Thirty years since the circular economy concept emerged: has it reached a consensus

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Working paper

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I. INTRODUCTION

The economy system is mainly based on extracting raw materials to be used as inputs that altogether with technology and labor will be transformed into final products that later will be sold to consumers. These products would be used through their life cycle, and will be replaced as soon as the object has accomplished its duty or a new product shows up in the market with better features, and replace the obsoletes ones. The obsolete products are thrown into landfills, or are incinerated which damages the environment not just by polluting, but by making firms require new raw materials to produce new goods (Andersen Mikael 2006). In addition, through all this cycle, some other facts are to be considered, such as the emission of pollutants when the production activities take place and when the final goods are used; such as CO2 emissions produced by cars. All of this is leading to different problems such the depletion of primary resources that causes economic and social problem, and the constant emission of pollutants is crucially affecting the environment. It is more than fifty years since the first warnings were given about the impacts that the current pollution caused by human activities (Carson 1962) and that the linear economy of extracting, transforming, consuming and disposing would have over all aspects of society (Boulding 1966). Throughout this period, different alternatives have been proposed to cope with this situation, such as environmental economics, blue economy or industrial ecology (D'Amato et al. 2017). Furthermore, there is also the "Circular Economy" (CE) concept that based on the previous and other environmental concepts promises to reach environmental goals without harming economic growth or even obtaining greater economic performances (Merli, Preziosi, and Acampora 2018), and is increasingly taking the attention of scientists, firms and politicians. The main idea behind CE is to transform the linear economy, into a loop where the waste produced by a process would become the input of another one, minimizing at its maximum the discarded materials and the pollution (Yuan, Bi, and Moriguichi 2006), but there is not a current agreement about what is CE in terms of it's the influence that previous disciplines have had over it, its principles, and its definition as it has been studied in different ways by the academia, by the private sector and by social planners (Homrich et al. 2018; Kirchherr, Reike, and Hekkert 2017; Masi, Day, and Godsell 2017).

The objective of this review is to condensate first what has been mentioned about the CE in terms of its history, what are the concepts that have been utilized to construct the actual understanding of the CE, its principles and finally its definition, in order to identify main antecedents, core principles and propose a new definition, with the goal to try to reach a consensus about CE. First, a background of what were the ideas, concepts or other terms that brought about the idea of circular economy is presented which will give a better understanding of what has been used to build the actual idea behind the CE. Then, an analysis of the principles used by different actors and a proposition of core ones is done, to finally review some definitions and propose a new one.

II. The rise of the Circular economy term

1- Origin of the term «Circular economy»

According to the literature, the notion of CE has been traced to the ideas provided by (Boulding 1966) who in his work of "The economics for the coming Spaceship Earth" was the first to suggest the idea of a "cyclical ecological system which is capable of continuous reproduction of materials" (Ellen Macarthur Foundation 2013; Winans, Kendall, and Deng 2017). He stated that earth has finite reservoirs of resources and pollution cannot be totally absorbed by nature, so we should take actions to prevent the scarcity of raw materials, and abate environmental pollution, facts that might cause bigger problems to society in the future. In the Club of Rome report, the limits to growth (Stager and Muller 1972), they talk about that at the current growth rate, the world will face problems to meet humanity needs as resources will get scarce and the environment will not be sufficient enough to absorb all the pollution produced, so they present the idea of a "growth equilibrium state" where pollution is decreased and materials are recycled more often which will decrease its depletion rate. (Stahel, W.R. and Reday 1976) stated in his report "The Potential for Substituting Manpower for Energy" the idea of an economy in loops that can increase the efficiency in use of resources and can prevent the production of waste. Some years later, he introduced the idea of selling the usage of products, and the increase of the productive life of goods as a way to have sustainable revenues and diminish the final waste produced by consuming products. The term CE was first mentioned by Pearce and turner 1990 in his work "Economics of Natural Resources and Environment" where it was stated that the current economy system is threatening the environment by converting it in a waste reservoir as producing activities are continuously producing waste and pollution, so the system should be transformed into a circular one by considering waste as a source for more resources (Geissdoerfer et al. 2017; Ghisellini, Cialani, and Ulgiati 2016; Su et al. 2013). In this way, the CE was born as a solution that will help to reduce resources tensions and reduce detrimental effects over the environment. But its actual understanding is more complex as it has been influenced by many other disciplines, concepts and many thoughts from different private and public stakeholders (Wautelet and Impakt 2018).

2- Concepts and disciplines that have been used as base for the construction of the CE idea

The actual understanding of CE has been founded in a broad of different ideas and concepts, which has make it difficult to reach a consensus over what really is a "Circular Economy" (Bocken, Olivetti, and Cullen 2017; Ellen Macarthur Foundation 2013). With this in mind (Homrich et al. 2018) has called the CE an umbrella concept which means that a concept is used to comprise the ideas of some others. The literature has identified many different concepts that have helped the construction of the actual idea of the CE. As (Yuan, Bi, and Moriguichi 2006) one of the first authors giving a review about CE says that CE in China has been founded over some concepts such as industrial economics, systems engineering, bionics, cleaner production and physics. (Andersen 2007; Su et al. 2013) has cited industrial ecology and industrial symbiosis as the disciplines founding the CE. These relationships are given mainly because the initial development of CE in China included mainly projects to increase resource efficiency in the industrial sector by creating eco-industrial parks. The Ellen Macarthur Foundation (EMF 2013) one of the greatest promoter of the CE in the private sector has identified seven concepts or disciplines that are been used to build the CE idea, industrial ecology, cradle-to-cradle, biomimicry, performance economy, blue economy, regenerative design and permaculture. Several other authors have reaffirmed the influence of industrial ecology and the schools of thought proposed by the EMF like (Ghisellini, Cialani, and Ulgiati 2016). Another concept that add up to create the idea of CE is natural capitalism (Ezzat 2016; Lewandowski 2016). More recently, other authors have been gathering other concepts that have been used to build up the concept of CE, such as (Masi, Day, and Godsell 2017) who gives an exhaustive list of disciplines and concepts as an antecedent for CE. T

his list includes cleaner production, system dynamics, system thinking, zero emission, industrial economy, ecological economics, environmental economics, and steady state economy. There are also some other concepts mentioned in the literature such as environmental science (Merli, Preziosi, and Acampora 2018), eco-industrial network (Winans, Kendall, and Deng 2017), bio-economy (D'Amato et al. 2017) and industrial ecosystems (Korhonen, Honkasalo, and Seppälä 2018). These last concepts are less mentioned by the literature, and they can be grouped into the group of concepts detailed by EMF. For example, eco-industrial networks and industrial ecosystems are concepts that fit the discipline of industrial ecology (Roberts 2004). (Wautelet and Impakt 2018) gives a review of the five main schools of thought that have influence the actual idea of CE, including Industrial Ecology, Cradle to Cradle, Performance Economy, Blue Economy and Biomimicry whit their contributions to circular economy. In this way, a list of the most influential concepts influencing the idea of the CE is provided in Table 1.

