

Understanding Circular Economy Awareness and Practices in Manufacturing Firms

Abstract

Purpose: Circular Economy (CE) has evolved as a result of the growing environmental awareness, environmental legislation and the need for social responsibility. However, awareness levels of CE are not as high as expected and practices are further behind than they should be, with a significant lack of research around the subject in the literature. This study therefore attempts to examine the current state of awareness levels and the practices around CE in manufacturing firms. Moreover, the study aims to empirically validate one of the earlier proposed CE models.

Design/methodology/approach: The study adopts a quantitative survey questionnaire based approach. More than 500 people from various manufacturing organisations were contacted directly over a 40-day long sampling process through the FAME database, personal contacts and LinkedIn. The survey resulted in 103 completed responses. Given the exploratory nature of the study, the data was mainly analysed using descriptive statistics. To validate the CE model, a correlation analysis was also conducted.

Findings: The research findings show that with the growing emphasis on CE across the globe by governing bodies, firms are becoming more aware of CE practices. The analysis also shows some useful insights on the state of each of the pillars (economic benefits, environmental impact and resource scarcity) of CE. Our findings also indicate that the environmental impact pillar of CE is at a more developed state than the other two pillars which are –mostly- in a research state.

Research Implications and Limitations: The study provides manufacturing firms with a thorough understanding of the state of CE practices and importance of its successful implementation. The findings of the study advocates consideration of all three pillars of CE by managers as a guide to plan for an efficient strategy around CE implementation. Moreover, our study adds to existing efforts by the academic community to raise the awareness towards CE practice among all relevant stakeholders. The findings of this study are based on the responses from a limited 103 survey responses from manufacturing firms.

Originality/value: This study adds to the very limited empirical literature on CE awareness and practices in manufacturing firms. This is also one of the first studies attempting to empirically validate an existing CE model.

Keywords: Circular Economy, manufacturing firms, awareness, practices, empirical.

1. Introduction

In recent years, the traditional economic model of “make-use-dispose”, which had proven to be an effective and widely acceptable approach of making business, has been put in question for various reasons (Stahel, 2016; Andrews, 2015). Whether that is becoming aware of the environmental impact of a firm’s activities, having to adhere to the environmental legislation or having to adjust to issues regarding the scarcity of resources, a need for a different economic model has been present since the early 2000s. One approach that appears to effectively provide solutions for these issues is Circular Economy (CE) (Kumar et al., 2019; Irani and Sharif, 2018; Lieder & Rashid, 2016).

CE is a term that first appeared in the last decade of the 20th century (Pearce & Turner, 1990), as an alternative to the traditional economic model and it is based on the basic principles of the Laws of Thermodynamics. However, the term remained in obscurity until it was first implemented by the Chinese government in the wake of the 21st century, through an initiative called the “Circular Economy Promotion Law of the People’s Republic of China” (Lieder & Rashid, 2016). The positive results of that implementation piqued the interest of manufacturing firms worldwide as well as governing bodies in the European continent. Having seen the vast improvements that were achieved in the Chinese landscape and realizing the opportunity behind the concept of CE, European officials decided that CE was an approach that needed to be promoted, as an alternative to the unsustainable current economic model (European Commission, 2015). Since then, a significant number of firms have started to look into CE and have attempted (and succeeded) to take advantage of the opportunities that it offers.

Although CE has gained momentum in recent years, the extent of implementation of CE principles in manufacturing firms across the globe is below expectations, primarily due to their low awareness as reported in recent studies by Masi et al. (2018) and Ormazabal, et al. (2018). There is also a lack of universally accepted frameworks/models that encapsulate the aspects of CE and there is no hard proof on the financial efficiency behind the adoption of such approach. There have been few attempts by researchers such as Laybourn (2015), Lieder & Rashid (2016) and Bocken et al. (2016) who proposed various models on CE. However, the literature lacks the empirical validation of the existing CE models proposed by various researchers. One of the major issues that the implementation of CE faces is the lack of evidence on its practical effectiveness. More importantly, the financial benefits of the implementation of the approach are a critical factor for most businesses, and it deters firms from adopting such an approach. This study therefore attempts to examine the current state of awareness levels and the practices around the CE approach in manufacturing firms. The study will also review the existing frameworks and models of CE implementation reported in the literature and aim to empirically validate one of the CE models. This study will therefore contribute to the limited empirical literature on CE awareness and practices in manufacturing firms.

