Expertise
and insight
for the future

Dominic Barrett

The implementation of the circular economy in the European Union

Metropolia University of Applied Sciences

Bachelor of Business Administration

European Business Administration

Bachelor's Thesis

28 April 2020

Metropolia
University of Applied Sciences

Author	Dominic Barrett
Title	The implementation of the circular economy in the European Union
Number of Pages	38 pages
Date	28/04/2020
Degree	Bachelor of Business Administration
Degree Programme	European Business administration
Instructor/Tutor	Michael Keaney, Senior Lecturer

The circular economy (CE) is an area that has received increased amounts of attention over the last decade. Since being installed in China in 2002, and the European Union (EU) in 2015, CE has been hailed as a new paradigm to allow the decoupling of economic growth from negative environmental impacts. Targets set under the United Nations (UN) 2015 Paris Agreement (PA) and the 2019 European Green Deal call for climate neutrality by 2050, with the first halving of emissions to be achieved by 2030. Within the EU CE has been positioned as a cornerstone for achieving these targets whilst allowing for sustainable economic growth.

The contrasting political systems of China and the EU and the divergent motivations for installing CE show how complex the practice of implementing policy can be. It is therefore the aim of this research to offer a contemporary view of the situation in relation to the implementation of CE within the EU to help define the strengths, weaknesses, and limitations of the strategy.

Keywords	Circular economy, European Union, Policy implementation

Contents

Glossary

3Rs	Reduce, Recycle, Reuse. A strategy for waste management.
C&DWM	Construction and demolition waste materials. The waste streams produced either during the construction or demolition of the built environment.
CBM/CEBM	Circular business models/circular economic business models. Business models which specifically focus on achieving circular economic objectives.
CE	Circular Economy. An economic system aimed at eliminating waste and the continual use of resources through closed loop practices.
CP	Cleaner production. The continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment.
EIP	Eco Industrial Parks. An industrial park in which businesses cooperate with each other and with the local community to reduce waste and pollution, efficiently share resources (such as information, materials, water, energy, infrastructure, and natural resources) and increase sustainability.
EU	European Union. The European Union is a political and economic union of 27 member states that are located primarily in Europe.
I4.0	Industry 4.0. Industry 4.0 is the trend towards automation and data exchange in manufacturing technologies and processes which include cyber-physical systems (CPS), the internet of things (IoT), industrial internet of things (IIOT), cloud computing, cognitive computing and artificial intelligence
IE	Industrial Ecology. The study of industrial systems that operate more like natural ecosystems.

IS	Industrial Symbiosis. Industrial symbiosis is the process by which wastes, or by-products of an industry or industrial process become the raw materials for another.
PSS	Product-service systems. Business models that provide for cohesive delivery of products and services. PSS models are emerging to enable collaborative consumption of both products and services, with the aim of pro-environmental outcomes
TBL	Triple Bottom Line dimensions of sustainability: economic, environmental and social. A framework or theory that recommends that companies commit to focus on social and environmental concerns just as they do on profits.

1 Introduction

In 2019 the European Union (EU) announced a global climate emergency. This research will therefore first look at what this means (Kammu et al. 2016: 1; Lenton et al. 2019: 592; Shepherd et al. 2020: 233; Willis et al. 2019) and how it can be quantified (EASAC, 2018: 4; Millar et al. 2017: 741; Rockström et al. 2017: 1269). Furthermore, it is important to understand how the climate emergency and the EU's circular economy (CE) action plan are related to each other, and to meeting the United Nations (UN) Paris Agreement (PA) – an agreement to lower emissions and tackle climate change, signed by 195 countries. The circular economy is an economic model where waste and pollution are designed out so that materials can be retained in circulation for longer.

This research will present the EU's solution to this emergency and give an overview of CE, including its origins, definitions, uses and limitations. With China being the only other notable example of widespread implementation of CE one of the main problems is to identify how such policy can be implemented when governance is not centrally planned. The motivations of China and the EU to implement CE seem to be considerably different with China using CE to facilitate rapid expansion whilst not suffering from a shortage of raw materials (Yuan et al. 2006: 4) and to allow leap-frog development with pollution being minimised (Geng and Doberstein 2008: 234). The EU to a certain degree focused on protecting against resource scarcity but a key motivator is boosting sustainable economic growth and not necessarily a focus on minimising pollution (European Commission 2015: 2). Research on CE implementation in China will allow a comparison with the EU, which will lead to the possibility to assess if either can learn from the other and how they can possibly collaborate in the future.

In 2020 the EU released A new Circular Economy Action Plan For a cleaner and more competitive Europe and set out its new strategy under the 2019 European Green Deal to halve emissions by 2030 and achieve climate neutrality by 2050. This is both a world leading commitment to environmental sustainability and statement of intent to transition towards a new economic model. The new CE roadmap is built of the previous work which the EU began in 2015.

To understand what the EU proposes it is necessary to review what has been achieved under the name of CE and what the plan is going forward towards the first halving of

GHG emissions in 2030 and neutrality by 2050. Therefore, defining key areas of European action such as waste prevention with the goal of closing or narrowing material loops, and redefining the economy in terms of new more circular business models will be assessed in detail. Literature in areas specific to closing material loops – and therefore protecting against resource scarcity and boosting EU's competitiveness – and therefore allowing a more sustainable economic future, will help to define if the EU is focused on the right areas.

The main aim of this research is to better understand the current situation of CE implementation within the EU alongside its motivations and goals. The implementation of CE in the EU is a complex, multidimensional area for analysis. It has therefore not been possible to cover every angle.

2 Literature review

Previous research was conducted in Spring 2019 at the Berlin School of Economics and Law, with the research focused on CE in a global context. The research for this paper has therefore been an ongoing process since 2019 and in some cases basic information from the previous paper has been included. With the EU releasing a new CE roadmap in early 2020, the decision was made to focus on CE implementation in the EU.

"Circular Economy" was used as a search term on Google Scholar with 1 620 000 results displayed. The top 12 articles were selected based on number of articles each had been cited in – "Cited by" – with the range of citations being from 507 – 1588. This analysis was completed to reveal the key themes into research on CE. Furthermore, by defining the most cited articles it was possible to identify critical pieces of work in relation to CE research.

1. Stahel, W.R., 2016. The circular economy. Cited by 597.
2. Kirchherr, J., Reike, D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Cited by 783.
3. Geissdoerfer, M., Savaget, P., Bocken, N.M. and Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm? Cited by 1216
4. Bocken, N.M., De Pauw, I., Bakker, C. and van der Grinten, B., 2016. Product design and business model strategies for a circular economy. Cited by 740.

5. Yuan, Z., Bi, J. and Moriguichi, Y., 2006. The circular economy: A new development strategy in China. Cited by 682.
6. Korhonen, J., Honkasalo, A. and Seppälä, J., 2018. Circular economy: the concept and its limitations. Cited by 539.
7. Andersen, M.S., 2007. An introductory note on the environmental economics of the circular economy. Cited by 507.
8. Lieder, M. and Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. Cited by 765.
9. Murray, A., Skene, K. and Haynes, K., 2017. The circular economy: an interdisciplinary exploration of the concept and application in a global context. Cited by 806.
10. Tukker, A., 2015. Product services for a resource-efficient and circular economy–a review. Cited by 957.
11. Su, B., Heshmati, A., Geng, Y. and Yu, X., 2013. A review of the circular economy in China: moving from rhetoric to implementation. Cited by 604.
12. Ghisellini, P., Cialani, C. and Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Cited by 1588.

Ebsco host, ScienceDirect and ProQuest databases were used to search for “Circular Economy” and “Literature review” in an advanced search with all words appearing in the title. This gave 18 publications with CE as the main theme. The search also revealed literature reviews based on CE but with varying subthemes, for example, Industry 4.0 (I4.0) – the most recent, or 4th industrial revolution focusing on new technologies such as big data analysis and the internet of things, comparisons between CE in the EU and China, reviews of CE business models (CEBM), reviews of the Ecodesign directive, the role of industrial ecology (IE) in CE. The abstracts of each were read and 13 of the publications were useful. ScienceDirect was also used to identify further papers on the subthemes identified. Furthermore, a separate search was conducted into CE implementation in China. This was done to offer a basis of comparison to the EU.

A variety of resources and reference materials were reviewed from the official website of the EU. Road maps, directives, action plans, and other materials were analysed and formed the background information into how the implementation of CE is being carried out in the EU. Such publications as: Closing the loop - An EU action plan for the Circular Economy (2015), A European Strategy for Plastics in a Circular Economy (2018), The European Green Deal (2019b), A new Circular Economy Action Plan For a cleaner and more competitive Europe (2020a), A New Industrial Strategy for Europe (2020d) were read in detail. Publications on the Ecodesign directive and background information on

unreleased publications, such as the Farm-To-Form Strategy, the EU Strategy for Textiles and the Strategy for a Sustainable Built Environment were also reviewed so that broad concepts were understood.