	Discipline	Definition	Reference
1	Industrial ecology	Studies how to create energy and materials flow in the production of goods and services imitating natural systems with the purpose of reducing its environmental footprint	(Erkman 1997; Lazarevic and Valve 2017; Valenzuela-venegas, Salgado, and Díaz-alvarado 2016)
2	Industrial symbiosis	The joint of two or more types of industries with the goal of a better use of resources during production	(Desrochers 2010; Neves and Leal 2010)
3	Industrial metabolism	Examines the flows of materials and energy between human activities and the environment	(Erkman 2001; Robert 1994)
4	Cleaner production	Promotes the idea of reducing waste and the production of pollution whit the objective of increasing economic performance	(Berkel and Willems 1997; Vieira and Amaral 2016)
5	Cradle-to-cradle	*"Products designed to regenerate the ecosystem as biological nutrients or to regenerate industries such as nutrients, components and materials in a 100% closed material loop."*	(Braungart, McDonough, and Bollinger 2007)
6	Biomimicry	*"Discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems"*	(Benyus 1997)
7	Performance economy	Selling services instead of products	(Stahel 2019)
8	Blue economy	*"Is where the best for health and the environment is cheapest and the necessities for life are free thanks to a local system of production and consumption that works with what you have"*	(Pauli 2016)

	Discipline	Definition	Reference
9	The sharing economy	*"a socio-economic system enabling an inter- mediated set of exchanges of goods and services between individuals and organizations which aim to increase efficiency and optimization of subutilized resources in society"*	(Hossain 2020; Muñoz and Cohen 2017)
10	Ecological economics	Is a discipline that from an holistic point of view tries to understand how all different human activities are interrelated with the natural environment	(Bergh 2001; Inge 2005)
11	Environmental economics	How the environment could be introduced into economic functions and propose policies in order to allow economic growth to continue while reducing environmental externalities	(Gendron 2014; Murray, Skene, and Haynes 2017)
12	Permaculture	Analyses ow humanity can decrease the use of energy and polluting activities by the use of environmental resources, and a better design of system following nature's examples	(Holmgren n.d.; Morel 2019)
13	Natural capitalism	Looks to reduce waste by closing the loop flow of materials, while shifting the product based economy to a service based one, and restoring natural capital that have been destroyed by human activities	(Homrich et al. 2018; L. H. Lovins and Lovins 2001)
14	System dynamics	System dynamics is an approach to understand and analyze a system's behavior over time.	(Hanim et al. 2018)
15	Regenerative design	Addresses actual environmental issues by analyzing a shift towards a cyclical flow of resources	(A. B. Lovins, Lovins, and Hawken 2017)

Table 1 : Ideas and concepts that have built up the CE idea (adapted from (Homrich et al. 2018))

(Lieder and Rashid 2016) in their review, they tried to group the different areas that are related to CE in six groups, Transformation of economic structures and business rationales, Regenerative design and critical materials Industrial ecology, Remanufacturing and closed-loop supply chains, Resource conservative manufacturing, and Governmental CE initiatives. But these groups are not really grouping the disciplines and concepts that have helped to construct the CE idea. Indeed, according to these authors, governmental CE initiatives talk about extended producer responsibility which is already integrated into the concept of cleaner production.

This many concepts share the idea of transforming the way how humans conceive the economy, in terms of producing consuming and throwing away to an economy where the environment is taken into account and in some extent how it also impacts human's health. It is possible to say that the main idea given by these concepts to the CE is that current economy should take into account the impact that their activities have over the environment, so a more efficient use of resources in production and consumption should be attaint by better design of production systems and products, and by new business models that take more into account the relationship with customers.

3- The influence of the different concepts to the CE idea

The CE is a theoretical concept that is still under theoretical construct and its final definition is still far from a complete agreement in the scientific community and in the grey literature (Homrich et al. 2018; Kalmykova, Sadagopan, and Rosado 2018; Merli, Preziosi, and Acampora 2018; Prieto-Sandoval, Jaca, and Ormazabal 2018; Wautelet and Impakt 2018). This situation is explained due to the several disciplines and other concepts that have been used by the academia and by practitioners to build up the concept of CE. The previous section describes the different concepts and disciplines that have been attributed to have influenced the idea of CE. This section will analyze how these concepts have influenced the actual idea of CE.

a/ Industrial Ecology – Industrial Metabolism – Industrial symbiosis – Cleaner production

Industrial ecology tries to build an industrial system that is conceive as an subsystem of the environment, whose interaction creates an interconnected system where materials and energy can flow with the objective to minimize the ecological impact of its activities (Lifset and Graedel 2015) altogether with a greater economic performance (Erkman 1997). Some principles that the industrial ecology should follow are described by (Erkman 2001). First in an industrial ecology, waste from one industry should be used by another one, products should be design in a way that they minimize their harmful effects, ensure equal or higher quality in all product's service while minimize the use of materials through all the cycle, and finally, reduce the use of fossil fuels. According to (Erkman 2001) industrial ecology integrates into its concept the use of industrial metabolism, which is seen as a concept that analyzes resource's cycle from its extraction process and how to reintegrate them into the environment at the end of their life cycle. Another concept integrated into the industrial ecology according to (Valenzuela-venegas, Salgado, and Díaz-alvarado 2016) is the industrial symbiosis, which has the objective to interconnect different industries in order to increase resource use efficiency in terms of materials, energy, or other synergies that would benefit industrial processes to reduce the impact over the environment and maintain or increase their economic performance. From an industrial symbiosis perspective, it is possible to create eco-industrial parks where the application of the preview detailed principles would be applied in a better way as geographical proximity would allow a better interchange of resources and reduce the energy used due to transportation. In addition, cleaner production is also a concept involved in the discipline of industrial ecology, as it is seen as a methodology to reach industrial ecology's objectives (Berkel and Willems 1997). Hence, industrial ecology integrates into its concept the field of industrial metabolism, industrial symbiosis and cleaner production, which altogether look to reduce detrimental effects over the environment through a new design paradigm of production activities and products that would reduce the use of resources, such as materials, energy and water and increase profitability (Saavedra et al. 2018). In this way the industrial ecology has influenced the CE idea by introducing the idea of waste as a resource for another product, think in systems, implementation of synergies among industries and integrate new design paradigms that would reduce the environmental burden of producing activities and products use.

b/ Cradle to cradle

The Cradle-to-cradle concept refers to transforming how industrial processes and goods are conceived, in a way that at the end of their life cycle, it would be possible to recover the materials used and use them either as biological nutrients to reinsert them into the environment or as a technical resources that can be used to produce new products, maintaining the resource statues of materials along all the producing cycle, leaving the cradle-to-grave approach to follow now a circular approach (McDonough and Braungart 2002). The main discussion within the cradle-to-cradle concept is the difference between eco-efficiency versus eco-effectiveness. The former looks to minimize emissions, decrease the use of resources use and reduce environmental impact, while the second seeks to change products and the materials associated in order to create a cycle where this resources can be reinserted into the production chain or into the environment as biological resources (Braungart, McDonough, and Bollinger 2007).

They argue also that in an eco-efficiency paradigm, recycling products that are not well designed to be recycled, will reduce the quality of materials, decreasing its value over time, while in an eco-effective paradigm, resources would maintain their value over each process and can be used constantly, so they point out the importance of designing products and processes accordingly to this perspective. Moreover, (McDonough and Braungart 2002) proposes some principles that the cradle-to-cradle has to follow; waste equal food which mean that any resource called before waste should be transformed in an input for a new resource, and create diversity means that industrial processes have to create different connections with different resources, different stakeholders and different cultures in order to create a more resilient system. In addition, to reach eco-effectiveness, they promote a reinvention in the relationship that products should have with consumers. This reinvention would involve changing the way how producers relate with ecological, social and economic systems, arguing that services are a good strategy to get this objective. Thus, the CE idea has taken from the cradle-to-cradle the fact that the production system has to redesign producing activities and how products are produced in order to make it easier to reuse the materials involved at the end of their life cycle either as technological resources or as biological nutrients, designing in this way the loops that resources should follow.

