterns to answer economic management challenges, especially at countries in development. In this sense, the concept of development has been setting new production models, aiming to reduce environmental degradation and problems of social and economic order. The main issues of the linear model are the great accumulation of waste and the excessive exploitation of resources.

Circular Economy comes as a solution to rethink the productive chain, where materials which have already been used would be reprocessed and reintegrated back into the chain, as the same component or as a new one. This theme has been ascending inside papers connected to sustainable development, this article intends to elucidate the questions surrounding Circular Economy, proposing a solid concept formed by different visions found in literature, analyzing the obstacles and efforts to be made for the success of the subject.

The choice for Circular Economy is linked to the objective of the literature review which has been conducted by this paper. The literature review must elucidate the theme, provide a better definition of the research problem and contribute to the analysis and discussion of the research's results.

2 WHAT IS CIRCULAR ECONOMY?

According to the World Economic Forum[6],

> "a circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models."

Some of the characteristics of a circular economy are, that it is an economic model where the value of the resources is fully utilized causing the pressure on natural resources to reduce, where recycle of wastes and product design are made for reuse in order to reduce the negative consequences related to waste generation[7,8].

The Ellen Mac Arthur Foundation[9], an important reference inside the debate of this theme, defines de principles of the circular economy as: design out waste, build resilience through diversity, rely on energy from renewable sources, think in systems, waste is food and the use of eco-effectiveness methods.

As the article follows, the concept and principles of circular economy will be deeply discussed in more specific ways.

2.1 SCHOOLS OF THOUGHT

These schools of thought help us to understand the principles and functioning of the circular economy. They concern production and construction processes focusing on resource efficiency and sustainability. The following schools will be explained and were chosen based mainly on a specific report by the Ellen Mac Arthur Foundation[10].

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6 FORUM, economic forum. **Towards the Circular Economy:** Accelerating the scale-up across global supply chains. Geneva: World Economic Forum, 2014, p. 15. Available at: <http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf>. Access: 20 august. 2018.

7 GREEN, State Of. **Circular Economy:** Denmark as a circular economy solution hub. Copenhagen: Nordic Ecolabel, 2016.

8 MINISTERS, Nordic Council Of. **Moving towards a circular economy:** Successful Nordic business models. Copenhagen: Nordic Council Of Ministers, 2015.

9 FOUNDATION, Ellen Macarthur. **Towards the circular economy:** economic and business rationale for an accelerated transition. Cowes: Ellen Macarthur Foundation, 2013, p.98.

10 FOUNDATION, Ellen Macarthur. **The circular model:** Brief history and schools of thought. Vancouver: Environment And School Initiatives, 2015, p.4.

The Regenerative Design school of thought, by John T. Lyle, emerged in 1996 mainly in the U.S.[11,12,13]. As mentioned in Table 1, this school makes possible for all systems to be managed in a regenerative manner, thinking beyond agriculture, differentiating from the long time trend of confining regeneration to agriculture, and also addressing the matter of sources[14].

Walter Stahel in 1984[15], developed the Performance Economy, which was the idea of an economy in loops that had impact over jobs, competitiveness, resources and waste. The four main goals of the Performance Economy are exposed in Table 1.

Cradle to Cradle, mainly developed by Michael Braungart and Bill McDonough in 2002[16], is besides a school of thought, a product certification process which is market-proven[17]. According to Table 1, which shows the three main objectives of Cradle to Cradle, that are waste equals food, which stands for the design of products which can be reused through biological and technical metabolisms as well as, for systems that collect and recover the value of the mentioned products right after they've been used; use current solar income, which stands for the maximization of the use of renewable energies in general, but mainly solar; and finally, celebrate diversity, which stands for the management of resources to maximize quality, healthy ecosystems, respect for local constraints and social responsibility.

Industrial Ecology, by Roland Clift emerged around the 2000's[18]. According to Table 1, this school focuses on resource flows, such as energy and materials, through industrial systems, and by that generating a closed-loop process, where waste is input and not an undesirable by-product as is commonly viewed. Another aim of Industrial Ecology is to make designing and production processes to respect the local ecological constraints and resources and paying attention to impacts.

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11 STUDIES, Lyle Center For Regenerative. **History of the Lyle Center.** 2014. Available at: <http://env.cpp.edu/rs/history-lyle-center>. Access: 07 august 2017.