The rest of the paper is organised as follows; Section 2 provides a brief literature review on the linear and 3R principles. This is followed by CE applications and limitation factors in Section 3. Section 4 reviews the existing CE frameworks and models, whereas Section 5 elaborates the research methodology followed in this study. Section 6 presents the findings and discussion of the study. Finally, Section 7 concludes the study by summarising key findings, highlighting the implications, limitations and future research directions.

2. Literature Review

2.1 Linear and The 3R's Principles

The aim of CE is to provide an alternative approach to the traditional (linear) economy model that is based on the concept of take-make-use-dispose (The Ellen MacArthur Foundation, 2014; Morlet, et al., 2016). Until recently, the traditional (linear) approach had proven to be effective for firms. One of the reasons behind this is the fact that it is a relatively simple, straightforward and proven method that requires no further investment on the part of the firms that embrace it. However, this approach seems no longer fit for the needs of the modern world, as virgin resources are finite and constantly deteriorate (Heshmati, 2015) (European Commission, 2015). A direct consequence of the domination of the linear economy model and, therefore, the increasing activity of the fast-moving consumer goods industry, is the inevitable environmental impact that is directly associated to the ever-increasing amount of waste produced and required to fulfil the needs of modern society (The Ellen MacArthur Foundation, 2013; Lieder & Rashid, 2016). Despite the financial advantages of the linear model, it is more than evident that the environmental implications of its continuous use have started to catch up to humanity and, if precautions are not taken, it will lead to serious issues (Yuan, et al., 2006; Preston, 2012; Pan, et al., 2015). In order to prevent a potential impending resource catastrophe, governments and institutions around the world have been taking measures, combating the issue, especially since the dawn of the new millennium. Various issues that have arisen with the linear model, and in conjunction with the increasing environmental awareness in recent years, led to the rise of CE as an approach that intends to combine business with sustainability of resources while maintaining environmental awareness (Singh & Ordonez, 2016; Lieder & Rashid, 2016; Kopnina, 2019). Having recognized the issues concerning the linear approach, the EU has been trying to raise awareness and promote CE practices through its institutions and, especially, through a collaborative program provided by the European Commission and the European Investment Bank called the “Circular Economy Finance Support Platform” that was launched in January 2017 (European Commission, 2017). However, due to the immaturity of the proposed measures, firms still mostly operate under the linear approach, rather than the CE model. Evidence shows that while governments and international institutions have understood the importance of CE and have made efforts towards promoting its implementation, those efforts are lacklustre, so far, and a lot more work needs to be put in them if firms are to abandon linear and adopt the CE approach (Kumar et al., 2019; Tam, Soulliere, & Sawyer-Beaulieu, 2019).

Having established how the linear approach is structured and how it fares in the modern business environment, it is deemed vital to understand the basic pillars that complement the CE approach (Lieder & Rashid, 2016). As opposed to the traditional view of make-use-dispose, CE uses a concept, which is called the 3R's and consists of a reduce-reuse-recycle methodology (Yuan, et al., 2006; Liu, et al., 2008; Heshmati, 2015; Goyal, Esposito, & Kapoor, 2018). While the origins of the 3R's term are not well known, they are usually being attributed to the 1970s, which saw the initial emergence of environmental consciousness in the U.S.A. (Pantheon Enterprises, 2017). In general, as it is expected, the term has been associated with the environment. However, the logic behind the 3R's approach has been implemented in other sectors such as information technology (IT), solid waste management, and plastic waste management (Gadde, et al., 1997; Alahari, et al., 2008; Anik et al. 2018; Wichai-utcha, & Chavalparit, 2019). While there are different ways to interpret the 3R's philosophy, as far as CE is concerned, the 3R's are considered to be the link between the financial and the environmental factors and the more practical side of the model, especially in production and consumption (Yuan, et al., 2006; Su, et al., 2013; Heshmati, 2015; Vasiljevic-Shikaleska, et al., 2017).