c/ Performance economy

The principal idea behind the performance economy a complete transformation of the paradigm of selling products to selling the service (performance) that a product provides (Stahel 2010). This might also be known as servitization or servicisation (Stahel and Clift 2016; Vandermerwe and Rada 1988). The main strategy in servitization is the product-service-system (Baines, Lightfoot, and Benedettini 2009). In the performance economy, producers keep the ownership of the product which internalizes the cost of waste and time (Stahel 2010). Indeed, if the producer keeps the ownership of the product, he would like to recover the materials used to produce the good in order to avoid buying new ones and reusing them in another producing process. Moreover, as the producer is the unique owner of the product, he would also like to increase as much as possible the lifetime of his goods in order to avoid new production costs, in this way he should design the product in a way that it would be easier to repair, refurbished, and also remanufacture. As the good at the end of its life cycle will return to the producer, who will be willing to reuse the different goods' components into the production cycle. Whit this in mind, it is possible to identify that the performance economy is integrating some of the cradle-to-cradle principles. Hence, in the performance economy, the objective is to manage the stock of resources and not its flow as it is done in an cradle-to-cradle where resources are changing from one producer to another (Stahel and Clift 2016). In the performance economy, there are different strategies for its implementation which includes the sharing economy. As the producer keeps the ownership of the products and consumers just pay for its use, sharing the use of a single good with many different consumers and maximizing its use becomes one of the strategies in the performance economy. For example, car, or washing machines sharing. But this strategy requires that consumers get engaged into the system, so they take the same or better care of products when they are being shared, otherwise it might have some undesirable consequences. For this reason, in a product service system an excellent relationship with the consumers is a key factor for its success (Mont 2001) In such a way, the performance economy has influence the CE in the idea of a complete change of the paradigm of selling products to selling services with the intention of increasing environmental performance and helping to reach sustainability. New business models are also one of the core additions that the performance economy has integrated into the CE. In fact, the performance economy demands for new ways of making businesses (selling services rather than goods), which has been integrated into the CE analysis made by some researchers (Brennan and Tennant 2013). Actually, according to (Kirchherr, Reike, and Hekkert 2017) 11% of the CE definitions reviewed by their paper, mention new business models.

d/ Blue economy

The blue economy theory, starts first from the idea that the actual economy that is called "Red Economy" is based on businesses that try to reduce costs by implementing, in most cases, an economy of scales and by substituting human labor by machines, which is a resource intense activity and very inefficient from an environmental point of view. In addition, the blue economy says that the emerging "Green Economy" who is based in the deployment of renewable technologies and materials, do not address the whole problem from a system point of view, as for example the production of biofuels needs the use of primary resources that would increase some tension over the use of the same resources for alimentary uses (Wautelet and Impakt 2018).

In this sense, the blue economy is defined as "the best for health and the environment is cheapest and the necessities for life are free thanks to a local system of production and consumption that works with what you have" (Pauli 2016). The blue economy tries to promote new business models and the application of innovative ideas in terms of how residual materials are used in order to reconcile human activity with the environment, and at the same time increase jobs and reduce production costs which will improve economic performance (Pauli 2020). This new business models should be inspired in how ecosystems work in terms on how every single resource is used to cover the ecosystem needs, and nothing is left as waste, applying in this way a cascade of resources that are used from one process to another. From this description the CE has been influenced by the blue economy in terms of that its concept involves the application of new business models (as in the case of the performance economy) that should involve the proposition of solutions that will improve economic performance, eliminate detrimental effects of human activities over the environment and ameliorate social indicators, which can be associated with sustainability.

e/ Biomimicry

Biomimicry is a science that promotes the idea of following nature's behavior, structure and architecture in order to design products and production systems that would lead to achieve sustainability (Benyus 2002). Biomimicry follows three main principles, nature as model, nature as measure and nature as mentor. With these principles, the biomimicry science says that human activities can learn from nature in order to design long lasting solutions, following nature standards in order to solve actual problems that society presents and erase the concept of waste. Another idea that biomimicry enacts is the idea of system thinking, because it is not possible to produce environmentally friendly products that will be transported by polluting vehicles. Biomimicry in this sense is also bases in innovation and in new business models that can integrate this vision. In this way, the CE has taken from the biomimicry the idea of system thinking and innovating how businesses are conceived.

f/ Ecological and environmental economics

Ecological economics and environmental economics are concepts that are interrelated as the former was born in order to complement the other (Venkatachalam 2007). On one hand, the field of environmental economics takes into account environmental rights into economic functions, giving more value to environmental resources (to those resources that are consider as scarce), it introduces the idea that the environment is not an unlimited place where to put all the pollution produced by human activities, and it has as objective to continue with unlimited economic growth (Norgaard 1985). One of the means to integrate the environment into economic functions is to monetize it, by finding the most accurate prize for the different externalities of the current economic system. On the other hand, the field of ecological economics says that in the environmental economics, it has not been taken into account all the limitations presented in the ecology, as the environment is analyzed from a merely economic point of view, and from a very narrow approach, so they consider into account all the environmental resources and other ecological constraints into economic analysis (Inge 2005). One of the main critics from ecological economics towards environmental economics is that the last keeps analyzing the economy as an open system inside a closed one. Hence, environmental economics tries to integrate environmental constraints to economic functions, while ecological economics thinks in terms of system and how the economy and the environment influence each other. These fields of economic analysis have evolved to integrate new variables into the different studies, but in terms of system thinking these fields are still lacking one primordial aspect that directly influence the economy and the environment and that is the social aspect. As analyzed by (Gendron 2014), this different fields that try to integrate environmental problems, just represent the elite's environmental crisis, as well as economic and governmental agendas, lacking in this way the integration of sustainable development objectives which means meeting current human needs without compromising the ability of future generations to cover their own needs.

If we look up to the main ideas that have been used to build the actual idea of CE, it is possible to agree that they have some common principles. First, all the concepts look to conciliate the relationship between human activity and the environment. Second, they promote changing the paradigm of calling something waste to calling it resource that can be continuously used, asking in this way a change in the way how we produce. Also, these concepts share the idea of system thinking, and understanding how every possible solution can impact overall the whole system, even though if they do not agree in the extension of the system.

Another common point that these concepts share, is the need for new business models that can allow the application of closing the loop strategies. In few words, all these concepts are looking for a redesign of human activities in order to erase any detrimental effect that they could have over the environment. In terms of what is the principal objective of these concepts, first all the concepts share the objective of economic growth, and there are some others that look to get a sustainable development. Sustainable development would be crucial for the success of any new concept as it integrate social variables. Indeed, (Baas 2008) recommend that in order to get greater progress in the field of cleaner production and industrial ecology, the different strategies should involve more stakeholders, including citizens. It becomes harder to apply any new policy to protect the environment if society, people do not have enough education to understand the importance of such policies. For example, if people do not cooperate with simple tasks as sorting and classifying waste, it is very difficult to reach a good performance in this activity (Knickmeyer 2020). This lack of cooperation might arrive due to the lack of information that people have and also the lack of trust in political strategies. Moreover, if people do not have enough resources to cover their basic needs, they will not be willing to cooperate with environmental protective strategies, as seen with the yellow vests riots in France. Therefore, taking into account just environmental constraints would lead to a failure of these new strategies, a complete focus over sustainable development should be the main objective.

4- The CE seen by governments around the globe

In Europe, CE-like applications have been tracked to the 70's where some laws for waste management and environmental protection (ideas regarding CE), have been applied first in Germany in 1976 (Wautelet and Impakt 2018), followed by other waste management initiatives in Switzerland in 1983, in Portugal in 1987, the United Kingdom in 1995 and 2000 in Denmark (Costa, Massard, and Agarwal 2010). Even though these applications do not mention CE or closing the loop, they share the idea that it is not possible to continue to use land to dispose waste as if it were infinite. Other firsts applications of CE-like policy in the world go back to 1991 where Japan approved the law of effective utilization of recyclables, in order to reduce waste disposals, and to move away from waste incineration which was causing some health issues to the population, and to ensure the access to raw materials for its industry (IES 2015; METI 2003).