3 Methodology

Literature based research was carried out using secondary data from databases such as Ebsco host, ScienceDirect, ProQuest and the official website of the EU. Being either academic journal articles, European Commission publications or publications from research institutions which specialise in CE. A literature review search was completed to establish a collated source of material which helped to determine key topics and themes, critical sources and definitions. The literature reviews read included systematic literature reviews, bibliometric, network and survey analysis. Data collection was not designed to be exhaustive but to give a holistic view of contemporary research of CE specifically related to the EU.

According to Türkeli et al. (2018:1244) the most research into CE has been conducted in either the EU or China with the pair collaborating the most globally. Therefore, separate research into CE implementation was conducted into China to offer a basis of comparison to the EU.

It was important to review documents published by The Commission and highlight the main points in the policy framework and what the EU wanted to achieve via CE. Before reviewing the material related to the European Green Deal and A new Circular Economy Action Plan For a cleaner and more competitive Europe, it was first necessary to understand what was accomplished in Closing the loop - An EU action plan for the Circular Economy and how logically the strategies followed on and supported each other.

4 Results

4.1 Recognising a climate emergency

2019 was a year where climate change received an increasing amount of attention. From school strikes and youth climate action leaders, to the EU's declaration of a climate crisis

just before Decembers United Nations Framework Convention on Climate Change in Madrid, or COP25. The EU doubled down on its belief of a global crisis by attempting to lead the planet in setting strong targets to reduce greenhouse gas (GHG) emissions by at least 50 per cent by 2030 and to aim for carbon neutrality by 2050 with the introduction of the European Green Deal. A broader agreement on such targets was needed to pave the way for COP26 in Glasgow in 2020 (which due to the Coronavirus outbreak has been postponed by a year) if medium-term targets of the PA have any chance of being met. Such reductions are deemed necessary to keep global warming to well below 2°C, with 1.5°C seen as the optimal target (IPCC 2018).

Capping a global rise in temperature to 1.5°C requires immediate action, with scientists suggesting that a business-as-usual approach will see rise of 3°C. The World Meteorological Organization (2019) stated that 2018 saw another record high year for GHG emissions, with a total rise of 4 per cent since countries committed to the PA in 2015. A reduction of 7 per cent a year will now be necessary to meet those targets and avoid irreversible climate damage.

Lenton et, al. (2019: 592) discuss the interconnectivity of global tipping points, some of which may have already been crossed. In a revised impact study from earlier reports published by the Intergovernmental Panel on Climate Change (IPCC) the increased severity at lower boundaries of degree change in global average temperature can cause a series of events, or tipping points, which have serious ramifications for human life on Earth. The melting of the Antarctic and Greenland ice shelf and thawing of permafrost and arctic sea ice will incur both sea rise and a slowdown of the Atlantic Ocean circulation. The change in this mechanism of water and salt exchange will have serious consequences on global weather patterns, and lead to a global cascade with feedback loops having evermore negative impacts, for example, a lack of ice reflecting heat causing ever more warming (Lenton et, al. 2019: 594).

Such tipping points are partly observable but mainly modelled, and therefore just projections. However, a study on the mass balance of the Greenland ice sheet from 1992 to 2018 using 26 individual satellites shows that ice is being lost 700 per cent faster than it was just a few decades ago (Shepherd et al. 2020: 233). Kammu et al. (2016: 1) and Willis et al. (2019) also discusses the interconnectivity of rising sea levels and water scarcity, where melting ice represents global stores of fresh drinking water which is

released periodically. Compounded by ever-growing population rates water scarcity is another growing global issue.

To begin to quantify the climate emergency Rockström et al. (2017: 1269) came up with the carbon law which stipulates that carbon dioxide (CO_2) emissions must peak in 2020 and then half every decade thereafter. The European Academies' Science Advisory Council set the remaining carbon budget at 1000 metric gigatons (Gt) of CO_2 for the remainder of the century, with 200 Gt CO_2 already been used (EASAC, 2018:4), whereas other research put the figure at 700 Gt CO_2 (Millar et al. 2017:741).

In November 2019 New Zealand's Prime Minister Jacinda Ardern was the first leader to pass legislation to commit to carbon neutrality by 2050 and meet its commitments under the PA. As previously stated, the EU followed suit by signalling to do the same at COP25 in December. By taking such a stance, Ursula von der Leyen, the new president of the European Commission, has continued the work began in part by her predecessor, Jean-Claude Juncker, who in 2015 set out a commitment to implement an EU-wide CE. The aim of which is to improve the EU's competitiveness, protect against resource scarcity and help better define a sustainable approach for Europe's future.

There is an increasing amount of research which shows that CE can be employed as a model at a micro, meso and macro levels to help provide sustainable closed loop solutions to many of the problems which cause climate change. Furthermore, CE has seen widespread implementation in China since the turn of the century, so the usefulness of policy can be directly observed. The task of implementing the new strategy in the EU on such a wide scale, must be scaled-up quickly to avoid irreversible environmental damage caused by crossing the boundaries of various interconnected tipping points, and to meet the targets of the PA. The challenge faced by the EU is how to enable the best use of this model and be a decisive voice in global climate change leadership.

4.2 The Circular economy as a solution: definitions, origins and limitations

Scientific research shows a global danger of reaching tipping points which may lead to irreversible and catastrophic changes to the Earth. This is certainly due, in part, to the current economic model beginning with industrialisation in Europe in the late 18th century. The linear economy can be described as a take-make-use-dispose model of production and consumption. To meet the targets of the PA a new paradigm must be installed by the world's leading economies. The EU proposed a CE in 2015 as a model to mitigate negative environmental impacts and continue towards a more sustainable economic future.

According to Ghisellini et al. (2016) the environmental economists Pearce and Turner, 1989, and the ecological economist Boulding, 1966, are some of the earliest contributors towards the origins of CE, with the former building on the ideas of the latter (Ghisellini et al. 2016: 4). Braungart and McDonough's cradle-to-cradle approach, Stahel's performance economy, and IE have also played significant roles in the development of CE ideas (Ellen MacArthur Foundation 2017).

Saavedra et al. (2018: 5) investigated the theoretical contribution which IE has made to CE by conducting a bibliometric analysis in an international context. The study found that CE would not have been possible without the contributing tools of IE, such as, industrial symbiosis (IS) and invention of eco-industrial parks (EIPs). Merli et al. (2018: 1) also found CE roots associated with IE but a literature review saw a rapid development in terms of interest from a scholarly perspective towards CE in its own right.

Kirchherr et al. (2017: 1) looked at 114 definitions of CE to give a critical analysis of what the term means to different people. The main finding was a link to the 3Rs (reduce, reuse recycle) with the aims of CE concerning economic prosperity, and increased environmental quality, though social benefits are not always considered. Surprisingly CE is not highlighted as a mechanism which leads to a systemic shift, and business models or consumers are not seen as enablers. This suggests that CE may have limited uses.

Geissdoerfer et al. (2017) wanted to specifically define whether CE was a new sustainability paradigm. Their definition of CE was "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-

lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer et al. 2017: 3).

Korhonen et al. (2017) see CE as a common-sense concept which resonates with the business community and policymakers alike. They suggest it seems counter intuitive to spend a lot of time extracting resources and designing products to only use them once. Korhonen offers "the first comprehensive attempt to make sense of the actual concept of the circular economy in terms of scientific research" (Korhonen et al. 2017: 11) and find that there is little which is conceptually new about CE. The research does show that CE is novel in its focus on maintaining the quality and value of material cycles and the promotion of both the sharing economy and more sustainable approaches on production and consumption.

Murray et al. (2017: 23) state CE "is an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being" (Murray et al. 2017: 1). The authors also find that CE lacks somewhat in the social dimension and therefore differs significantly form sustainable development (Murray et al. 2017: 1).

Though the specific amount of weight carried by the social dimension under CE is debated research finds that the current linear model does not consider environmental or social objectives and is only focused on economic objectives. By comparison CE can be used as a tool to complete both economic and environmental objectives, whilst sustainable development can achieve economic, environmental and social objectives (Sauvé et al. 2016: 2).

Türkeli et al. (2018: 1259) found that research needs conducting into the societal aspects of CE, adding that more needs to be done on "global sustainability rather than only focusing on the economic and material efficiencies, and also [future research] should account for rebound effects and other critical feedbacks in the political economic systems". Rebound effects occur when potential emissions reductions are not gained because of, among other things, behavioural choices.

According to Merli et al. (2018: 719) CE is often used alongside other environmental strategies, but when used in conjunction with the Triple Bottom Line (TBL) dimensions of sustainability not enough academic research has been conducted into the social

aspects of the concept and better definitions are needed as to the specific role CE can or should play. Scholars need to better understand what the impacts on wider society will be as we transition into a more circular global economy. Ghisellini et al. (2016) do not see CE as an appropriate tool in growth orientated economies and state that CE is more appropriate in steady-state economies where the emphasis may be environmental protection and a shift towards new patterns of production and consumption (Ghisellini et al. 2016: 17-18). Though China seems to be a rather notable exception to this point.

From this analysis it can be said that primarily CE is focused on the 3Rs with emphasis on maintaining the integrity of materials already produced and attempting, where possible, to tighten or even close material loops. It is a sustainability paradigm which reuses old concepts in a new way and is more focused on economic and environmental dimensions than social ones. Further research is needed into how CE can be supported by other models which ensure the social aspect under the TBL is given a similar weight.