As far as 'Reduction' is concerned, this is mainly related to the minimization of clean raw materials and resources by implementing the required changes in the production line, while consumers are encouraged to be more prudent of the products they use and the environmental impact of their actions (Su, et al., 2013; Heshmati, 2015; Anik et al. 2018). At the same time, as it can be easily assumed, 'Reusing' refers to the re-introduction of waste and by-products to production as resources until those are used to their full potential (Su, et al., 2013; Heshmati, 2015; Wichai-utcha, & Chavalparit, 2019). Finally, 'Recycling' promotes the development of processes that look to take advantage of the full capability of each resource, in order to achieve the sought reduction in clean materials (Su, et al., 2013; Heshmati, 2015).

2.2 CE Applications and Limitation Factors

Unarguably, the implementation of CE holds several benefits impacting environmental and economic strategies (Yuan, et al., 2006; Kumar et al., 2019). Yuan, et al. (2006) and Zhijun & Nailing (2007) report that the Chinese Government has identified three steps/levels that needed to be put into action towards a successful and effective implementation of a CE.

The first step (microscopic) consists of a strict Cleaner Production (CP) approach that needs to be carried out by all individual firms that operate in China and, especially, by firms that produce heavy pollution. As it is expected, for a firm to be able to achieve the CP law metrics, they need to adapt their processes in various aspects (i.e. raw materials and energy for production, after-life effects for the finished product). Despite the severity of the measures taken, the Chinese government succeeded in making CP auditing attractive and sought by manufacturing firms, as individual firms that pass those audits successfully were offered significant financial rewards (Yuan, et al., 2006; Zhijun & Nailing, 2007; Geng & Doberstein, 2008; Ghisellini, et al., 2016).

The second step (mesoscopic) attempts to create a network between eco-friendly industrial firms that facilitates their collaboration while at the same time empowering the regional economy. Through this network, the government attempted to improve partnerships between firms and promote the potential sharing of infrastructure among them. One of the most successful measures towards that goal has been the development of Eco-Industrial Parks (EIPs) and zones. That success is evident when looking at the number of Chinese EIPs, which were estimated to be more than 100 in 2006 and surged to more than 1600 in 2015. The main objective of these parks is to promote the reuse of waste and by-products between the firms that are based there, assisting, therefore, in the development of new supply chain strategies for the resources of those firms (Yuan, et al., 2006; Zhijun & Nailing, 2007; Geng & Doberstein, 2008; Thieriot & Sawyer, 2015; Ghisellini, et al., 2016; Zeng, et al., 2017).

The third step (macroscopic) consists of the development of what the Chinese government calls “eco-cities/municipalities/provinces”. Through this step, local Environment Bureaus are trying to achieve sustainability in industrial production as well as in the consumption of materials, while, at the same time, reducing pollution levels in the specified area. Under that goal, these eco-areas, which are also known as CE areas in the literature, are also looking for ways to assist in the fulfilment of four main CE requirements (Yuan, et al., 2006; Zhijun & Nailing, 2007; Geng & Doberstein, 2008; Ghisellini, et al., 2016).

All these three levels (micro, meso and macro) are related and inter-dependent. For example, macro level initiatives can result in disturbances at the micro-level and reduced levels of environmental performance (White et al., 2015; Masi et al. 2018). Due to the amount of CE literature originating from China and its proven success, the micro/meso/macroscopic approach has been accepted to be the fundamental method used to define practices of CE (Heshmati, 2015). In the UK, Scotland has also recently decided to endorse CE practices and promote change in processes towards CE. In collaboration with three important stakeholders, i.e. Scotland’s Enterprise Agencies, Zero Waste Scotland and the Scottish Environment Protection Agency, the Scottish Government has set a number of targets in August of 2015 that need to be fulfilled by 2025 at the latest, with its main focus laying on significant reduction (33%) of food waste (The Ellen MacArthur Foundation, 2015).

One of the most important and well-known initiatives following European environmental legislation in recent years is the “2020 Climate and Energy Package”, which sets three main targets that the EU needs to achieve, as a whole, by the year 2020. Three specific targets were (European Commission, 2007): reducing greenhouse gas emissions by 20% compared to 1990; increasing energy generation by renewable/resources (at least 30%), and increasing energy efficiency by at least 20%. This package set targets in five specific sectors (Employment, R&D, Climate Change and Energy Sustainability, Education, Poverty and Social Exclusion) that must be achieved through a number of proposed measures (European Commission, 2007). In mid-2014, CE was first introduced, only to be taken back and reintroduced in late 2015 with various alterations and revisions (European Parliament, 2016). The European Parliament (2016) made an

assessment of the situation regarding CE and proposed new environmental directives that would look to promote it and take care of some important issues that concern waste and environmental impact in the EU. In addition to that, a number of other targets were set for the years 2025 and 2030 respectively. Having recognized the potential of adopting CE, European governing bodies (through the European Commission and the European Parliament) have started making significant efforts in its promotion.