The first application of a policy embedded into the CE concept has been tracked to Germany that in 1996 after they approved the CE law, which enacted a better management of waste in order to reduce the use of land for waste landfilling, it demanded producers to better design their products, so it will be easier to recover materials and reuse of products (Geng, Sarkis, and Ulgiati 2013; Ogunmakinde 2019). The next application of CE is tracked to China that in 2002 the central government accepted the CE as a strategy to reach sustainable development in the country and reduce the impacts of the increasing economic growth over the environment by reducing, reusing and recycle of resources (Mcdowall et al. 2017; Yuan, Bi, and Moriguichi 2006). But it is in 2009 that China implemented a more ambitious strategy for promoting the CE by passing the law "Circular Economy Promotion Law of the People's Republic of China" where the focus remains on reducing, reusing and recycling of resources including all economic sector and not just for waste management, but for all type of resources (CCICDE 2008). China has had a top-down approach when applying the CE (Merli, Preziosi, and Acampora 2018). Its application has regarded more an application of cleaner production and consumption and the application of the 3 Rs principles (Wautelet and Impakt 2018). It has also followed an industrial ecology approach as it has enacted the recovery of different resources in production from industries at all different level, macro, micro and meso (Mcdowall et al. 2017).

The first initiatives for an implementation of the CE from a European perspective started with the 2008 directive on waste (Smol, Kulczycka, and Avdiushchenko 2017). Then in 2014 with the "Towards a Circular Economy: a Zero Waste Programme for Europe" the European Union showed the increase interest existing over the CE concept. In 2015, with the "Closing the Loop - An EU Action Plan for the Circular Economy", Europe is engaged to reach a circular economy where they propose different strategies to develop more sustainable products, empower consumers to practice CE principles and to foster CE strategies among all economic sectors. Europe has shown to have a bottom-up approach when applying CE policies (Merli, Preziosi, and Acampora 2018), with a perspective that seeks a system transformation, and is based mainly in the cradle-to-cradle theory, which includes initiatives such as the green labeling for products (Mcdowall et al. 2017; Wautelet and Impakt 2018).

Some European countries have already applied some strategies mentioning directly CE, In France the CE was first mentioned in 2007 at the "Grenelle de l'environnement" policy discussions and it was adopted in 2014 by the relative law for the energy transition and green growth, with the objective to reduce wastage of resources and to close-the-loop regarding materials use. Denmark, historically has been one of the countries that has concentrated its efforts towards a better management of waste, and resource recovery, but it is not until 2015 that the country showed a direct interest over the CE concept, thanks to the report developed by the Ellen McArthur Foundation "Potential for Denmark as a circular economy" (Ellen Macarthur Foundation 2015). Although, Denmark has not mentioned explicitly the CE, some initiatives embedded in the CE have been applied; such as better design of products for the recovery of materials, reduction of waste incinerated in order to increase recycling rates. The United Kingdom, has been one of the first regions in Europe to promote a better management of resources with the 1995 environmental act, it also has one of the most representative companies that has been promoting the CE concept, The Ellen McArthur Foundation, but they have not promoted CE, nonetheless, the region have not promoted the CE as it should have been expected (Hill 2018). It is just Scotland and Wales that have directly adopted an strategy towards the CE in 2016 (UK-Parliament 2016). More recently, in 2018 that England through new resource and waste strategies, England has set its ambitions to get towards a CE in order to reach sustainability (UK-Government 2018). Their approach includes policies promoting resource efficiency and new design strategies. The Netherlands are one of the countries that have adopted a very committed strategy towards a CE by adopting a program to reach a waste free economy by 2050 in 2016. In this program their strategy is based in increase resource efficiency, designing strategies to ease the remanufacture, and repairing of products. They also propose to redesign policies to ease the access to information, to financial resources and to give market incentives along with the inclusion to more stakeholders (Government-of-the-Netherlands 2016).

In the rest of the world, CE-like initiatives have been applied. Like, in United States, where the CE has been covering much more force over the last years. Its application is embedded principally into the reuse, recycle and remanufacture of materials, and their initiatives are not as implemented as in China or at in the European Union (Circular Colab n.d.). However, some initiatives from the performance economy have been applied specially a better design of products to ease the recovery of materials in order to better apply the principles mentioned previously. In Canada, CE initiatives have not been yet applied consistently due to the government being concentrated in targeting climate change and clean growth, yet some initiatives are surging as a result of increasing research in this topic and partnership with private actors (Cairns, Ogden, and Mcfatridge 2018). In South America, there is still an important delay in terms of waste management presented in most of the countries, and even though the CE has shown many opportunities to address with this issue and improve many other economic, social and environmental challenges, the CE has not been a priority in the political agenda of the governments of this region (Margallo et al. 2019). Nonetheless, the private sector has regarded the CE as an opportunity to improve their businesses and their ecological impact as well as their social performance, by applying different CE strategies (Kowszyk and Maher 2018). There have been businesses that are applying CE principles such as better design of products and systems, as well as a better recovery of resources with integration with communities. Africa has shown a similar pattern as Latin America countries. Governments are concentrated in coping with social issues and searching for economic growth, and in terms of environmental policy it is mainly applied a recovery of resources (Desmond and Asamba 2019).

(Desmond and Asamba 2019). Moreover, there is a lack in documenting and analyzing the few possible CE projects developed in the continent, and it seems that the way how the CE is analyzed in Europe could not produce the same effects in this part of the world. In addition, the application of CE strategies in developing countries might lead to worsening the situation in some developing countries when the application of CE strategies are applied without taking into account all the involved stakeholders. As an example, it is possible to identify that taxing CO2 emissions in one country, might lead to an increase in another country that is not imposing the tax.

III. Scientific evolution of the CE

1- Precedent literature reviews:

There have been a number of previews literature reviews about CE that have analyzed its evolution over time. The objective of this section is to give a summary of these preview reviews, so it is possible to have an idea of how the analysis and the studies about CE have evolved during time.

The first papers analyzing the CE have come from Chinese researchers due to the different laws that the Chinese government has approved in order to promote the CE concept (Q. Liu et al. 2009). One of the first papers analyzing the CE was done by (Yuan, Bi, and Moriguichi 2006) that in his review of CE origins, and the evolution of the implementation in China, found that CE has its origins mainly in cleaner production and industrial ecology, and its application in China follow mostly the application of cleaner production strategies, the creation of eco-industrial parks and eco-cities with the focus a more efficient use of resources. (Andersen 2007) gives an introduction about the CE its fundamental principles and its relationship with environmental economics. He concluded that there have been important advances in terms of pricing externalities, but there are more challenges to overcome in terms of combining knowledge from different fields. So a CE has to address this challenge in order to get to sustainability. (Preston 2012) in his review shows that the CE is applied inconsistently by governments and companies as there is not a real agreement about its concept. Then he proposes some strategies that would help a better application of CE strategies; this includes, first a redesign of industrial systems that allow a better use of resources along all the production chain and among the different industries, promote new designing strategies and the implementation of cradle-to-cradle principles, and finally, apply actions to change customer's behavior. (Su et al. 2013) review how the CE has been implemented in China, covering concepts, and actual practices and try to condensate most of the advances developed in this sector. Their principal results show that the implementation of CE have occurred in the micro, meso and macro level, in the areas of consumption, production, and waste prevention. Moreover, they found that in terms of indicators for the application of the CE include mainly the measurement of the application of the 3 R's reduce, reuse, and recycle. With (Heshmati 2015) work concluded that the main applications of the CE have occurred in China from a fragmented perspective, and that there is not an unified effort in terms of research, and that for the evaluation of the application of CE rest on the evaluation of the implementation of the 3 R's.