12 FOUNDATION, Ellen Macarthur. **Schools of Thought.** 2017. Available at: <https://www.ellenmacarthurfoundation.org/circular-economy/schools-of-thought/regenerative-design>. Access: 07 august 2017.

13 KOPNINA, Helen; BLEWITT, John. **Sustainable business: Key issues**. Routledge, 2014.

14 FOUNDATION, 2013.

15 KOPNINA; BLEWIT, 2014.

16 Ibid.

17 INSTITUTE, Cradle To Cradle Products Innovation. **Home.** Available at: <http://www.c2ccertified.org/>. Access: 07 august 2017.

18 ECOLOGY, International Society For Industrial. **History.** 2017. Available at: <https://is4ie.org/about/history>. Access: 07 august 2017.

Janine Benyus, is the woman who developed the school called Biomimicry, by the year 1997[19]. Biomimicry, stands on three main principles, as exposed in Table 1: nature as a model, nature as a mentor and nature as a measure. Being, nature as a model: to emulate nature's forms, processes, systems and strategies on problem solving; nature as a mentor: to use an ecological standard for innovations; and, nature as a measure: to look at what we can learn from nature instead of what we can extract from it.

Finally, Blue Economy, by Gunter Pauli, school that emerged in 1998[20]. Some of the objectives of Blue Economy are exposed on Table 1, the full report concerning this school has 21 founding principles, innovating ideas for job creation and collaborative projects.

Table 1 – Circular Economy Schools of Thought

School	Authors	Main Idea
Regenerative Design	John T. Lyle	All systems could be orchestrated in a regenerative manner, meaning that process themselves renew or regenerate the sources of energy and materials that they consume.
Performance Economy	Walter Stahel	Product-life extension, long-life goods, re-conditioning activities, and waste prevention.
Cradle to Cradle	Michael Braungart and Bill McDonough	Waste equals food, use current solar income, and celebrate diversity.
Industrial Ecology	Roland Clift	Study of material and energy flows through industrial systems, create closed-loop process where waste is input, production in accordance with local ecological constraints and resources.
Biomimicry	Janine Benyus	Nature as a model, nature as a mentor and nature as a measure
Blue Economy	Gunter Pauli	Use of one product waste to create a new one, solutions according to the local environmental constraints and resources, as well as promoting a hands-on focus.

Source: Elaborated by the authors, 2018.

19 KOPNINA; BLEWITT, 2014.

20 Ibid.

3 PRODUCTION PROCESS AND THE ROLE OF CONSUMERS

An extremely important feature of circular economy would be commerce, which implies on production and buying processes, as well as the role of the consumers. In a circular economy the production process of an efficient product, starts by the design. Some key characteristics of the circular design are: use materials that can be reused to maintain the highest value, products that can be used for as long as possible so that its parts can have a great value, diversify the use of components when they are no longer useful in their initial function in order to keep the resources within the economy and increase further value, use inputs that facilitate recycling, innovation instead of solutions at the end of life of the product[21,22,23].

According to the Nordic Council Ministers[24], there was general consensus that the

> "producers should improve on circularity by designing products for long life including design for reuse and repair; a certification scheme for reused and repaired products would improve markets for these types of products, and that improved communication and transparency via best-practice presentations, mentor schemes and increased dialogue would help generating the general knowledge- and information flow, which is needed."

As for the role of the consumers in the circular economy it is through their market power that they can choose products and services which are better for the environment and that will provide monetary savings and increased quality of life, as well as supporting innovation in technology and business solutions[25]. As for companies engaging on the selling process of circular products, they should focus on consumption patterns to create the demand for their products[26].

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21 FOUNDATION, 2013.

22 COMMISSION, European. **Towards a circular economy:** A zero waste programme for Europe. Brussels: European Commission, 2014.

23 GREEN, 2016.

24 NORDIC Council Ministers, 2015, p. 5.

25 COMMISSION, European. **CIRCULAR ECONOMY:** Closing the loop Helping consumers choose sustainable Products and Services. Brussels: European Commission, 2017.

26 GREEN, 2016.

4 TRANSITION TO A CIRCULAR ECONOMY

The European Commission[27] lists some benefits of the adoption of the circular economy model, which are: new business opportunities as the demand for products and services that are supportive of circular principles increases, many growth opportunities for cost-effective and innovative solutions in companies, and more and new jobs in the areas of design, reuse, and repair.