The literature indicates that the implementation of CE is still at an exploratory stage, with most firms still scratching the surface of the massive potential of the CE (Masi, et al., 2018). Due to the fact that the term of CE has only started to become popular in the European continent in the last recent years, there seem to be fluctuations and uncertainty, as far as the awareness levels are concerned, with a range of between 35% (Ormazabal, et al., 2018) and 65% (Masi, et al., 2018) of respondent questioned having heard of CE before, much lower than the 90% awareness level which was measured in China (Liu & Bai, 2014), where CE was introduced more than 10 years ago. However, some evidence reported in the literature shows that the majority of the firms that do business in the European continent are applying some of the aspects of CE, e.g. Scandinavian-based firms that operate on a global market (Swedish CE research begun earlier than the rest of Europe) (Lieder & Rashid, 2016). For instance, the Swedish vacuum waste collection systems firm Envac has created a system to turn waste into electricity (Törnblom, 2014) (Heshmati, 2015), whereas Ragn-Sellsföretagen AB (a recycling firm) tries to maximize the potential of garbage (Acheampong, 2016). Finally, INREGO, a Swedish firm, refurbishes used electronics and redistributes them to schools and other reselling firms (Acheampong, 2016). Since the term CE and the exploration of its potential in the Western world are relatively recent (mostly after 2010), there is a severe difficulty in finding studies on the implementation of CE in firms (Sunniva, et al., 2017).

2.3 CE frameworks/models

Although CE has gained a lot of popularity in recent years, there is a lack of studies that have attempted to propose frameworks/models to successfully implement CE practices in organisations. Moreover, those which have presented some sort of framework have failed to successfully visualize the steps needed for a firm to be able to adopt CE and for a state authority to be able to promote that adoption through tangible instructions. One of the reasons is that none of these models have been fully tested enough to be proven successful (Drabe & Herstatt, 2016; Sunniva, et al., 2017).

The first of these models that is deemed noteworthy is the model developed by Laybourn (2015), which proposes a step-by-step methodology towards implementing CE. While this model can be considered a good guideline, as it suggests the steps that need to be considered during the transition of a firm from linear to circular, it is lacking in some respects (Murray, et al., 2017). First of all, it can be argued that, as a model, it is more business-oriented, rather than focusing on the environmental impact of the firm's products as well as neglecting the consideration of

scarcity of resources. In addition to that, it fails to take a more detailed look into the changes that are due to occur in the business model and the changes that need to occur in the supply chain to fit that new model. Finally, there seems to be a distinct oversight on the direct impact of the legislative environment in which a firm operates. Having located the weaknesses, Lieder & Rashid (2016) have later proposed a more comprehensive model that attempts to display the correlation between the three key pillars of the framework; a) Environmental Impact, b) Resource Scarcity and c) Economic Benefits, and how changes in one directly affect the other two, while at the same time taking into account the different scopes and stakeholders that are affecting and are being affected by each of the three pillars. As an example of how this model is interpreted, it can be argued that, all firms look to improve their financial situation and increase their competitive advantages over their competition. In order to achieve that, they need to come up with a specific business model that fits their targets, design their products in alignment with their goals, etc. (De los Rios, 2017). While this is happening, though, they need to be aware of how these objectives impact the environment as well as how much they are depending on clean resources (Lieder & Rashid, 2016).

In order for a wide-spread CE implementation to become successful, Lieder & Rashid (2016) suggest that, in conjunction with individual efforts, there needs to be an institutional effort as well. While their model focuses mainly on national efforts, institutional efforts need to be made at a macro, meso and microscopic level as suggested by other studies, e.g. Yuan, et al. (2006), Zhijun & Nailing (2007), and Ghisellini, et al. (2016).