4.3 Implementation of the CE in China

China began its path towards CE when it formally accepted the strategy in 2002, in a bid to increase sustainability and improve efficiencies in materials and energy use (Su et al. 2013: 215). According to Yuan et al. (2006: 4) China's motivations for implementing a CE approach are focused around the "aims to alleviate the contradiction between rapid economic growth and the shortage of raw materials and energy". Mathews et al. (2008: 479) suggests that as a relative latecomer to industrialisation China had the option to capture a competitive advantage by adopting newer, and less pollution heavy technologies, therefore making its development quicker and cleaner. Geng and Doberstein (2008: 234) also investigate how CE allows challenges and opportunities for achieving 'leapfrog development' and set out barriers and challenges to the implementation of CE in China to avoid environmental damage.

Kalmykova et al. (2018: 190) developed a tool for the implementation of CE by constructing CE strategy and implementation databases. This led to the discovery that many market-ready solutions already exist which can be applied to different parts of the value chain to allow instant efficiency improvements. Some aspects, such as the recovery, consumption and use parts of the value chain received the most attention, whilst manufacturing, distribution and sales are rarely involved in CE.

Most of the literature on the development of CE in China defines how a centrally coordinated approach by the State Environmental Protection Administration (SEPA) enacts change on a micro (individual or business), meso (EIP) and macro (city or province) level. At a micro level focus is on fundamentals, such as Ecodesign, waste minimisation, and cleaner production (CP) (Kalmykova et al. 2018: 233). According to Feng and Yan (2007: 97) CP can also be utilised to phase out toxic materials and waste production, and to minimise any negative effects associated with the product over its entire lifecycle

At a meso level the development of EIPs allows trading of industrial by-products such as heat energy, wastewater and manufacturing wastes (Yuan et al. 2006: 6). So far, the formation of EIPs within Europe is limited to a few examples, such as, Kalundborg industrial complex in Denmark. Moreover, the development of a secondary waste market by the EU is one of the first steps towards developing IS and the construction of more Chinese style EIPs. Feng and Yan (2007: 97) see EIPs as an enabler of material and energy flow, where waste, such as heat, can be used as a viable input in another process forming symbiotic relationships between those involved. These processes simultaneously reduce waste and maximise the value of resources. Performance indicators at an EIP level are defined by governmental agencies which focus on the implementation of 3R principles and TBL aspects (Su et al. 2013: 223)

At a macro level, cities like Shanghai and provinces like Jiangsu enable vast areas where both production and consumption can be better factored in. By defining specific cities and regions as CE hot spots the government helps push specific objectives and goals by offering low-interest loans, tax reductions, and research and development funds (Geng & Doberstein 2008: 237). Feng and Yan (2007: 95) researched the relationship between legislation and realising the importance of public involvement. They defined an economic development index, a green development index, and a human development index to better understand and improve future strategic CE implementation. Furthermore, CE cities and provinces involve four systems: the industrial system, the infrastructure, the cultural setting, and social consumption. All 4 systems are interlinked and with the industrial strategy setting patterns of consumption and everything being built on a well-defined infrastructure system (Feng and Yan 2007: 98).

In a study by Rantaa et al. (2018) the implications for both policymakers and firms deciding how to implement CE were identified by comparing general and regional

specific drivers and barriers of CE implementation in China, the EU and the US. The study found that by building on institutional theory and using multiple case studies in each of the regions the EU would need to begin an approach where normative and cultural cognitive pillars do not undermine the regulatory framework that it aims to set out to accelerate the change to a CE (Rantaa et al. 2018: 79). In particular reuse suffered from a cultural cognitive bias whereas recycling was a typically accepted, or normative practice. Moreover, while regulation plays a key role in the transition to CE it alone will not be enough without further research into normative and cultural-cognitive conditions in different regions which may act as barriers.

Geographically speaking most CE research is focused on China and the EU, with CE being used as a tool to simultaneously deal with economic growth, environmental issues and combat resources scarcity (Merli et al. 2018: 718-719). Türkeli et al. (2018) find that the Journal of CP is the most important outlet for publications on CE. China and the EU actively produce the most research on CE and have the highest amount of co-authorship focusing on the themes of “emergy analysis, indicators; resource efficiency, food waste, zero waste; eco-cities, lifestyle and governance” (Türkeli et al. 2018: 1244).

McDowall et al. (2017: 7-8) state that the Chinese view the concept of CE much more broadly than the EU, with the strategy in China stemming from a process of rapid industrialisation and the need to avoid an equally rapid rise in pollution. Furthermore, the EU feels less need to combat pollution directly and places more emphasis on employing CE as a tool to reduce resource scarcity and strengthen its economy. Ghisellini et al. (2016) find that China is one of the few countries which implements CE as a top-down national policy, whereas the EU – and many others – use it as a bottom-up tool for implementing environmental and waste management policies (Ghisellini et al. 2016: 11).

McDowall et al. (2017: 7-8) concludes that lessons can be lernt by the EU from China’s long running experiences with CE policy. China’s creation of EIPS and ecocities is a much wider implementation than anything considered by the EU, with the use of IS within EIPs being a world leading enabler of circular material streams as a macrolevel industrial strategy. However, though China’s aim has been to avoid the pollutants released during industrialisation it is impossible to grow, as China has, without some serious environmental repercussions. The EU must ensure under the Just Transition Fund that the mistakes made by China do not force citizens to suffer even when scaling down areas which historically engage in industries which are large emitters.

The Chinese can also gain knowledge from EU CE action according to McDowall et al. (2017: 7-8), especially in areas such as increased consumption driven by a growing middle-class. Such necessary production directives and regulations may be important under similar entities as EcoDesign and Ecolabelling to better ensure the integrity of products in meeting CE standards along their entire lifecycles. China and the EU have different systems of governance and implement CE in different ways. However, the pair should continue to share ideas, research and learn from each other as global leaders not only in research but also in implementation of CE (McDowall et al. 2017: 7-8). To facilitate collaboration Türkeli et al. (2018: 1259) suggest that Chinese and EU institutions use the kind of academic sponsorships which have a long history between Chinese and American Universities as it may help accelerate the transition to CE.

The main issues concerning how thorough implementation of CE in China is relates to a "lack of reliable information, shortage of advanced technology, poor enforceability of legislation, weak economic incentives, poor leadership and management, and lack of public awareness" according to Su et al. (2013: 223). Further discussion on the implementation of CE in the EU should shift its focus from recycling waste to adjusting industrial structure, developing new technology, and reforming industrial policy (Yuan et al. 2006: 5).

China has close to 20 years' experience of implementing CE at a huge scale. Though the methods of governance are clearly different and the catalyst for choosing CE as a strategy divergent, it is clear there are many similarities in the process of implementation. Therefore, as academic research shows, there are lessons to be lernt for the EU and areas where cooperation can be beneficial for both parties and all global partners. Though China uses a centrally planned top-down strategy, the EU has existing infrastructure and policy which can be reconfigured to work towards CE goals. Also, both China and the EU began by focusing on waste management before moving onto wider implementation, such as the creation of EIPs. The EU differs most from China with its focus on consumers and the new CE policy on electronics will look to challenge global tech companies such as Apple and Huawei. In this respect the EU seems to be positioning itself as a global leader in CE.

4.4 EU implementation of CE: 2015-2020

The main objective of the EU in its first CE plan was to allow for sustainable economic growth whilst protecting against resource scarcity and volatile prices (European Commission 2015: 2). From 2016-2020 the Commission helped to generate public financing of more than €10 billion from various sources, such as Horizon 2020, the Cohesion Policy, and The European Fund for Strategic Investments (European Commission 2019d: 1). A key area of success was the European Strategy for Plastics in the CE which was launched in 2018 and looked to ban single use plastics and some fishing gear which were the main maritime polluters (European Commission 2019d: 2). Other key areas the EU targeted were food waste, improvements under the Ecodesign Directive to target production and consumption, new targets for all waste including construction and demolition waste materials (C&DWM) and the introduction of a specific CE monitoring framework (European Commission 2019d: 3-4).

The European Green Deal is a road map towards climate neutrality by 2050. This will be achieved simultaneously with the decoupling of economic growth from resource use whilst leaving no person behind. Key elements of the European Green Deal are the European Climate Law, which has the objective of making the EU's commitments to carbon neutrality legally binding and, A new Circular Economy Action Plan For a cleaner and more competitive Europe, which looks to build on the previous CE road map: Closing the loop - An EU action plan for the Circular Economy.

Part of the focus of the new CE action plan is the lifecycle of products, – and to a lesser and yet undefined sense services – which, through both legislative and non-legislative methods look to define how the methods of production and consumption can fit better within a paradigm of circularity as opposed to linearity. Aspects of design, manufacturing and consumption are addressed by making sure the possibility - and in some cases right – to allow the 3Rs to be factored into EU value chains.

In synergy with the objectives laid out in the Industrial Strategy (European Commission 2020a: 6), the Commission will enable greater circularity in industry by: reviewing industrial emissions, looking at enabling IS, developing a Bioeconomy Action Plan and expand digitalisation to better track material use.