In public institutions and management, circular economy also offers many benefits such as: the use of green public procurement, which accompanies financial saving provisions, economic stimulus, durability of purchase, resource efficiency and recyclable products[28].

4.1 LINEAR ECONOMY

Linear economy refers to the concept that has been applied worldwide lately, meaning that raw materials are collected and added value to make products, which are used and - after the use - become waste and are thrown away[29,30], as represented on Figure 1.

Figure 1: Linear economy production system.

Source: Elaborated by the authors, based on Government of the Netherlands, 2017.

As exposed in Figure 1, linear economy refers to a linear process involving the extraction, production, consumption and waste generation, with little or no attention to environmental impacts and pollution generated[31]. In this regard, linear economy is based in the "production and consumption of

27 COMMISSION, 2017.

28 COMMISSION, 2017.

29 NETHERLANDS, Government Of. **From a linear to a circular economy.** 2017. Available at: <https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy>. Access: 18 august 2017.

30 STAHEL, Walter R. Circular economy: a new relationship with our goods and materials would save resources and energy and create local jobs. **Nature**, v. 531, n. 7595, p. 435-439, 2016.

31 SAUVÉ, Sébastien; BERNARD, Sophie; SLOAN, Pamela. Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. **Environmental Development**, v. 17, p. 48-56, 2016.

goods that (partially) ignore environmental externalities linked to virgin resource extraction and the generation of waste and pollution"[32].

Companies in a linear economy make money by producing bigger and faster products, selling high volumes of cheap goods to a demanding and growing population[33] - as stated by Kenniskaarten[34], "because of population growth and increases in prosperity, the number of consumers with a higher degree of material consumption, will increase by three billion in 2030" - which is no longer a feasible production model for a planet with as much limited resources as Earth due to the uncertainty of materials availability[35,36].

The need of constant production that the linear economy generates a "more is better" unsustainable thought, referring to the excessive need of constant production to meet human needs that are increasingly demanding, which generates a scenario of endless resources extraction, endless unmet human needs and endless waste dump[37].

In this sense, linear economy needs to be entirely replaced with an alternative system in which products are designed and optimized for a cycle of disassembly and reuse[38,39,40].

4.2 TRANSITIONING

As a sustainable trial and a concept between linear and circular economy, emerges the reuse economy system. This system intends to recycle the used products to put them on the market one more time, characterizing the cycle exposed on Figure 2, which is one step closer to a linear economy become a sustainable circular economy.

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32 Ibidem, p.49.

33 STAHEL, 2016.

34 KENNISKAARTEN. **What are the disadvantages of the current linear economy?** 2017. Available at: <https://kenniskaarten.hetgroene-brein.nl/en/knowledge-map-circular-economy/ce-disadvantages-linear-economy/>. Access: 22 august 2017.

35 Ibid.

36 LACY, Peter et al. Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth. **Accenture,** Chicago, v. 1, n. 1, p.1-14, dez. 2014.

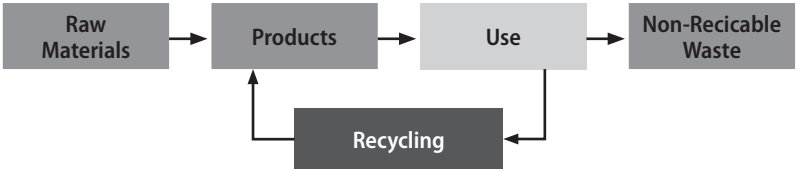
37 ECOMENA, **A Glance at Waste-Free Economy.** 2016. Available at: <http://www.ecomena.org/waste-free-economy/>. Access: 22 august 2017.

38 FORUM, World Economic. **From linear to circular:** Accelerating a proven concept. 2017. Available at: <http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/from-linear-to-circular-accelerating-a-proven-concept/>. Access: 21 august 2017.

39 ECOMENA, 2016.

40 KENNISKAARTEN, 2017.

Figure 2: Reuse economy system.