With the worked developed by the Ellem McArthur Foundation and the law promoting CE in Europe by the European commission, the interest overall the CE concept has increased considerably. (Ghisellini, Cialani, and Ulgiati 2016) developed an extensive review about the CE and its possible implications in the alleviation of environmental burden caused by business-as-usual economic activities, concluding that CE has its roots in environmental economics and industrial ecology, and its implementation highlights the development of new technologies, innovation and the application of recycling strategies, and little applications of reuse one. Finally, it is concluded that CE is not a model for a growth oriented economy where efficiency cannot cope with rebound effects and other challenges; rather it looks for a steady state economy, and the CE would be a crucial strategy towards a new production, consumption and social dynamic paradigm.

(Lieder and Rashid 2016) made a review on CE in the context of manufacturing industry, concluding that CE is mainly related with reduction of environmental damage, a better use of resources, and analyzing waste generation. CE research has neglected business and economic perspectives, as well as social aspects. This present risks for CE implementation as it does not include explicit benefits for all stakeholders. (Lewandowski 2016) investigated the CE economics in terms of business models, finding that not many researches has been done in this specific topic, and those analyzing it, have done it with respect to other topics underlying the CE; such as, sustainability, industrial ecology and cleaner production and they analysis can be reflected by the ReSOLVED framework proposed by the EMF. Moreover, there is a lack of research on how to apply CE principles can be fit into business models' framework. To cover this, they have developed a circular business model canvas in order to help business models to apply CE strategies. (Sauvé, Bernard, and Sloan 2016) compare sustainable development and environmental sciences with the CE theory, finding out that CE is a concept that is gaining more momentum as it is the one that show a clearer path to reduce environmental burden. Moreover, they found that CE researches have put more emphasis in dealing with environmental problems and economic challenges, neglecting social issues. (Murray, Skene, and Haynes 2017) traced the antecedents of the CE concept, finding that it remains as a young field and it requires a more accurate definition, also that it can contribute to sustainable development

if it includes social issues into its analysis, otherwise with not well defined objectives, the CE might give misleading results. (Kirchherr, Reike, and Hekkert 2017) after reviewing 114 CE definitions, they principally found that from these definitions, the most used principles are recycle, followed by reuse, and reduce, altogether with waste hierarchy. The system perspective is also a popular feature among the definitions reviewed and that this perspective has increase in used after the proposed definition by the EMF, showing the influence that it has had over the CE community. Finally, it shows that these definitions do not show a clear link between sustainable development and CE, especially because the main objective that this definitions look is economic growth and they do not include social aspects.

(Winans, Kendall, and Deng 2017) gives a review of the history and current applications of the circular economy showing that for a successful application of a CE, it is needed well designed strategies such as standardization for the use and recycle of products along all the industrial cycle that would assure the quality of materials over time, and with a permanent evaluation of its performance. It is also recommended that for a successful implementation of CE initiatives, it is needed social innovation that involves the community, with also a clear message about the benefits for all the stakeholders. (Masi, Day, and Godsell 2017) review the CE in order to find a common understanding in terms of CE definitions finding that the convergence of the CE definition has been difficult due to the many different concepts that it has as antecedents. The study also found three supply chains that falls into the CE understanding, Eco-Industrial Parks, environmental, sustainable and green supply chains, and close-loop supply chains. Finally, the application of supply chains that fit the CE concepts might be difficult without strong governmental support. (Rizos, Tuokko, and Behrens 2017) analyzes the understanding of the CE concept, finding that as the CE is rooted in many disciplines, its interpretations have been diverging. The main difference is about the main objective of the CE, first there are some interpretations that regard a better management of resources, and there are other concepts that look for a complete transformation of the economic system which involves several stakeholders. Moreover, in terms of application of CE, even though the literature shows important benefits when applying a CE, in order to avoid undesirable effects, a complete analysis of all the parameters involving sustainability should be done.

(Geissdoerfer et al. 2017) study the CE and its difference or similarities with respect to sustainable development, showing that most authors have put more interest in studying the environmental and economic performance of the CE rather than a systematic analysis with respect to an complete analysis over all aspects of society, a behavior that is also shown in sustainable development studies. In addition, it is concluded that most authors simplify the CE to material recovery, waste management and emissions reduction, and when social aspects are tried to be taken into account, it is just refer to jobs creations as there is not a clear understanding on how the CE can help to cope with this challenge. Finally the CE is seen as a more operational paradigm than the sustainable concept which is seen as very divers. (Blomsma and Brennan 2017) points out some of the concepts that have been used to cope with environmental and sustainability issues, and finds that the CE has stood out as it acts as a catalytic concept that can help to increase the discussion and help to cover the gap with respect to what is useful and operational in terms of resources management. Also, The CE has taken more interest because it present in a clearer way the ability to extend life-cycle of resources in order to create value and minimizing value destruction.

More recently, (Kalmykova, Sadagopan, and Rosado 2018) identifies that the main actors in applying CE are governmental entities, NGOs and consultancy firms, and the main strategies in the application of a CE are stock optimization, eco-efficiency and eco-effectiveness, waste reduction, and the 4 Rs. This research has also contributed to the creation of a CE database which details 45 strategies. (Prieto-Sandoval, Jaca, and Ormazabal 2018) give four principal aspects that a CE definition should have, "the recirculation of resources, and energy, the minimization of resources demand, and the recovery of value from waste, a multi- level approach, its importance as a path to achieve sustainable development, and its close relationship with the way society innovate".

(Homrich et al. 2018) presents the trends and gaps towards the convergence over the CE concept, finding particularly that the CE model has omitted in its analysis legislative, institutional and cultural challenges, and that industrial symbiosis, ecoparks and supply chain are the main groups for the application of CE.

Moreover, the main applications of CE in China concern the strategies of industrial symbiosis and ecoparks. It was also found that some of the CE case studies lack empirical validation, and that a common nomenclature is needed. In terms of ecoparks it was shown that it has successful examples in terms of how to externalities, transaction costs and the application of industrial symbiosis can contributes to get a CE.