Digitalisation is viewed as an important tool which the Commission will use to benefit the transition to a CE and is planning to establish a common European Dataspace for Smart Circular Applications with data on value chains and product information (European Commission 2020a: 5). The Commission is also reviewing various options, such as digital passports which will store product information on product lifecycle, repairs and upgrades. Within the construction industry digital logbooks will be used in a similar way to track the lifecycle of buildings (European Commission 2020a: 11)

Effective taxation can help to shape behaviour and fund change. The EU plans to use the Emissions Trading System, a cap and trade system which allows the limiting of emissions and trading of emission allowances, to reflect its climate objectives and impose accurate carbon pricing under the Energy Taxation Directive (European Commission 2019b: 5). A carbon border adjustment tax will look to offset the risk that imports do not allow for carbon leakage, where non-EU products with considerably higher emissions replace climate friendly alternatives (European Commission 2019b: 5). Fossil fuel subsidies should end (Club of Rome 2018: 4; European Commission 2019: 10,) and climate neutral and positive solutions should receive increased subsidies.

Furthermore, airlines should have a reduction to their free allowance under the EU Emissions Trading System (European Commission 2019: 11). Global cooperation is important so the EU plans to work with the G20 to push through commitments to ban fossil fuel subsidies (European Commission 2019: 21). While revising the Energy taxation Directive the Commission also plans to better price in the impact of aviation and maritime fuels by revaluating the status of tax exemption (European Commission, 2019: 10).

The sustainable product policy framework will have the aim to mainstream green products both within the EU and in global markets. This initiative will widen the Ecodesign directive beyond energy related products. This is at the core of the new CE action plan and therefore by definition, at the core of the European Green Deal. Another cornerstone of EU CE action is to embed the right to repair into EU consumer and product policies by 2021. This is key to fighting planned obsolescence where products are designed or updated during their lifetime in a way which causes them to prematurely fail (European Commission, 2020a: 5) and making sure products can be easily upgraded or repaired, are more durable or reusable, and are made up of high quality recycled materials which are not toxic (European Commission 2020b: 1).

Supporting the Ecodesign directive will be voluntary instruments such as the EU Ecolabel and the EU green public procurement (GPP) (European Commission 2020a: 3). Due to the significant weight of purchasing power of public authorities – 14 per cent of EU GDP – the EU can substantially increase demand for sustainable products and will ensure this by setting minimum mandatory GPP (European Commission 2020a: 5). Furthermore, because the EU single market provides such a wealth of potential consumers there is an opportunity to set global standards in product sustainability and influence product design and value chain management worldwide (European Commission 2020a: 3).

Electronics continue to be one of the fastest growing waste streams in the EU, with current annual growth rates of 2 per cent, and it is estimated that less than 40 per cent of electronic waste is recycled in the EU20 (European Commission 2020: 7). A Circular Electronics Initiative' will aim to lengthen product lifetimes install a universal charger for phones, tablets and other similar devices (European Commission 2020: 7). There will also be a new system designed to allow deposits and refunds on old electrical devices and their hardware (European Commission 2020: 7).

Textiles are the fourth highest user of primary raw materials and water, and fifth biggest GHG emitters. The Commission will begin the process of defining the collection of textile waste, which Member States must ensure by 2025 (European Commission 2020b: 2). The Commission will also look to incentivise CEBMs, such as Product-service systems (PSS), develop better material and production processes, and increase transparency and collaboration within the industry (European Commission 2020: 10)

In 2018 A European Strategy for Plastics in a Circular Economy was introduced (European Commission 2018) culminating in measures such as the banning of single use plastics and some fishing gear in the EU by 2021. However, consumption of plastics will double in the next 20 years (European Commission 2020a: 19), with EU demand in 2015 for plastics equating 49 million tonnes (European Commission 2018: 2). Improved measures under the new CE action plan are better labelling of bio-based plastics and other biodegradable or compostable plastics so consumers have clearer information about how to recycle waste streams (European Commission 2020a: 9-10).

Minimum requirements for product composition of recycled materials will be introduced, with suggested areas including packaging, construction materials and vehicles (European Commission 2020a: 9). Adding microplastics will be restricted and their

accidental release from, for example, tires and textiles will be investigated. Processes to increase microplastic capture in water will also perused (European Commission 2020b: 2).

The building sector consumes about 50 per cent of all extracted material and is responsible for more than 35 per cent of the EU's total waste generation (European Commission 2020a: 11). GHG emissions from construction processes are around 5-12 per cent of total national GHG emissions, but improved material efficiency could save 80 per cent of those emissions (European Commission 2020a: 11). The Commission will adopt a new comprehensive Strategy for a Sustainable Built Environment to promote circularity principles throughout the whole lifecycle of buildings.

Buildings also account for 40 per cent of all energy consumed, and current figures on renovation throughout the EU are between 0.4 and 1.2 per cent (European Commission 2019:9). A 'Renovation Wave' will be initiated to double these numbers and enable meeting energy efficiency and climate objectives (European Commission 2019: 9, 2020a: 11). The Commission will also propose to work with various stakeholders to identify the barriers to renovation. Innovative financing schemes will be available under InvestEU with the aim to organise renovations in large enough blocks to enable economies of scale and better financing terms. Areas such as social housing, hospitals and schools will also be renovated so money saved through long-term energy efficiency can be better spent (European Commission 2019: 10)

An estimated 20 per cent of the total food produced is lost or wasted in the EU. The Farm-to-Fork strategy will look at decreasing this figure and increasing productivity of value chains (European Commission 2019: 12). Currently, transport makes up 25 per cent of the EU's GHG emissions and the figure will need to be reduced by 90 per cent to allow for neutrality by 2050 (European Commission 2019: 10). By June 2021 the Commission will revise legislation on the CO_2 emissions standards of cars and vans so that from 2025 onwards a pathway to zero emission mobility will be more achievable (European Commission 2019: 11).

When waste is unavoidably created there will be the opportunity to turn it into high-quality secondary raw materials. Harmonisation of EU waste labelling and collection will help standardising procedures. There will be a complete review of the rules on the export of waste from the EU and intensified monitoring of the illegal export of waste to third-party

countries (European Commission 2020b: 3). Such exports often result in negative environmental and health impacts in the countries of destination (European Commission 2020a: 14).

Waste management must be improved in the EU with rates consistently rising. Efforts will be directed towards a minimum of 50 per cent of municipal waste to be recycled across the EU with a plan to harmonise bin colours and key waste types by further expanding Ecolabelling (European Commission 2020a: 12). It is worth noting that several countries are likely to fail to meet the 50 per cent minimum for 2020.

The new CE action plan continues the work begun by the roadmap of 2015 by looking to create a well-functioning EU market for secondary raw materials. Without actionable solutions of how to turn waste into secondary and tertiary inputs the idea of circularity is inept. However, to compete with primary raw materials they must be able to compete on safety, performance, availability and cost (European Commission 2020a: 14). This issue will in part be balanced by the enforcement of minimum recycled material composition amounts in a wide range of products.

The Commission will propose a Just Transition Mechanism, including a Just Transition Fund, to “leave no one behind”. According to the Commission the just transition fund will aim to limit the damage to communities susceptible to adverse socioeconomic impacts of the European Green Deal, especially those who depend on fossil fuels or carbon-intense processes (European Commission 2019b: 16). The EU is responsible for 40 per cent of the world’s public climate financing (European Commission 2019b: 22), but the private sector will also play a key role in the green transition.

The EU’s 2020 CE plan also proposes the launch of a Global Circular Economy Alliance to begin the discussion on management of natural resources. The idea is to begin negotiations and advise other nations to implement a plastics strategy similar to the EU’s. Trading partners will also be encouraged to become more circular under the terms of bilateral, regional and multilateral policy dialogues (European Commission 2020b: 3). Furthermore, the EU will look to work closely with the UN to ensure meeting both its commitments to the PA and the UNSDGs, whilst using diplomatic channels open in the G7, G20 (who are responsible for 80 per cent of global GHG emissions), and the World Trade Organisation (European Commission 2019: 20).

As part of the EU's new CE road map various legislative and non-legislative policies, directives, regulatory frameworks, requirements, initiatives, targets, reporting and certification systems will be launched between 2020-2022 (European Commission 2020e: 2-4).