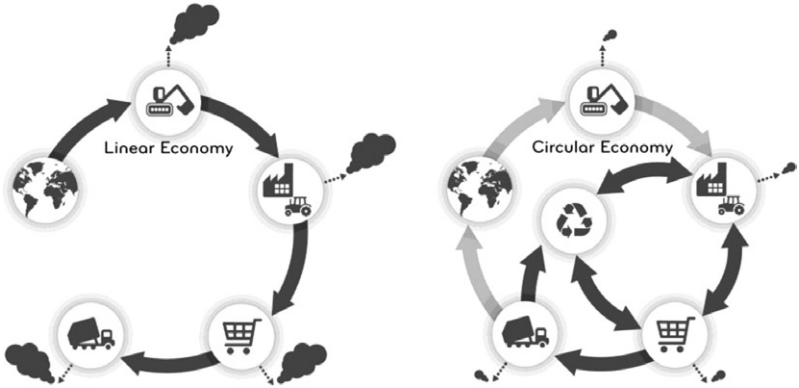


Source: Elaborated by the authors, based on Government of the Netherlands, 2017.

Making the full switch from linear to circular economy requires a change in production and use of resources, depending on the idea of making more with less and without accumulative toxics, recycling and reversing the global loss of ecological productivity[41]. The transition to a circular economy also depends on people, who must be willing to give up on unbridled consumption[42].

Circular economy replaces the end-of-life concept in linear economy with restoration, where waste does not exist and all products go through a policy of reuse, contrasting the linear cycle[43]. Figure 3 exemplifies the switch from linear to circular economy and its main environmental impacts.

Figure 3: Linear and circular economy



Source: Sauvé et al., 2016, p. 52.

41 ECOMENA, 2016.

42 Ibid.

43 FORUM, World Economic, 2017.

As expressed in Figure 3, the switch from linear to circular economy generates way less waste and pollutants in the whole process – production, transportation and use[44]. In this regard, the transition to a circular economy involves the development of sustainable practices that take into account the emissions of pollutants and waste to the environment, decreasing the use of primary virgin resources and investing in recycled sources for production; awareness raising of the consumer public; revaluation of the human needs that decreases the obsolescence of the products; and investments in public sustainable policies raised from the government.

Despite the advantages of transitioning to circular economy, there are still some barriers for the current linear economy system to become sustainable, as the disadvantages the enterprises face when trying to implement a circular model in a linear system; transitional investments, which can be expensive; the need of changing current labor regulations and agreements; the fact that many companies focus on a short-term perspective, which might not be as profitable in a circular as much as it is in a linear system; and the high price of recycled materials, which is not competitive with the price of virgin resources[45]. These barriers to a full circular economy accomplishment are addressed in the next topic.

4.3 OBSTACLES

Presently, the biggest challenge for the implementation of Circular Economy is the actual production process. An effective way to implement the concept would be to change how consumers choose products, how they are produce and mostly the way they are discarded[46].

Among the many challenges for the adoption of Circular Economy the ones which endure the most are generally related to the need for a deep change among the culture of companies, governments and also individuals in general. Such challenges present themselves even bigger to some products in particular (such as products which are produced by multiple suppliers,

44 SAUVÉ ET AL., 2016.

45 KENNISKAARTEN, 2017.

46 MANAGEMENT, Rwm – Resource And Waste; MANAGEMENT, Ciwm – Chartered Institution Of Waste. **Ever-decreasing circles:** Closing in on the circular economy. Birmingham: Rmw/ciwm, 2014.

or suppliers from various locations, and also products which suffer constant changes in its composition or characteristics)[47]. Another relevant point are the alternatives which have been discussed for leasing models of products instead of sale, which broad adoption depends on deep changes in our consumption culture[48].

An issue which is not approached broadly by Circular Economy is the social dimension. The concept focus mostly on the environment and balanced production processes, even though that benefits society, it is necessary to include social aspects if the concept is to be treated constantly in the sustainable development debate. Therefore, Circular Economy does not bring much clarity on to how equity and opportunities will be achieved more easily, a problem that has grown constantly in the modern world[49].

4.4 EFFORTS BEING MADE

Presently China is the country that has developed the most on the concept of Circular Economy and has put it in practice, that way having as a result an increase in domestic growth in a large scale[50]. The country defines Circular Economy "in legislation as a generic term for reduction, reuse and recycling activities in production, circulation and also consumption of products"[51].