(Wautelet and Impakt 2018) gives a review on how the different concepts that have been used as based for the CE have influenced over its current understanding, showing that first these concepts show an agreement in that the current industrial economic system is not sustainable, and that the economy altogether with the environment and society all forming one ecosystem have to be taken into account to find an holistic solution. In addition, most of these schools of thought ask for a redesign either of producing systems and/or products. (Ruiz-Real et al. 2018) made a bibliometric analysis of 743 articles finding that the CE is a famous strategy applied by governments, and companies when conciliating the environment with economic activities from very diverse types of industries and mainly focusing on environmental performance. This research also finds that the most related areas of knowledge, interested in a crossed relationship with CE are environmental science ecology, business economics, and engineering. (Türkeli et al. 2018) shows first that governmental initiatives have increased the interest in the academia about the CE, first in China in 2002 after they approved the CE law, and then in Europe in 2015 after CE plan proposed in the European Union and that currently there are initiatives in cooperation between both regions. As a conclusion, they strongly propose to include research on CE and the social aspects of it, and that it should include objectives related to sustainability and not just research about economic benefits in order to prevent rebound effects. (Lahti, Wincent, and Parida 2018) made a research about CE and sustainable business models, finding that there are huge uncertainties for it especially when the relationship between them and customer's behavior as well as the unspecified attributes need for product design. They have also found that there is not a clear framework on value creation in this new type of business models that will foster a change from a linear model that present lower uncertainties. (Merli, Preziosi, and Acampora 2018) analyzes how the CE is studied by the academia, finding that the academia altogether with policy makers have found in the circular economy a good strategy towards a balanced development. Accordingly, scholars approach the CE from a macro perspective for it analysis, from a micro prospective for its operationalization and from a meso level for its implementation from an industrial ecology point of view. It is concluded also that the motivation of a CE is sustainability and it lack social aspects in the analysis and implementation. Finally, the primordial sub-sector of the CE is waste-management with studies applying cleaner production methods. (Korhonen, Honkasalo, and Seppälä 2018) made a review about the concept of CE and its limitations, concluding that the CE is a promising strategy as it has attracted the attention from businesses as well as policy makers, as the CE remarks that all resources have value and it tries to retain value along the production cycle. Anyway, the CE faces many challenges, first, in terms of thermodynamics, defining its boundaries, overcoming rebound effects, and path dependencies, as well as defining inter and intra organizational strategies. (Hobson 2019) makes a revision about what are the means to get to a CE, concluding that the CE should be enclosed into a new thinking of the system that cope with daily base consumption which can push the transformation of goods and services that meet actual needs. (Fan et al. 2019) study how the CE can contribute to sustainable development, and identifies some challenges that the concept has to overcome in order to be a solid strategy towards a greener economy, such as finding economic resource to finance CE projects, as well as enough data that support decision making, find the mean to increase the use of technologies into CE initiatives, and creating a more integrated relationship with the different stakeholders. (Suárez-Eiroa et al. 2019) proposes seven operational principles in order to reach a CE, which include adjusting outputs from the system to absorption rates, closing the system, maintaining the value of resources within the system, reducing the system's size, designing for CE, and educating for CE. (Marrucci, Daddi, and Iraldo 2019) have researched about the integration of sustainable consumption and production tools to reach a CE, finding that the principal tools to promote the CE are environmental management system, green public procurement, eco-design, ecolabel and energy label and environmental technology verification. (Chiappetta Jabbour et al. 2019) analyzes the CE from a human approach in order to understand its role on its implementation, and they propose a framework to integrate green human resource management with CE business models. Finally, there is (Corona et al. 2019) that gives a review of current metrics applied to asses CE initiatives, finding that actual metrics do not consider sustainable solutions simultaneously for the environment, the economy and society, as there is not a current understanding of what is a CE. This metrics are mostly considering just material circulation and are neglecting the reduction of the use of resources. Besides, life cycle assessments methods, that have been identified to be one of the most used metrics, faces some challenges for its application in a product-service system when it is applied in a regional or a global scale, as benefits in one level can get detrimental effects on another one. Finally, it shows the major challenges that these metrics have to overcome consist on correctly measuring CE goals in terms of sustainability dimensions, well integrating scarcity or primary resources and correctly evaluating the quality of materials over time.

2- Principles

The CE has been evolving during time as more attention has been granted to it by scientists, policy planners and practitioners, so many concepts have been used to build the actual idea of CE, the same has happened to the principles attached to it. A principle is defined as a fundamental truth or proposition that serves as the foundation for a system or belief. With that being said, through the literature review, different principles have been identify, and in this section we condensate what have been stablished in the literature as principles for the CE.

Early publications about the CE concept, have used as main principles the 3 Rs, this means reduce, reuse and recycle (Su et al. 2013; Yong 2007; Yuan, Bi, and Moriguichi 2006), some other authors have used also recover (Reh 2013). This is mainly due to the fact that the law proposed in 2002 by the Chinese government mainly promotes these activities, and that most of the publication preview to 2013 come mainly from Chines authors (Geissdoerfer et al. 2017; Kirchherr, Reike, and Hekkert 2017). The reduce principle refers to decrease the use of materials in consumption and production, the reuse principles calls for giving another life to a good or a material that in the current economy would be discarded into landfills. One idea that can be integrated into the reduce principle is "slowing the curve" which has been vastly associated with CE (Bocken, Ritala, and Huotari 2017). Slowing the curve means reducing the speed as how primary resources are being reintroduced into the production cycle, keeping at maximum the value that products have in time. This idea has been neglected from literature because from the business point of view, slowing the circle is mostly associated with selling fewer products, which is seen as reducing profits. The slowing the circle idea goes along some new business practices such as product-service system models and other practices that through remanufacturing prolong products' life cycle. The recycle principle tries to process the materials (that otherwise would be discarded, and that cannot be fit within the action of the previous principles) in order to produce another unit of itself with the same or lower properties. It is also related to the closing the loop idea (Bocken, Ritala, and Huotari 2017), which means that value should be produced by resources that are consider waste. Finally, the recover principle refers to use products that would be thrown away as inputs to produce energy or something else. Other authors have included some other Rs to the CE principles, such as refusing, repairing, refurbish, remanufacture, and repurpose (van Buren et al. 2016; Korhonen, Honkasalo, and Seppälä 2018). Some authors argue that these last principles can be covered by the 4 initial principles. For instance, refusing which means that the economy should prevent the use of resources and rethinking which can be included in reducing, and repairing, refurbish, remanufacture, and repurpose can be included in recover (Anastasiades et al. 2020).

In 2013 (Ellen Macarthur Foundation 2013; EMF 2013) proposed some new principles for the CE, which seems a more complex explanation of the 4 Rs cited before and arguably they can be included on them. These principles are:

- Design out waste: produce goods in a way that their components can be used to produce something else using the minimum amount of resources and energy
- Build resilience through diversity: create different connection in production in order to reduce uncertainties
- Rely on energy from renewable sources: Use the abundance of renewable energies such as solar and wind
- Think in systems: analyze and understand how one activity can influence all its surroundings and the consequences that it might attaint
- Waste is food: if the components of a products cannot be reused or recycled, they should be able to be absorbed by nature
- Think in cascades: extract extra use from products or materials by using them in other applications

The principles proposed by (EMF 2013) have evolved over time and in 2016 they have proposed new principles (EMF 2016), including

- Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flow
- Optimize resource yields by circulating products, components and materials at the highest utility at all times in both technical and biological cycles
- Foster system effectiveness by revealing and designing out negative externalities

Finally in 2019, an update to these preview principles is shown in (EMF 2019):

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

According to (Homrich et al. 2018) the principles enacted by the EMF have been used more by firms and practitioners, meanwhile in the academia, the debates about the different principles of the CE have increased its intensity. The 4 Rs have been constantly used by most of the review like (Anastasiades et al. 2020; Z. Liu et al. 2018; Prieto-Sandoval, Jaca, and Ormazabal 2018). In fact, (Kirchherr, Reike, and Hekkert 2017) after their review of 114 concepts about CE, identifies the core principles of the CE, which includes the 4 Rs. Other principles identified where waste hierarchy and systems perspective, principle that has been used by 42% of the definitions reviewed by this author. Systems perspective includes three different levels for the application of CE, the micro, meso and macro level. The micro level refers to consumers and firms; the meso level refers to regional levels and eco-industrial parks; while the macro level refers to national and global scales. Some authors argue that this last systems perspective disaggregation level is lacking one important link, the supply chain level that would be the interlinkage between the previous micro, meso and macro levels (Masi, Day, and Godsell 2017; Merli, Preziosi, and Acampora 2018). In this way, the supply chain level should have its place as a principle of the circular economy, as it is needed to think as system and coordinate its deployment from all different perspectives. In addition, some other authors have discussed about the waste hierarchy principle and the case that without an holistic analysis of value creation of resources, or products throughout the supply chain, undesirable consequences can be attaint, especially if the value creation is just analyzed from an environmental point of view (Iacovidou et al. 2017). It is given as example, that co-firing coal with biomass will reduce the efficiency of the boilers and produce as waste a type of ash unsuitable for other type of applications. Or, the case that in the EU around 46% of the post consumed plastic was exported to the east where it was reprocessed in low quality facilities that produced dangerous emissions, altogether with badly paid workers, giving as consequence some externalities that would have been prevented if an optimal and holistic analysis and application throughout the supply chain and from a social, economic and environmental point of view would have been done.