Table 1. Key actions to be taken by the EU, edited from (European Commission 2020e: 2-4)

Supporting the circular economy transition through the Skills Agenda, the forthcoming Action Plan for Social Economy, the Pact for Skills and the European Social Fund Plus.	as of 2020
Supporting the circular economy transition through Cohesion policy funds, the Just Transition Mechanism and urban initiatives	as of 2020
Making the CE work for people, regions and cities. Supporting the circular economy transition through the Skills Agenda, the forthcoming Action Plan for Social Economy, the Pact for Skills and the European Social Fund Plus.	as of 2020
Supporting the circular economy transition through Cohesion policy funds, the Just Transition Mechanism and urban initiatives	as of 2020
Circular Electronics Initiative, common charger solution, and reward systems to return old devices	2020/2021
EU Strategy for Textiles	2021
Strategy for a Sustainable Built Environment	2021
Revision of the rules on waste shipments	2021
Legislative and non-legislative measures establishing a new "right to repair"	2021
Legislative proposal for a sustainable product policy initiative	2021
Reflecting circular economy objectives in the revision of the guidelines on state aid in the field of environment and energy	2021
EU-wide harmonised model for separate collection of waste and labelling to facilitate separate collection	2022
Launch of an industry-led industrial symbiosis reporting and certification system	2022

4.5 Is the EU on the right path?

Research shows that key areas which the EU identified in 2015 already have existing managerial and technological solutions that can achieve the first halving of emissions by 2030 and carbon neutrality by 2050. Falk et al. (2018) state that targets to meet revised emissions in energy, critical materials, heavy industry, built environment, CEBMs and mobility can be achieved through a strategy of climate leadership, policy implementation and exponential technological growth.

Housing is the largest annual expense for EU citizens at a cost per household of €9,600 with buildings creating 36 per cent of total CO_2 emissions. Construction is one of the largest sectors accounting for 8.8 per cent of EU GDP and almost 14 million jobs. Most citizens live and work in ever expanding cities (Ellen MacArthur Foundation 2015: 82).

Therefore, the process of how buildings are designed, constructed, renovated and demolished are of critical importance.

From a design point of view both the creation of shared spaces and new lighter building technologies, such as cross laminated woods with considerable higher tensile strength can help revolutionise the sector if it is willing to modernise. Such new technologies lessen the need for production of energy intensive elements such as steel and concrete and act as natural carbon sinks. Further research needs to be completed on the lifecycle emergy analysis and more studies which focus on the whole life cycle of buildings (Ghisellini et al. 2018: 637). Focus on CP in early life phases is essential to ensure greater recovery of C&DW (Ghiselli et al. 2018: 637 quoting Esa et al. 2017).

Some solutions in construction involve the 3D printing of building modules which can be quickly and easily put together and taken apart. Retrofitting can see the energy use of buildings fall by 20-30 percent and new CEBMs can help to utilise existing space better. Digital atomisation in the form of sensors, AI, solar panels or even simply new windows can reduce the amount of energy used or lost through lighting, heating and ventilation (Falk et al. 2018: 46-47).

Regulation will be needed if such CEBMs aim to improve utilisation, with a growing backlash from residents of some of Europe's biggest cities against Airbnb as much needed residential space sits idle. EU offices are only used at an occupancy rate of 35–40 per cent (Ellen MacArthur Foundation 2015: 82). CEBMs will play a role in limiting demand for new construction as business incorporate a sharing economy on a wider scale. Distance working, hotdesking and other new models will become normalised (Falk et al. 2018:48), especially in the wake of coronavirus where working habits have changes considerably.

Construction and demolition account for 25–30 percent of all waste generated in the EU, with excess materials not being recycled and problematic and often toxic mixed waste streams providing issues during demolition. PVC and lead based materials make recovery particularly challenging (Ellen MacArthur Foundation 2015: 82). Ghisellini et al. (2018: 618) explore the environmental and economic impacts of the 3Rs of CE within the C&DWM through a systematic literature review and find that refurbishing existing buildings was both environmentally and economically more beneficial than new constructions. The goal of the renovation wave discussed in the new EU action plan

therefore has the potential to contribute towards a circular and more carbon neutral Europe.

The average European household spends €5,800 on car mobility each year, including taxes. This represents almost 20 percent of the annual gross income of the average European worker (Ellen MacArthur Foundation 2015: 54). Transport accounts for 21 per cent of global emissions with 73 per cent of that figure accounting for short distance travel (Falk et al. 2018: 53).

Figures from Falk et al. (2018: 55) and the Ellen MacArthur Foundation (2015: 12) show the average car is parked 95 and 92 per cent of the time respectively. Clearly this is a serious problem and the likelihood of a rise in CEBMs offering PSS transport service is high, especially for the short distances. Increases in walking, biking and public transport are the more traditional mobility options to decrease emissions, but the rise of apps offering sustainable mobility options and lightweight electronic solutions have grown substantially throughout the world in the last few years (Falk et al. 2018: 55).

The banning of the internal combustion engine is becoming a mainstream option for many European countries as car production switches solely to electric and hybrid models. However, GHG reductions can only be significant if the electricity to power the new fleet is derived from renewable sources. The growth of the sharing economy for electric vehicles powered by clean energy offers an economic boost for EU enterprises and an opportunity to decrease emissions substantially, whilst also greatly decreasing the amount of traffic and the number of vehicles sitting idle.

The EU states that it will aim to increase the circularity of its energy plans, but this is an area where progress is slow. According to figures from Rockström (2017: 1270) global fossil fuel subsides amass $500 - $600 billion, with the International Monetary Fund estimating a mere $300 billion (Ellen MacArthur 2015: 22). The Club of Rome (2018:4) and Falk et al. (2018: 12) agree that fossil fuel subsidies should be stopped immediately with the money being redirected towards renewables. If renewables, such as wind and solar, grow by 50 percent of historical rates then the EU can reduce emissions in energy production by 50 per cent by 2030 (Falk et al. 2018: 8). With oil prices collapsing due to Coronavirus in 2020 it will be interesting to see if this will accelerate a change to a more secure and sustainable energy source or if cheap prices will see governments and businesses buying the commodity at a low price and filling their reserves.

Feeding the global population equates to 22.5 per cent of annual emissions (Falk et al. 2018: 62) with the Ellen MacArthur Foundation finding that in the EU 31 per cent of that food is lost or wasted each year (2015: 19). Average EU food spending per household is €6,600 a year, but the system is inefficient, and waste is created throughout the supply chain (Ellen MacArthur 2015: 70).

More work will need to be done not only in food waste prevention, but in education on diet, with plant-based alternatives playing a key role in limiting EU emissions from food. The Farm-to-Fork strategy will be rolled out in Spring 2020, with early targets suggesting "40 per cent of Common Agriculture Policy should contribute to climate action [and] 30 per cent of the maritime fisheries fund should contribute to climate objectives" (European Commission 2019c: 1).

It seems that with the implementation of the Just Transition Fund, under the European Green Deal, the Commission looks to tackle the underdeveloped social dimension which CE is often said to have. By literally stating the Just Transition will "leave no one behind" the Commission is acknowledging and planning for the issue.

4.5.1 Closing loops

De Man & Friege believe that a total ban on landfilling organic waste is key to closing nutrient loops (2016: 95) but see the idea of the cradle-to-cradle approach as lacking validity due to the constant downgrading of materials (2016: 93). Saavedra et al. (2018: 1519) found that future research of CE from an IE perspective, could focus on solid waste management. This can help collaboration between companies, EIPS and local communities, with the goal of facilitating IS. EU municipal waste recycling rates currently stand at 40 per cent with Member States figures ranging from 5-90 per cent (European Commission 2015: 8).

Saavedra et al. (2018: 1514), note that the inception of more EIPs is an important step in meso level CE development as EIPs help facilitate energy and waste flows associated with IS through by-product exchange. According to Gregson et al. (2015, quoted in Saavedra et al. 2018: 1518) conceptually the integration of IS in CE necessitates by-product and waste exchange as secondary inputs. From a technical contribution various IE tools support CE, such as CP and EcoDesign, but in very different ways. CP is helpful for reducing negative effects associated with emissions, whereas EcoDesign can help to

instigate closed loops by designing products with circular strategies in mind. Therefore, the interconnectivity of combatting existing environmental issues through emissions reductions and rethinking design is a self-enforcing strategy which the EU seems to be following.

Developing useful and accurate indicators is an essential element of the CE in the EU. A 2018 study by Virtanen et al. attempted to fill a research gap in relation to material flows on a regional level. The study aimed to define material flows in Päijät-Häme, Finland, a region with a road map for moving towards a CE. The material flows measured were ash, phosphorous, plastics, textiles and waste wood. Most available data were in relation to waste flows not total material used in production and data from the many producers operating on a SME level were not included at all. The study highlights a lack of adequate information at regional or even national level in areas such as construction and demolition waste, where the EU have a 70 per cent target rate for recycling of non-hazardous waste (Virtanen et al. 2018: 1023). Furthermore, available data were often estimations of national averages in processes related to plastic and textile waste which were extrapolated to a regional level. The study's authors state that the lack of accurate data shows the complexities of implementation of CE at the most basic level.

Polverinia and Miretti (2019) state that the Ecodesign directive plays a large role in mitigating the negative environmental impacts of products by being able to ingrain CE principles into the entire lifecycle of products. Their research finds that the Methodology for Ecodesign of Energy-related Products, an analytical tool for product assessment needs to be updated. The paper suggests factoring in externalities, switching from lifecycle costs to 'equivalent annual cost' and by defining lifecycle costs as a function of energy use and material costs. Such methodological improvements are enablers of improving various performance measures of products covered under the EcoDesign directive, such as, durability, reparability, spare part availability, recyclability and composition and contribution towards secondary raw materials. Interestingly these are some of the key areas to be implanted by the EU following the new CE action plan in 2020, with both the methodology being extended to encompass a much wider amount of products – mainly electronic and ICT devices – and the enacting of the right to repair and various other measures highlighted in the previous section.