The country, also has many regulatory measures focused on conservation and the use of the environment, as well as for the implementation of Circular Economy through the use of two governmental agencies: the Ministry of Environmental Protection and the National Commission for Reform and Development[52]. Besides that, a series of laws and policies related to Circular Economy were introduced over the last decade: Law for Promotion of Cleaner Production from 2003[53].

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47 COMMONS, House Of. **Growing a circular economy:** Ending the throwaway society. London: House Of Commons/ Environmental Audit Committee, 2014.

48 MANAGEMENT, 2014.

49 MURRAY, Alan; SKENE, Keith; HAYNES, Kathryn. The circular economy: An interdisciplinary exploration of the concept and application in a global context. **Journal of Business Ethics**, v. 140, n. 3, p. 369-380, 2017.

50 HESHMATI, Almas. A Review of the Circular Economy and its Implementation. **Browser Download This Paper**, 2016.

51 PRESTON, Felix. **A Global Redesign?: Shaping the Circular Economy**. London: Chatham House, 2012, p.3.

52 REN, Yong. The circular economy in China. **Journal Mater Cycles Waste Management,** Tokyo, v. 9, n. 1, p.121-129, out. 2007.

53 CHINA, The National People's Congress Of The People's Republic Of. **Law of the People's Republic of China on Promotion of Cleaner Production.** 2002. Available at: <http://www.npc.gov.cn/englishnpc/Law/2007-12/06/content_1382101.htm>. Access: 10 august 2017, p.1.

> This Law is enacted for the purpose of promoting cleaner production, increasing the utilization ratio of resources, reducing and preventing pollutant-generating, protecting and improving the environment, protecting human health, and promoting the sustainable development of the economy and society.

Law for the Prevention of Pollution and Solid Waste from 2005[54]

> This Law is enacted for the purpose of preventing and controlling environmental pollution by solid waste, ensuring human health, maintaining ecological safety and promoting the sustainable development of the economy and society.

and the Law for the Promotion of Circular Economy from 2009[55]

> This Law is formulated for the purpose of promoting the development of the circular economy, improving the resource utilization efficiency, protecting and improving the environment and realizing sustainable development.

Other countries taking action on Circular Economy are those in the European Union, which has agreed on some strategies to optimize resource use in the scope of the Europe Strategy 2020. EU has also started initiatives approaching base materials safety. Some relevant strategies taken by countries in the organization include the National Program of Resource Efficiency in Germany and the material roundabout in the Netherlands (a hub for materials and products recycling). In the United Kingdom, a series of studies about Circular Economy has been produced, focusing on economic instruments and raw materials safety, these studies have been produce by the environmental think tank of the country and the Green Alliance[56].

5 CONCLUSION

Circular Economy is a concept based on nature's intelligence, starting from the idea of decomposing organic waste which end up becoming fertilizer. It comes as a counterpart to the present production process which is linear to

54 CHINA, The National People's Congress Of The People's Republic Of. **Law of the People's Republic of China on Prevention and Control of Environmental Pollution by Solid Waste.** 2005. Available at: <http://www.npc.gov.cn/englishnpc/Law/2007-12/12/content_1383723.htm>. Access: 10 august 2017, p.1.

55 CHINA, National People's Congress Of The People's Republic Of. **Circular Economy Promotion Law of the People's Republic of China.** 2009. Available at: <http://www.lawinfochina.com/display.aspx?id=7025&lib=law>. Access: 10 august 2017.

56 PRESTON, 2012.

the circular process, where waste is input for the production of new products. It follows a rational use of resources. With the cascading use of materials, resources remain the biggest period of time possible in the economy, without being discarded. When a product reaches the end of its cycle with the first consumer, it can be shared and have its utilization expanded. After the reuse of the product is exhausted, it can be a material for upcycling, reforms, remanufacturing and, as a final step, recycling. Present recycling alternatives operate over consuming goods which have not being projected with this type of care.

Circular Economy is presented as a catalyst for competitiveness and innovation, being understood as a supplier for short term benefits and long term strategic opportunities in face of challenges such as: reducing the volatility of prices on raw materials and the limitation of supplying risks, promote new relations with the costumer, new business models, improve competitiveness in the economy, and contribute for the conservation of the natural capital, emissions and waste reduction, and also combat to climate change.

These benefits provide some opportunities for future studies. This paper suggests for new articles to approach circular economy on the scope of urban agriculture, developing countries and the Sustainable Development Goals by the United Nations.

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