Bocken et al. (2016) proposed another model for CE. According to their study, there are three different strategic approaches when attempting to transition from a Linear Economy to a CE model: a) Slowing resource loop, b) Closing resource loop, and c) Narrowing resource flow. As a firm moves towards each of these strategies, then the move from linear to other economic models happens. In addition to the various models that are proposed in their work towards achieving a slowing resource or a closing resource loop, Bocken, et al. (2016) proposes a relatively simple framework towards the implementation of CE where the basic steps of product design and business model are explained for both aspects. Despite of the fact that this model appears to be more sensible (it has yet to be tested), it is considered to be simplistic, as it disregards the impact of those decisions on the environment as well as the potential scarcity of the resources used. In addition to that, it focuses specifically on the strategy of OEMs while overlooking the legislative landscape that may dictate some aspects of the firm's operations. Finally, while slowing and closing are indeed important aspects of a CE, they are only a small part of the strategy that a firm needs to adopt in order to achieve CE.

Due to their weaknesses and disadvantages, the models developed by Bocken, et al. (2016) and Laybourn (2015) are deemed insufficient, when compared to that of Lieder & Rashid (2016), which, while not perfect, is more comprehensive. In this study, we therefore refer to the model developed by Lieder & Rashid (2016) to get a better understanding of awareness levels and practices of manufacturing firms. The literature argues that this model fails to acknowledge the

financial viability of the initiatives, before a firm decides to adopt them (Pompini & Moncaster, 2017). As a lot of firms currently feel that there is no economic potential from the implementation of CE (Ormazabal, et al., 2016), it is important to include it in the model in some way or form. In addition to that, the literature suggests that, currently, most firms have not considered the introduction of a system where products are returned to them at the end of their use (Masi, et al., 2018). It is evident, therefore, that a more in-depth analysis of the Economic benefits of the model may be useful, in order to help firms understand the full potential of CE.

Despite the existence of these oversights, though, it can be argued that the aforementioned model is comprehensive and provides an excellent holistic view of the correlation between financial and environmental implications. This study will therefore attempt to verify the model developed by Lieder & Rashid (2016) and elicit any aspects that may have been overlooked.

3. Methodology

The study adopts a survey questionnaire based design to collect primary data. Given the positivist nature of the research, the study first involved a comprehensive review of the current CE understanding and practices. The literature review identified a number of models and argued to identify the most suitable model that demanded empirical validation. The study narrowed down to the model proposed by Lieder & Rashid (2016), which is based on the three essential pillars of; a) Environmental Impact, b) Resource Scarcity and c) Economic Benefits. An online survey questionnaire was then created using the Qualtrics survey tool to collect the data. The research process therefore included three phases: survey design, data collection and data analysis as elaborated below.

3.1 Survey Design

The survey questionnaire was developed to understand the awareness of CE among manufacturing firms as well as to verify the three pillars of the Lieder & Rashid's (2016) model. The questionnaire was divided into three parts. The developed questionnaire was first validated by inviting 10 academic and industrial experts. The feedback provided by these experts was then used to modify the questionnaire before circulating it to manufacturing firms. The first part of the survey questionnaire included questions related to the demographics of the respondents, second part focused on investigating the awareness towards CE, whereas the final part focused on investigating its practices. However, the third part was further divided into five sections; a) Economic Benefits, b) Resource Scarcity, c) Environmental Impact, d) Relationships and e) Implementation Strategy (see Table 1).

[Insert Table 1 here]

3.2 Data Collection

An online survey questionnaire was then created using the Qualtrics platform and distributed to respondents working in various manufacturing sectors. The respondents (mainly managers of manufacturing firms) were contacted through the FAME database (Fame is a database of firms in the UK and Ireland), personal networks as well as the professional networking platform LinkedIn, which is now increasingly becoming a reliable platform for the fast collection of research data (Papacharissi, 2009; Masi et al., 2018). More than 500 respondents from various manufacturing organisations were contacted over a 40-day long sampling process. After sending initial round of invitations to respondents, a follow up e-mail was sent to remind the participants once every week over the duration of the data collection period. In case of LinkedIn, specific groups of professionals were targeted in specific areas such as circular economy, manufacturing, business excellence and sustainability. The survey questionnaire link was then publically shared in the LinkedIn group societies, alongside a cover letter that described the research and its objectives. Personal contacts of authors were also requested to distribute the questionnaire among their own professional networks. Thus, a ‘snowballing’ sampling technique contributed in broadening the pool of respondents (Horwitz et al. 2006). In total, 103 completed responses were obtained, resulting in a response rate of nearly 20%. Although the response rate may be considered relatively low, it is still pondered acceptable as Hardigan, et al. (2012) reports that web response rates are always lower than those conducted through other means, with research suggesting web/email surveys to be usually achieving a response rate close to 11%. The research followed strict ethical guidelines to ensure the confidentiality of the respondents. The first page of the survey included a participant information leaflet (PIL) to inform them of what was involved in the research and how the data would be used, in order to ensure consensual participation and to give participants the option to refuse to take part if they did not agree.