4.5.2 Circular Economy Business Models

Stahel (2016) theorises that ownership will give way to stewardship and discusses three kinds of industrial economy: linear, circular and performance, where a performance economy is a PSS style system where products are rented to users under CEBMs and manufactures retain ownership and have responsibility for repair and waste. It is thought that by shifting this responsibility towards the manufactures they will be more motivated to better design products with 3Rs in mind. In the performance economy manufactures are forced to offer long-lasting solutions, rather than simply products, and therefore profits are generated directly from waste prevention (Stahel 2016: 436). With the EU being focused on the economic impacts of CE from the very beginning well formed CEBMs will be important in achieving the strategy.

Bocken et al. (2016) state that “business model and design strategies will need to go hand in hand. Potentially, we will need multiple business model and design strategies, approaches, methods, and tools to support the move to a circular economy” (Bocken et al. 2016: 317). Stahel (2016: 438) believes tax policy should be realigned so that consumption of finite resources, not on renewable resources - including human labour - should be levied. Value added tax should apply to industries and methods of production which are not sufficiently circular but be exempt from CEBMs which employ, for instance, the 3Rs. “In Europe significant advances have been achieved in the pricing of externalities by means of truly interdisciplinary analysis which accounts in detail for the environmental consequences” (Andersen 2007: 133), meaning that environmental economic approaches are having a measurable impact in effectively taxing the negative impacts of products and industries in the EU.

Rosa et al. (2019a: 1) found that most CEBMs are focused around the 3Rs offering PSS, with business model canvas being the most used classification framework. Typically, the majority of CEBMs are based on recycling though there seems to be growing potential in use and product centred PSS. It is also noted that there seems to be a large research gap between how linear and circular business model evolution will occur. It is believed that the complexities of this issue mean that though solutions may be suggested to policy makers, the chances of them being implemented at a SME level is unlikely (Rosa et al. 2019a: 12). Therefore, it is of critical importance for the EU to enable such business models, in areas such as PSS, and easily allow SMEs to operate by removing barriers and providing incentives.

According to Rantaa et al. (2018: 79) there needs to better utilisation of all 3R's which are central CE principles. Currently there is a disproportionate emphasis on recycling (Rantaa et al. 2018: 70; Rosa et al. 2020: 13) and in some cases the end value of recyclables is less than the costs associated with their production. However, Rantaa et al. (2018: 80) admit that its findings may be somewhat biased due to a large percentage of case studies involving waste management companies.

CE literature has a lot of focus on waste management and CP, however, there needs to be much more research committed to methods of production and consumption. According to analysis by Merli et al. (2018: 719) on CEBM, more research is needed into design and innovation strategies to slow material and resource loops, a central element of CE.

Tukker (2015: 12) defines PSS as "an integrated bundle of products and services which aims at creating customer utility and generating value". Tukker (2015: 13) summarises that PSS can be useful as the same level of service can be achieved via the renting and sharing of a lesser total number of goods. However, consumers then tend to treat the products with less care leading to more damage and can lead to shortened lifetimes. Therefore, PSS does not offer a definitive solution. Furthermore, for firms to make the shift from product producers to product and service suppliers it is not always financially possible.

Rosa et al. (2019b: 940) suggests that managers are not always aware of the benefits of implementing CE. In their research they interviewed experts in the Waste from Electrical and Electronic Equipment sector to better understand PSS-based CEBMs and found that when comparing academic literature from a systematic review and opinions of industry experts both agreed that PSS-based CEBMs are the most likely models to achieve circularity. A transparent discussion by the EU which involves all stakeholders is needed to ensure a deep understanding of the benefits of CE in relation to PSS.

Technological advances must be utilised to assist the implementation of CE. I4.0 technology such as 3D printing, big data management and IoT will certainly help achieve circularity quicker if used in areas such as the lifecycle management of products and will act as digital enablers (Rosa et al. 2020: 1679). In an earlier paper, Rosa et al. (2019a: 14) show new research opportunities and which CEBMs governments could effectively subsidise based on archetypes they created in specific sectors. The "Exchange"

archetype suggests the importance of defining if integration between concepts such as CE and I4.0 are viable. Furthermore, according to Sassanelli et al. (2019: 451) a specific CE performance assessment of CEBMs needs to be developed, in order to provide practitioners with an assessment tool quantifying benefits deriving from CE.

Rosa et al. (2019b; 2020) found that more research into how technology can be utilised into CEBMs and CE strategies to aid the decision-making process for managers under either Circular I4.0 or a Digital CE models, where either circularity defines the use of I4.0 technologies or vice versa. De Jesus et al. (2018: 3014) find that eco-innovation (EI) can play a key role in the promotion of cooperation between CE actors. Furthermore, the development of indicators and sound scientific measurement criteria will greatly aid the transition towards circularity and allow both policy makers and managers to make more logical choices.

Sassanelli et al. (2019: 451) defined a framework which can effectively measure how circular a company is. Their review finds evidence of a plethora of existing tools which measure various aspects of circularity. Design for X is used at a product design and development level, whereas Life Cycle Assessment and Material Flow Analysis are well known tools for assessing the entire lifecycle of products. A framework was developed which from a policy point of view can be used to create a process where firms and their products can be certified in a similar way to organic certification schemes. Such circular Key Performance Indicators can be used by companies throughout the product design process to compare not only completely different products but different versions of the same product dependent of the circular benefits of each.

Manninen et al. (2018) developed a framework for evaluating the environmental value propositions of CE business models. Where the term environmental value proposition (EVP) is defined as “an absolute value being a promise of environmental improvement, which a company provides to the environment by its impacts throughout the whole value chain” (Manninen et al. 2018: 413). The framework consists of an EVP table and a step-by-step approach towards an evaluation process. The framework was then tested on 3 CEBM cases. The idea was that companies can then use the framework to design new CEBMs or can verify and/or evaluate the environmental benefits and sustainability of existing business models. However, limitations were suggested because environmental benefits were only estimates derived from the EVP. A more scientific method than

estimation needs to be developed in the future for the model to be useful in a wider context.

Lieder and Rashid's (2016: 48) framework proposes a consistently applied strategy from the top-down and the bottom-up simultaneously to better retain interest from all stakeholders. It is also important to equally favour economic and environmental goals and not focus to strongly on either at the detriment of the other. The CE Monitoring Framework will be updated in 2021 so that changes outlined in the new CE plan can be included and more variation should be included to better suit all stakeholders.

Supply chain redesign is a complex and problematic area for CE policy. To begin to address the issue Bressanelli et al. (2019: 7416-7417) conducted a systematic literature review and then constructed a framework encompassing challenges and levers to potentially act as solutions. Manages would then be able to use the framework as a starting point to assess implications and risks of undertaking CE strategies and which levers can be used to minimise or avoid associated risks. The researchers highlight the limitations of this study as the framework was tested in four case studies which were chosen for their appropriateness and not because they were a representational sample. The generalisation of the findings is therefore not possible though the study acts as a first step into the discussion on how supply chains can be optimised with CE principles in mind.

5 Conclusion

The main purpose of this paper was to investigate how CE was being implemented within the EU and what the projected impact could be to secure a more sustainable economic and environmental future. Though CE is not a particularly new concept, it has gained increasing amounts of attention during the last decade from academia, policy and decision makers alike. CE has a focus on the 3Rs with an emphasis on maintaining the integrity of materials already produced and attempting, where possible, to tighten or even close material loops. The diminished application of the model towards achieving social objectives give pause, but in highlighting a Just Transition towards carbon neutrality, and leaving no one behind, the EU may be supporting CE in a known area of weakness.

China has close to 20 years' experience of implementing CE at a huge scale. Though the methods of governance are clearly different and the catalysts for choosing CE as a strategy divergent, there are many similarities in the process of implementation. Therefore, as academic research shows, there are lessons which can be lernt for the EU and areas where cooperation can be beneficial for both parties. Though China uses a centrally planned top-down strategy, the EU has existing infrastructure and policy which can be reconfigured to work towards CE goals. However, it is important to realise that a mixture of top-down and bottom-up strategies may work the best, and policy implementation alone will not be enough to realise the full potential of CE and avoid rebound effects.

Both China and the EU initially focused on waste management and CP before moving onto wider implementations. In China this was, among other things, the creation of EIPs where IS can be initiated. In the EU the next stage is focused around production and consumption, with policies such as the Sustainable Product Policy framework and Circular Electronics Initiative which attempt to tackle planned obsolescence and install the right to repair in an extended line of products under the Ecodesign directive. The EU will also use its considerable buying power to mainstream green products through areas such as Green Public Procurement. Increasing the market for secondary raw materials and working towards the inception of more EIPs will be facilitated by the launch of an industry led IS reporting and certification system beginning in 2022. Expanding CE beyond waste management, consumption and production and into wider implementation such as material and energy flows will be an important part of the EU's Industrial Strategy in the future.