(Kalmykova, Sadagopan, and Rosado 2018) has identified some other principles that the CE should be taken into account, the eco-efficiency entails that it should minimize the resources and pollutants from a system, and eco-effectiveness which mean that the production of goods and their associated activities should be in line with the environmental system. Moreover, (Masi, Day, and Godsell 2017) in his review points out four core principles of the CE. The CE as a regenerative and restorative economic framework, in which it has to decouple economic growth from environmental degradation, it seeks to preserve economic, social, and environmental value, and it has to contribute to system resilience. Furthermore, (Suárez-Eiroa et al. 2019) proposed some operational principles that would help a better application of the CE. These principles include adjusting inputs to the system to regeneration rates, adjusting outputs from the system to absorption rates, closing the system, maintaining resource value within the system, reducing the system's size, designing for circular economy, educating for circular economy. Arguably most of these principles can be included in the previous detailed principles (the 4 Rs), but what is important is that the social aspect of CE is starting to be taken into account. With the preservation of economic, social and environmental value, and educate for CE principle, the authors tries to highlight that the CE is a complete change of paradigm from all of society points of view, and that without a change in customers behavior most of the CE principles are very difficult to reach. In fact, (Elia, Gnoni, and Tornese 2017) points out that eco-design strategies for products development cannot be accomplished without a change in customer's behavior. In addition, (Anastasiades et al. 2020) has identified that a change in user's behavior would be needed to change, so it would be possible to actually close the loop. (Esmaeilian et al. 2018) make some remarks about the fact that people's interaction is needed even to accomplish the basic concepts of recovering and recycling as households have to be willing to pre-sort waste previous disposing the resources in specific containers.

From this review of principles that have been mentioned in the literature about CE, it is possible to identify the core ones that have been used and those that should be applied in order to have a better deployment of a CE strategy. First as most of the CE publications agree, the 4 Rs (reduce, reuse, recycle, and recover) are part of the core principles of CE. These principles encompasses most of the philosophies promulgated by the CE idea in terms of decreasing the use of resources, extending the life time of products and resources, closing the loop through recycling and if waste should be produced, it has to be employed to produce something else. Next, we have the principle of system thinking which includes the micro, meso, macro and supply chain level which allows the analysis of possible effects of the CE application in the whole system.

Following, the principle of redesign is proposed. This principle makes reference as the need of changing the way how the economy produces, in terms of making goods to last longer, to make it easier to recycle or recover its components, avoiding in this way the production of undesirable waste or any kind of emissions that would harm the environment and/or people's health. In his report about CE performance indicators (Haupt, Vadenbo, and Hellweg 2017) gives a review about how an specific design of products allow a better or worst performance in the recycling process. In addition, it makes reference also to the fact that it has to change how people is taken into account in the economic system, not just as a unit of labor but as a parameter that can shift how the economy works by itself, transforming in this way, all aspects of society for a better and more effective application of a CE.

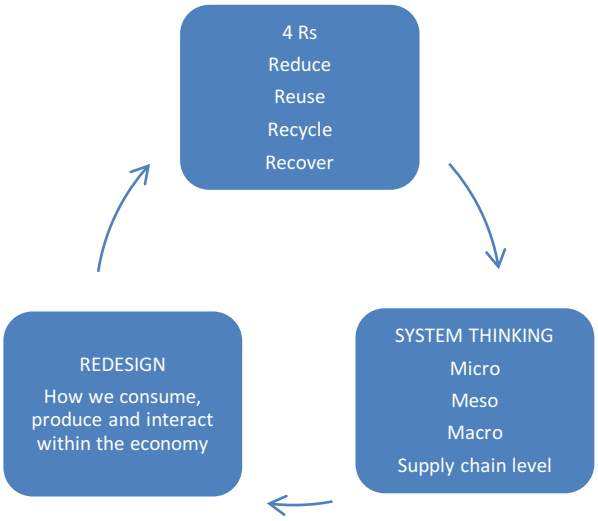

Fig. 1 : Prposed principles for the CE

IV. Towards a circular economy consensus:

As shown before the idea of CE has been associated with many different disciplines and other concepts, and it has also been associated with diverse principles. Its definition has followed the same pattern and many different definitions have been proposed over time. In order to analyze how it has evolved, first an analysis of the objectives of CE will be performed then it will be performed an analysis of the CE definition.

1- Objectives of the circular economy

As shown previously, the CE was first seen as a main idea to improve waste management, increase economic growth and has evolved to include objectives such as sustainable development. After the review of 114 definitions (Kirchherr, Reike, and Hekkert 2017) talks about the principal objectives integrated into those definitions. One of the remarks done is that the highest agreement among those definitions is the look for economic growth in 46%, which shows that there is still a large path towards reach a consensus about what is the real aim for the CE. In the second position, environmental quality is the second objective most mentioned by those definitions. One important remark in this review is the absence of social objectives into the definitions. This is confirmed by other reviews that were not covered by (Kirchherr, Reike, and Hekkert 2017), such as, (Chiappetta Jabbour et al. 2019) who shows that the "human side" of the circular economy has not been taken much into account. With these in mind, some authors argue about the idea that the ultimate goal for the CE is to reach a sustainable development, as many authors sees the CE as a condition to reach sustainability (Geissdoerfer et al. 2017; Heshmati 2015). (Schroeder, Anggraeni, and Weber 2019) concludes that CE implementation can contribute directly to 21 of the sustainable development goals stablished by the United Nations, and it can indirectly help to reach 28 additional goals. Hence, it is possible to see that there is still not a common agreement on what is the real objective of the CE, but there is a trend that links CE with sustainable development, and this is the next step to take in order to have a more effective CE (Bocken, Olivetti, and Cullen 2017; Murray, Skene, and Haynes 2017). Indeed, analyzing the final objective of the disciplines that have been used as based to build the CE concept; it is possible to conclude that the ultimate objective of the CE is the sustainable development.

2- Definition

One of the main definitions used by researchers and by policy makers is the definition proposed by the Ellen MacArthur Foundation which has had an important impact over all the stakeholders involved in the CE paradigm. An example of the papers using the EMF definition includes (Clement 2020; Farooque et al. 2019; Gabriel, Do Carmo Duarte Freitas, and Tavares 2020; Leal et al. 2019; Sandin and Peters 2018). Another definition that has had an important impact is the one proposed by (Geissdoerfer et al. 2017), followed by the one proposed by (Kirchherr, Reike, and Hekkert 2017). The most relevant definitions of CE are shown in