3.3 Data Analysis

Having defined the data collection procedure that was followed, the next step was to provide an analysis of the different tools and techniques that were used as a means of making sense of the results acquired. The survey data was analysed using SPSS 24.0. As the nature of the study was exploratory, the data was first subjected to a descriptive analysis. The findings of the descriptive analysis were mostly presented in the form of charts/diagrams. To check the reliability of the measures used in the questionnaire, a Cronbach Alpha test was carried out. Finally, to test the impact of the three pillars of Lieder & Rashid’s (2016) model, a correlation and regression analysis were carried out.

4. Findings and Discussion

4.1 Demographics

The first part of the survey consisted of demographic questions that would enable an understanding of the respondents, the size of the firm they were working for, their location and their experience in the field. A number of responses came from the automobile (15%), aerospace (9%), technology (7%), food manufacturers (6%), apparel (5%), machinery (3%), textile (3%), paper (2%), pharmaceuticals (1%), steel (1%), and automotive parts (1%) manufacturers. However, a number of firms (47%) did not specify the type of manufacturing they were involved with. This was, potentially, due to the lack of a comprehensive list of manufacturing sectors provided in the questionnaire. When asked about the size of their organisations, around 56% of the participants reported to be from SMEs (within this category around 39% firms employed less than 50 people while 17% employed between 51-250), whereas 44% respondents reported to be working for large organisations. Figure 1 provides an overview of the location of the respondents. As it is evident from the graph, the majority of the respondents came from the EU (55%), followed by UK & NI (22%), and North America (19%). When asked about their position within their firms, around 10% of the respondents were at CEO level, 9% were at a Managing Director level, 20% were either Managers or Supervisors, and 27% were Engineers in an operations, quality, production or process improvement department. The rest of the respondents did not specify their position. With regard to their experience, the data showed that participants who worked for less than 2 years, 2-5 years and 5-10 years were equally distributed to around 20% per group. While 28% of them worked for 10-25 years within the industry and only 9% respondent worked for more than 25 years.

[Insert Figure 1 here]

4.2 CE Awareness

The next set consisted of questions that attempted to encapsulate the current state regarding the awareness of CE in people employed in manufacturing firms. Specifically, respondents were asked a series of questions regarding their knowledge of various terms, their knowledge on European and British legislation on CE and their views on the remaining value of their firm's products. The first two questions intended to get a brief understanding of the level of awareness of CE as a term. When looking into the data, it was surprisingly pleasant to see that 70% of the responders had heard of the term before while 63% of them declared that they were familiar with the term, instead of having just heard of it. This comes as a verification of the work of Masi et al. (2018), who found an awareness level of 65%, but is contradictory to the work of Ormazabal, et al., (2016), who suggested that only 35% of local SMEs have heard of the term. However, as CE awareness has been growing over the years, the findings are not surprising. On the other hand, the data also shows that awareness levels in the West are still far off to those in Asia and especially in China, where research suggests 90% of respondents being aware of the term (Liu &

Bai, 2014). Of course, this can be easily explained, as the Chinese government has been strongly pursuing and implementing CE for more than a decade, while the West has just started realising its true potential.