Our built environment, mobility and food account for around two thirds of GHG emissions and a considerable amount of household incomes. These are therefore the most important areas to achieve neutrality by 2050 under the European Green Deal, and meet the targets set by the PA. However, the ability of European government to dictate where we live, how we travel and what we eat is extremely limited. The EU must redefine its stance on energy and look at ending fossil fuel subsidies and incentivising the development of renewables. This process will be done by increasing sustainability under National energy and climate plans (NECP), but concrete action is as yet undefined. A new Strategy for a Sustainable Built Environment alongside a renovation wave will look to increase circularity in the construction and demolition sector, where as the Farm-to-Fork strategy will look to rethink the entire value chain for

food consumption. Tackling emissions in mobility will come via a ban on the internal combustion engine and the promotion of CEBMs for transport and the increase in public transport, cycling and walking.

With the EU being focused on the economic impacts of CE from the very beginning well formed CEBMs will be important in achieving the strategy. The growth of the sharing economy for electric vehicles powered by clean energy offers an economic boost for EU enterprises and an opportunity to decrease emissions substantially, whilst also greatly decreasing the amount of traffic and the number of vehicles sitting idle. Therefore, it is of critical importance that the EU enable such business models, in areas such as PSS for the use of electric vehicles and allow SMEs to operate by removing barriers and providing incentives. Furthermore, it is important to scale up the implementation of market ready solutions and technologies to with the aim of reducing GHG emission quickly.

Other popular CEBMs for SMEs will evolve out of the reviewed Ecodesign directive and the right to repair. Tax exemptions for circular business and heavier tax for non-renewable industries can help accelerate the circularity of such models. Certification schemes like those achieved by organic producers would help businesses show consumers how sustainable they were in a transparent way. Simple frameworks need to be made available to managers and owners of SMEs to simplify the process of assessing the circularity of products and business models.

Closing material loops will be achieved via the inclusion of mandatory recycled materials in products, continued regulation in plastics, and stricter targets for EU wide recycling. The banning on the exporting of waste to countries where standards are not aligned with EU policy should be rushed through to protect the health of foreign workers and the integrity of the EU's CE action plan and hopes of a global circular alliance.

The main limitation of this research is related to the lack of other critical sources towards the new CE road map – mainly due to the fact it was only release in March 2020. However, it was deemed important to review the most up to date material available from the Commission to give a contemporary analysis of the state of play of CE in the EU. The research conducted on China to give a basis of comparison was also deemed necessary but could have been its own area of research. Finally, the two

main concepts of closing material loops and CEBMs were identified as key areas for deeper research as they seemed to reflect the main ambition of the EU's definition of CE, that is to protect against resource scarcity and create a more sustainable economy.

Future research needs to be conducted in how effective the strategies and methods under the CE road map are in meeting the targets of the European Green Deal and the PA. A focus on production, consumption and waste management will not by itself achieve neutrality by 2050. The creation of EIPs driven by a more circular European Industrial Strategy will be necessary. It is also important to follow how the EU will include strategies on built environment, food and mobility alongside updating NECPs to better achieve emission reduction targets.

References

Andersen, M.S., 2007. An introductory note on the environmental economics of the circular economy. *Sustainability science*, *2*(1), pp.133-140. Available at: < https://doi.org/10.1007/s11625-006-0013-6> [Accessed 16/04/2020]

Bocken, N.M., De Pauw, I., Bakker, C. and van der Grinten, B., 2016. Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), pp.308-320. Available at: <https://doi.org/10.1080/21681015.2016.1172124> [Accessed 16/04/2020]

Bressanelli, G., Perona, M., & Saccani, N. 2019. Challenges in supply chain redesign for the Circular Economy: a literature review and a multiple case study, International Journal of Production Research, 57:23, 7395-7422, Available at: <https://doi.org/10.1080/00207543.2018.1542176> [Accessed 16/04/2020]

Club of Rome, The. 2018. Climate Emergency Action Plan. A Collaborative Call for Climate Action. Available at: < https://mahb.stanford.edu/wp-content/uploads/2019/02/COR_Climate-Emergency-Plan.pdf> [Accessed 16/04/2020]

EASAC policy report 35 February 2018. Negative emission technologies: What role in meeting Paris Agreement targets? ISBN: 978-3-8047-3841-6. Available at: <https://easac.eu/fileadmin/PDF_s/reports_statements/Negative_Carbon/EASAC_Report_on_Negative_Emission_Technologies.pdf> [Accessed18/04/2020]

Ellen MacArthur Foundation. 2019. Schools of Thought. Available at <https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought> [Accessed 16/04/2020]

Ellen MacArthur Foundation, SUN, McKinsey Center for Business and Environment, 2015. Growth Within: A Circular Economy Vision for A Competitive Europe. Available at: <https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf> [Accessed 27/04/2020]

European Commission. 2015. *Closing the loop - An EU action plan for the Circular Economy*. Brussels. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614> [Accessed 27/04/2020]

European Commission. 2018. A European Strategy for Plastics in a Circular Economy. Brussels. Available at:< https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF> [Accessed 17/04/2020]

European Commission. 2019a. Report from The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. On The Implementation Of The Circular Economy Action Plan. Brussels, 4.3.2019. Available at: <http://ec.europa.eu/environment/circulareconomy/pdf/report_implementation_circular_economy_action_plan.pdf> [Accessed 27/04/2020]

European Commission. 2019b. *The European Green Deal.* Brussels. Available at: <https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf> [Accessed 13/04/2020]

European Commission. 2019c. From Farm to Fork. Brussels. Available at: <https://ec.europa.eu/commission/presscorner/api/files/attachment/860605/Farm_to_fork_en.pdf.pdf> [Accessed 19/04/2020]

European Commission. 2019d. Circular Economy Package Report: Questions & Answers. Brussels. Available at: <https://ec.europa.eu/commission/presscorner/detail/en/MEMO_19_1481> [Accessed28/04/2020]

European Commission. 2020a. *A new Circular Economy Action Plan For a cleaner and more competitive Europe*. Brussels Available at: <https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF> [Accessed 13/04/2020)

European Commission. 2020b. *Questions and Answers: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe.* Brussels. Available at: <https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_419> [Accessed 13/04/2020]

European commission. 2020c. Proposal for a regulation of the European parliament and of the council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law). Brussels. Available at: <https://ec.europa.eu/info/sites/info/files/commission-proposal-regulation-european-climate-law-march-2020_en.pdf> [Accessed 13/04/2020]

European Commission. 2020d. *A New Industrial Strategy for Europe.* Brussels. Available at: < https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf> [Accessed 13/04/2020]

European Commission. 2020d. *A new Circular Economy Action Plan For a cleaner and more competitive Europe Annex*. Brussels Available at: <https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan_annex.pdf> [Accessed 27/04/2020]

European Commission. Communication from The Commission. Ecodesign Working Plan 2016-2019. Brussels, 30.11.2016. Available at: <https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf> [Accessed 01/04/2020]

Falk, J. Gaffney, O. Bhowmik, A. Borgström-Hansson, C. Pountney, C. Lundén, D. Pihl, E. Malmodin, J. Lenhart, J. Jónás, K. Höjer, M. Bergmark, P. Sareen, S. Widforss, S. Henningsson, S. Plitt, S. Shalit, T. Exponential Climate Action Roadmap. Future Earth. Sweden. September 2018. Available at <https://exponentialroadmap.org/wp-content/uploads/2018/09/Exponential-Climate-Action-Roadmap-September-2018.pdf> [Accessed 04/04/2020]

Feng, Z., and Yan, N. 2007. Putting a circular economy into practice in China. Sustainable Science 95–101. Available at: < DOI: 10.1007/s11625-006-0018-1 f> [Accessed 12/04/2020]

Geissdoerfer, M., Savaget, P., Bocken, N.M. and Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm?. Journal of cleaner production, 143, pp.757-768. Available at: <https://doi.org/10.1016/j.jclepro.2016.12.048 > [Accessed 27/04/2020]

Geng, Y., and Doberstein, B. 2008. Developing the circular economy in China: Challenges and opportunities for achieving 'leapfrog development'. International Journal of Sustainable Development & World Ecology 15 pg 231–239. Available at:< DOI: 10.3843/SusDev.15.3:6> [Accessed 27/04/2020]

Ghisellini, P.Cialani, C. Ulgiati, S. 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, Vol: 114, Page: 11-32. Available at <https://doi.org/10.1016/j.jclepro.2015.09.007 > [Accessed 27/04/2020]

Ghisellini, P., Ripa, M., Ulgiati, S.,. 2018. *Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review.* Journal of Cleaner Production Volume 178, 20 March 2018, Pages 618-643. Available at: <https://doi.org/10.1016/j.jclepro.2017.11.207> [Accessed 27/04/2020]

IPCC. 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, inthe context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp. Available at <https://www.ipcc.ch/sr15/> [Accessed: 27/04/2020]

de Jesus, A., Antunes, P., Santos, R., Mendonça, S. 2018. Eco-innovation in the transition to a circular economy: An analytical literature review. Journal of Cleaner Production Volume 172, 20 January 2018, Pages 2999-3018. Available at: <https://doi.org/10.1016/j.jclepro.2017.11.111> [Accessed 27/04/2020]