Highlighted CE definitions	
(Kirchherr, Reike, and Hekkert 2017),	A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and be- yond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.
(Yong 2007)	the circular economy defines its mission as resolving the problems from the perspective of reducing the material flux and making the material fl ow balanced between the ecosystem and the socioeconomic system
(Su et al. 2013)	CE, embedded in the original concept, has gradually been shifted from narrow waste recycling to broad efficiency-oriented control during the closed-loop flows of materials at all stages of production, distribution and consumption
(Masi, Day, and Godsell 2017)	the CE as a regenerative and restorative economic framework, which (b) decouples economic growth from environmental degradation and which (c) seeks to preserve economic, social, and environmental value while, d) contributing to system resilience.
(Korhonen, Honkasalo, and Seppälä 2018)	Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading1-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates
(Prieto-Sandoval, Jaca, and Ormazabal 2018)	The circular economy is an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes
(Bastein et al. 2008)	circular economy is an economic and industrial system based on the reuse of products and raw materials, and the restorative capacity of natural resources. It attempts to minimize value destruction in the overall system and to maximize value creation in each link in the system.8 The goals of the system are to counteract the depletion of natural resources; phase out waste, greenhouse gas emissions and the use of hazardous substances; and make a complete transition to renewable and sustainable energy supplies.
France	La transition vers une économie circulaire vise à dépasser le modèle économique linéaire consistant à extraire, fabriquer, consommer et jeter en appelant à une consommation sobre et responsable des ressources naturelles et des matières premières primaires ainsi que, par ordre de priorité, à la prévention de la production de déchets, notamment par le réemploi des produits, et, suivant la hiérarchie des modes de traitement des déchets, à une réutilisation, à un recyclage ou, à défaut, à une valorisation des déchets.
China 2008	CE is the general term for the activities of decrement, recycling and resource recovery in production, circulation and consumption
EU 2015	circular 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
(Chiappetta Jabbour et al. 2019)	it is predominantly understood as using post-consumption products, resources, and packaging to create new value through the exchange of linear flows of energy and materials for closed-loop systems of production and consumption
(Marrucci, Daddi, and Iraldo 2019)	The CE concept is grounded in the study of real world and nonlinear systems, in order to facilitate effective flows of materials, energy, labor and information
(Fan et al. 2019)	The circular economy is a system developed by minimizing the use of energy, natural resources and waste generation The paradigm of the circular economy includes minimizing inputs of raw materials and outputs of waste, keep resources value within the system as long as possible and reintegrating products into the system when reaching the end of life
(Palafox-Alcantar, Hunt, and Rogers 2020)	A CE is a set of principles and tools which aim to contribute to the planet's sustainability by minimizing the extraction and degradation of materials, promoting resource and energy conservation (reduce, reuse, recover and recycle) and driving the regeneration of its input sources. As such it fosters a willingness to, and facilitates, the repair and upgrade of products through innovative and systems thinking and embraces waste as a primary resource, allowing its reintroduction into the consumption system. The CE is inclusive with the environment, society, governments, companies and academia, and boosts the development of resilient business models in which various forms of value are captured through cooperation.
(Geissdoerfer et al. 2017)	A regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.
(EMF 2013)	The circular economy refers to an industrial economy that is restorative by intention. It aims to enable effective flows of materials, energy, labor and information so that natural and social capital can be rebuilt. It seeks to reduce energy use per unit of output and accelerate the shift to renewable energy by design, treating everything in the economy as a valuable resource. The idea goes beyond the requirements of the production and consumption of goods and services.
(EMF 2019)	The circular economy is a systems-level approach to economic development designed to benefit businesses, society, and the environment. A circular economy aims to decouple economic growth from the consumption of finite resources and build economic, natural, and social capital

Table 2 Most important definitions found in the literature review

After the analysis developed in this review, the following proposition is proposed:

"The circular economy is an economic system that seeks to contribute to sustainable development (covering current needs without compromising those of tomorrow), by dissociating economic growth from environmental impact and social inequalities, redesigning the way how it consumes, produces and interacts with the environment and with society itself, through innovative business models and a sustained public policy seeking an optimal implementation of the 4 Rs, namely «reduce, reuse, recycle and recover», always aiming to minimize the consumption of resources, with a systemic approach when it is deployed at the micro (companies and households), meso (industrial synergies, regions), macro (country and global) and supply chain levels (interaction between previous levels)»

This definition tries to include first, some of the ideas that the disciplines used to build the CE concept have been promoting, in terms of the system thinking, then the innovation that business models have to implement, and then the application of the redesign of how society consumes, produces and how it interacts between each of its actors. This has the intention to call for actions from all aspects of society, as the circular economy demands a complete engagement, including a global perspective; otherwise there might be adverse effects. Some definitions as the one proposed by (Kirchherr, Reike, and Hekkert 2017) puts all the weight of the shift towards CE on business models, but as shown previously, the transition towards the CE has started from the policy aspect, which is the case of China, and the European Union, but also from the private sector like the case of the EMF that has had a huge impact over the transition to the CE. In addition, this definition tries to integrate also the use of the 4 Rs that have been widely promoted by many researchers and policy makers, but followed by the word "optimal" with the purpose to replace the waste hierarchy principle proposed by some other actors. As shown before, the waste hierarchy might not be the most useful guide to the application of these principles as it can lead towards not desired outputs. Moreover, its application should happen at the different levels of the economy, the micro, the meso and the macro level, including the interaction between them. Finally, as the ultimate goal for the CE is sustainable development, as increasingly claimed by researchers, and as most of the concepts involved in the construction of the CE idea have stated. Sustainable development means to have greater economic growth, while improving environmental and social quality.

V. Conclusion

In this review, we first looked at the history of CE, from its origins to the concepts that served as a basis to build its current notion. Thus, CE was born as a strategy that can help to reduce the stress on resources and negative effects on the environment. It has been influenced by different environmental approaches, including industrial ecology, the cradle-to-cradle concept, performance economy, blue economy, and biomimicry. In this way, CE can be seen as a catalytic concept that creates a link between these different approaches. In this way, the CE inherited several ideas that explain the lack of consensus on its principles, objectives and definition.

It is also shown how gradually the policies of various governments around the world have started to incorporate CE strategies. These kinds of policies first emerged in Asia responding to an approach to increase resource efficiency at the industrial level, and then in Europe, where these policies were aimed for better waste management. It is China that is giving impetus to CE as an approach that can help decouple economic growth from environmental destruction through its early adoptions of CE as a development strategy in the country. From this point on, the CE begins to attract the attention of academics.

Therefore, an analysis of the evolution of academic studies relating to CE has been developed, in order to point out its principles, objectives and definitions. It is clear that CE is seen as an approach that can help to break the paradigm of economic growth and environmental destruction, particularly targeting the conservation of resources. Then, waste in an EC should be called resource that can be used by other production or consumption processes, and if this is not the case, these resources will have to be reintegrated into the environment as nutrients, always retaining a systemic approach. However, CE has mainly been implemented from an industrial economy perspective, targeting better use of resources at the time of production and better waste management. The main principles used are the application of the 3 Rs (reduce, reuse and recycle). It is also suggested that the CE should go beyond seeking an increase in the efficiency of resource use as rebound effects may occur with an increase in production. Rather, the CE should aim for sustainability. Finally, CE should include social aspects because it is through a shift in individuals' behavior that will be possible to change paradigms and facilitate the transition to CE. Constant support from public policies also appears essential.

After this review, a circular economy definition is proposed:

"*The circular economy is an economic system that seeks to contribute to sustainable development (covering current needs without compromising those of tomorrow), by dissociating economic growth from environmental impact and social inequalities, redesigning the way how it consumes, produces and interacts with the environment and with society itself, through innovative business models and a sustained public policy seeking an optimal implementation of the 4 Rs, namely «reduce, reuse, recycle and recover», always aiming to minimize the consumption of resources, with a systemic approach when it is deployed at the micro (companies and households), meso (industrial synergies, regions), macro (country and global) and supply chain levels (interaction between previous levels)*».

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chaire modélisation prospective au service du développement durable

Les cahiers de la Chaire

Thirty years since the circular economy concept emerged: has it reached a consensus

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Working paper