The next part of the survey was aimed at verifying which aspects of CE were most associated with the term itself (Figure 2). As it is evident, the majority of the basic concepts of CE, such as a closed loop supply chain, the 3R's etc. are, admittedly, strongly associated with the term. On the other hand, it was surprising to see a division on whether the use of renewable energy and the elimination of waste in the production are part of CE. In a final attempt to grasp the real understanding and potential misconceptions surrounding the term, respondents were given the short definition of CE given by the *Engineering and Physical Sciences Research Council (EPSRC)* of the UK and asked whether they believed their firms are presently implementing a similar approach. Given that statement, it was interesting to see that 50% appeared to agree with that fact, whereas the other 50% disagreed. To understand the degree to which firms are aware of the regulations regarding CE, more than 55% of respondents showed they were aware, while 45% appeared to have no idea on what those are. This shows that although awareness on CE and its potential opportunities have increased over the years, there is still a lot of work that needs to be done in the area. An attempt was also made to verify the knowledge of respondents on the concept of the 3R's (Reduce, Reuse, Recycle). The results proved to be encouraging, since the vast majority of the people had heard of this concept before (85%). This is very different when looking into the results of Liu & Bai (2014), where people struggled to write the names of the 3 concepts when asked. Of course, the two questions were not entirely similar, as agreeing to knowing and producing the terms when asked are expected to have very different results.

[Insert Figure 2]

When asked about the remaining value of products at the end of their life, 71% of responders believed that the disposal of products at the end of their life-cycle is unnatural. This is very encouraging, since it means that employees of manufacturing firms are becoming more and more aware of the importance behind taking advantage of the remaining value of their products, until those are rendered useless. In fact, 84% of responders declared being aware of the remaining value of the products disposed. This information is useful, as it can be a key element when attempting to promote CE in conjunction with a Closed-Loop Supply Chain as a way to transform the whole business. Around 52% of the respondents agreed that their firms attempt to make their products reusable. It is understandable that making a product reusable can be problematic or even impossible for some sectors, such as aerospace or some chemicals sector. For this reason, respondents were asked whether having exact knowledge of the remaining value of products would cause them to consider changing the policies of the firm. Around 67% of respondents agreed that this kind of knowledge would allow their firm to turn its products reusable. Finally, when asked whether they were aware of the impending resource scarcity issue that is expected to rise in the following years (Heshmati, 2015; European Commission, 2015), around 80% of respondents stated that they were aware of this issue.

In general, CE appears to be increasing in awareness, something which is really encouraging when considering the fact that it is currently in a nuisance state in the EU and the UK. In addition to that, manufacturing firms have understood the remaining value of their products but appear to be reluctant to change their business models in order to take advantage of that fact. Since this is one of the gaps that CE attempts to close, it can be argued that manufacturing firms may become more and more willing to make these changes if more concrete evidence on the economic benefits and the value of their disposed products are found.

4.3 Manufacturing Practices

The aim of this part of the study was to encapsulate the practices of manufacturing firms concerning CE as the concept is described by Lieder & Rashid (2016). Specifically, each one of the 3 pillars of the model were scrutinized to understand whether they were considered when firms made strategic decisions. The respondents were first asked whether their firms were considering implementing or were already implementing CE. Around 43% of the respondents mentioned that their firms were not considering at all CE, whereas only 7.5% of those firms had been implementing it successfully. What is really interesting though is seeing that interest in the area had led to about 50% of firms being at some stage of consideration, whether that is initiating implementation or planning to consider it.

4.3.1 Economic Benefits

It is evident that there is an imbalance between the CE implementation levels and the consideration of potential economic benefits from such implementation. Figure 3 (a) and 3 (b) shows the opinion of respondents' on the economic benefits and design of the business model for CE. It is clear that around 44% do not consider any economic benefits of CE implementation while around 38% do not consider design of business models for successful CE implementation. Despite of the imbalance in the degree to which this is being considered, it is important to note that perhaps the same firms that have not considered implementing CE at all are the ones that have not considered those benefits. As is the case with most strategic decisions that concern the economic benefits and the growth of profitability, those need to be or become part of the design process of the business model. Figure 3 (b) also shows that a significant number of firms are already including some aspects of CE in the design of their business model, whereas quite a few are also in the process of considering it. This should be considered encouraging, as it seems that businesses look for ways to include CE in their strategic planning, even if they are not implementing them at this point.