Kummu, M., Guillaume, J., de Moel, H. 2016. The world's road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Sci Rep 6, 38495. Available at:<https://doi.org/10.1038/srep38495> [Accessed 27/04/2020]

Kalmykova, Y., Sadagopan, M., Rosadocet, L. 2018. Circular economy – From review of theories and practices to development of implementation tools. Resources, Conservation & Recycling 135 190–201. Available at:<https://doi.org/10.1016/j.resconrec.2017.10.034 > [Accessed 27/04/2020]

Kirchherr, J., Reike, D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resources, conservation and recycling, 127, pp.221-232. Available at: < https://doi.org/10.1016/j.resconrec.2017.09.005> [Accessed 27/04/2020]

Korhonen, J., Honkasalo, A. and Seppälä, J., 2018. Circular economy: the concept and its limitations. Ecological economics, 143, pp.37-46. Available at: <https://doi.org/10.1016/j.ecolecon.2017.06.041> [Accessed 27/04/2020]

Lenton, T., Rockström, J.,Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W., & Schellnhuber, H. 2019. Climate tipping points — too risky to bet against the growing threat of abrupt and irreversible climate changes must compel political and economic action on emissions. Nature Vol 575 28 November 2019 592-595 Available at: <https://www.nature.com/articles/d41586-019-03595-0> [Accessed:13/04/20]

Lieder, M. and Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of cleaner production*, *115*, pp.36-51. Available at: < https://doi.org/10.1016/j.jclepro.2015.12.042> [Accessed 27/04/2020]

de Man, R., & Friege, H., 2016. Circular economy: European policy on shaky ground. Waste Management & Research 2016, Vol. 34(2) 93–95 Available at: <DOI: 10.1177/0734242X15626015> [Accessed 18/04/2020]

Manninen, K., Koskela, S., Antikainen, R., Bocken , N., Dahlbo, H., Aminoff, A.. 2018. Do circular economy business models capture intended environmental value propositions? Journal of Cleaner Production Volume 171, 10 January 2018, Pages 413-422. Available at: <https://doi.org/10.1016/j.jclepro.2017.10.003> [Accessed 27/04/2020]

Mathews, J., Tang, Y. & Tan, H. 2008. China's move to a Circular Economy as a development strategy. Asian Business & Management Vol. 10, 4, 463–484. Available at:< https://doi.org/10.1057/abm.2011.18> [Accessed 27/04/2020]

McDowall, W., Geng, Y., Huang, B., Barteková, E., Bleischwitz, R., Türkeli, S., Kemp, R. and Doménech, T. 2017. Circular Economy Policies in China and Europe. Journal of Industrial Ecology, 21: 651-661. Available at: <doi:10.1111/jiec.12597> [Accessed 16/04/2020]

Merli,. R,Preziosi, M,. & Acampora, A,. 2018. How do scholars approach the circular economy? A systematic literature review. Journal of Cleaner Production 178 (2018) 703-722. Available at:<https://doi.org/10.1016/j.jclepro.2017.12.112> [29.03.2020]

Millar, R., Fuglestvedt, J., Friedlingstein, P. 2017. Emission budgets and pathways consistent with limiting warming to 1.5 °C. Nature Geoscience 10, 741–747 (2017). Available at: <https://doi.org/10.1038/ngeo3031> [Accessed 18/04/2020]

Murray, A., Skene, K. and Haynes, K. 2017. The circular economy: an interdisciplinary exploration of the concept and application in a global context. Journal of business

ethics, 140(3), pp.369-380. Available at < https://doi.org/10.1007/s10551-015-2693-2>. Journal of Business Ethics. 10.1007/s10551-015-2693-2. [Accessed 16/04/2020]

Pardo, R. Schweitzer, J.P. 2018. 'A long-term strategy for a European circular economy – setting the course for success', Policy Paper produced for the Think2030 project, Brussels, November 2018. Available at < https://ieep.eu/uploads/articles/attachments/f99f1ac9-83a0-47e0-a0a2-74f3ce528ad8/Think%202030%20Circular%20Economy.pdf?v=63710011292> [Accessed 16/04/2020]

Polverinia, D., Miretti, U., 2019 An approach for the techno-economic assessment of circular economy requirements under the Ecodesign Directive. Resources, Conservation and Recycling Volume 150, November 2019, 104425. Available at: <https://doi.org/10.1016/j.resconrec.2019.104425> [Accessed 16/04/2020]

Rantaa, V., Aarikka-Stenroosa, L., Ritalab, P., Mäkinena, S., J. 2018. Exploring institutional drivers and barriers of the circular economy: A cross regional comparison of China, the US, and Europe. Resources, Conservation and Recycling Volume 135, August 2018, Pages 70-82. Available at: <https://doi.org/10.1016/j.resconrec.2017.08.017> [Accessed 26/04/2020]

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic,N.,& Schellnhuber, H., J. 2017. A roadmap for rapid decarbonization. Science 355 (6331), 1269-1271. Available at: <doi: 10.1126/science.aah3443> [Accessed 16/04/2020]

Rosa, P., Sassanelli, C., Terzi, S.. 2019a. Towards Circular Business Models: A systematic literature review on classification frameworks and archetypes. Journal of Cleaner Production Volume 236, 1 November 2019, 117696. Available at: <https://doi.org/10.1016/j.jclepro.2019.117696> [Accessed 16/04/2020]

Rosa, P., Sassanelli, C., Terzi, S. 2019b. Circular Business Models versus circular benefits: An assessment in the waste from Electrical and Electronic Equipments sector. Journal of Cleaner Production Volume 231, 10 September 2019, Pages 940-952. Available at: <https://doi.org/10.1016/j.jclepro.2019.05.310> [Accessed 16/04/2020]

Rosa, P., Sassanelli, C., Urbinati, A., Chiaroni, D., & Terzi, S. 2020. Assessing relations between Circular Economy and Industry 4.0: a systematic literature review, International Journal of Production Research, 58:6, 1662-1687, <Available at: DOI: 10.1080/00207543.2019.1680896> [Accessed 25/04/2020]

Saavedra, Y. Iritani, D. Pavan, A. Ometto. A., Theoretical contribution of industrial ecology to circular economy. Journal of Cleaner Production 170 (2018) 1514 – 1522. Available at: <https://doi.org/10.1016/j.jclepro.2017.09.260> [Accessed 16/04/2020]

Sassanelli, C., Rosa, P., Rocca, R., Terzi S.. 2019. Circular economy performance assessment methods: A systematic literature review. Journal of Cleaner Production Volume 229, 20 August 2019, Pages 440-453. Available at: <https://doi.org/10.1016/j.jclepro.2019.05.019> [Accessed 16/04/2020]

Sauvé, S. Bernard, S. Sloan, P. 2016. Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. Environmental Development, Vol: 17, Page: 48-56. Available at:<https://doi.org/10.1016/j.envdev.2015.09.002> [Accessed 16/04/2020]

Shepherd, A., Ivins, E., Rignot, E. 2020. Mass balance of the Greenland Ice Sheet from 1992 to 2018. Nature 579, 233–239 (2020). Available at: <https://doi.org/10.1038/s41586-019-1855-2> [Accessed 21/04/2020]

Stahel, W.R., 2016. The circular economy. Nature, 531(7595), pp.435-438. Available at:< https://www.nature.com/articles/531435a.pdf> [Accessed 13/04/2020]

Su, B., Heshmati, A., Geng, Y. and Yu, X., 2013. A review of the circular economy in China: moving from rhetoric to implementation. *Journal of cleaner production*, *42*, pp.215-227.Available at: < https://doi.org/10.1016/j.jclepro.2012.11.020> [Accessed 16/04/2020]

Türkeli, S., Kemp, R., Huang, B., Bleischwitz, R. McDowall W. 2018. Circular economy scientific knowledge in the European Union and China: A bibliometric, network and survey analysis (2006-2016). Journal of Cleaner Production 197 (2018) 1244-1261. Available at:<http://doi.org/10.1016/j.jclepro.2018.06.118> [Accessed 16/04/2020]

Virtanen, M., Manskinen, K., Uusitalo, V., Syvänne, J., Cura, K. 2019. Regional material flow tools to promote circular economy. Journal of Cleaner Production Volume 235, 20 October 2019, Pages 1020-1025. Available at: <https://doi.org/10.1016/j.jclepro.2019.06.326> [Accessed 25/04/2020]

Willis, J. K., Kemp, A., and Strauss, B.H. 2018. James Balog/Extreme Ice Survey. Smithsonian Institution. Available at:< https://ocean.si.edu/through-time/ancient-seas/sea-level-rise> [Accessed 16/04/2020]

World Meteorological Orginization. 2019. Greenhouse gas concentrations in atmosphere reach yet another high. Available at:<https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-atmosphere-reach-yet-another-high> [Accessed 13/04/20]

Yuan, Z., Bi, J. and Moriguichi, Y., 2006. The Circular Economy: A New Development Strategy in China. Journal of Industrial Ecology Volume 10, Number 1–2. Available at:<DOI: 10.1162/108819806775545321> [Accessed 17/04/2020]