[Insert Figure 3 (a) and (b) here]

With regard to the relationship between CE and the design of products within a firm, just 31% of the respondents appeared to be omitting that possibility at the moment, whereas around 69% of the firms were somewhere between the planning and implementation stages. A significant number (70%) of respondents argued that their firms were considering or implementing the use

of specific materials for the purposes of creating an environmentally sound business model. Despite of that declaration, though, it is difficult to understand whether this has anything to do with the consideration of CE or just with the firm's environmental policies in general. Since CE and Closed-Loop Supply Chains (CLSCs) are often linked together, it can be argued that the results of this question provide a more appropriate response, since the use of specific materials and the design of products can be environmentally friendly, but the existence of a CLSC –in sectors where that is applicable- is even more important in the successful implementation of CE. Around 33% of firms were not considering the design of a supply chain structure, however, around 67% were currently considering or implementing the new supply chain structure. In general, when looking into the results of this part of the survey, it appears that firms are starting to realise the potential of CE in its financial strategies. This is why they have started restructuring their business models, their supply chain structures and the way they choose and use their materials.

4.3.2 Resource Scarcity

The second pillar of the model of Lieder & Rashid (2016), which is being put under scrutiny, is the scarcity of resources and how that scarcity affects the strategic decisions of firms in relation to CE implementation. The findings show that despite of their awareness of the upcoming resource scarcity, a significant number of firms (35%) seem to be unable to deal with that issue, maybe due to their reluctance to start considering CE before concrete evidence on its success is presented. Following that, respondents were asked to declare whether their firms consider the correlation between CE and the use of regenerative resources. The findings show that there is a distinction between firms that have implemented that successfully (albeit being only 15%) and firms that are planning to consider or are currently considering it (45%). Taking into account the targets set by the EU and the UK through the Europe 2020 Package, this seems to be surprising, as individual firms are expected to be further ahead towards that aspect. A significant number of firms seem to identify and are currently in the process of trying to take advantage of the circular potential of their resources through the use of Closed-Loop Supply Chains. However, 34% of respondents omitted this possibility, while 40% have it under consideration, with 12% implementing it successfully. One might make the assumption, therefore, that firms which have identified those issues are starting to look into different ways and methods that can help them to get through a difficult period unscathed.

Respondents were then asked whether CE is being considered when taking strategic decisions, depending on how critical these circular materials are in ensuring the continuous operation of the firm. When faced with that dilemma, employees were divided, as 37% of firms seem to have never considered that aspect, 26% were in the consideration process and 15% were already implementing it successfully. This result was expected, as it is evident that numerous firms have identified that weakness and are working towards it, while others may not be considering it due to the sector in which their business operates, as suggested before. Finally the survey asked how the implementation of CE is being affected by how volatile the materials of each firm are. More

than 43% of them appeared to be uninterested in that aspect, while the majority of firms were either planning to consider or have it under consideration at the time of the survey. Finally, only 8% of responders claimed to be implementing CE successfully towards facing resource volatility issues.

In general, as it was the case with economic benefits, data showed that firms have started to realize the importance of implementing CE to improve their performance in the aspect of resource scarcity, albeit at a smaller pace, since –in general- firms seem to be further behind than they are for economic benefits. However, it might be argued that this result is expected. First of all, a firm’s main goal is to achieve profit and, therefore, economic benefit is their main goal. Additionally, as resource scarcity is –for most sectors- a future issue, rather than an existing situation, it can be argued that it is natural for firms to focus elsewhere for now, rather than in potential future problems.

4.3.3 Environmental Impact

The third, and final, pillar that was investigated as part of this study concerns the environmental impact of the firms’ activities. As shown in Figure 4, only 15.38% of those firms disregard that impact. While this may be surprising, a better look into the data reveals that an important portion of those firms concern aerospace firms, where safety is much more important than minimizing the environmental impact of the firm’s activities. While the rest of the cases cannot be identified that easily, one might assume they might be similar. What is really encouraging is the fact that almost 45% of the firms declared to be implementing their environmental plan effectively and efficiently, with another significant number of them having it under consideration. Except for general questions on the environmental impact, we went in further detail and examined the differences in solid wastes produced, emissions produced and the aggravation of local landfills, all related to the firm’s activities. When asked about the solid wastes and emission generation issues, around 15.8% and 20% firms completely disregarded them respectively.

[Insert Figure 4 here]

In general, except for firms disregarding that aspect, they seem to be further behind at the degree of implementation of CE. Only 46% and 38% of the firms are implementing solid wastes and emission generation plans respectively. With regard to landfill activities about 33% of firms were completely omitting this aspect of CE, while –on the other hand- 39% of them are implementing it successfully whereas about 17% of the firms were in the process of considering it. Therefore, it seems that firms are divided on this issue, with the majority having realized its importance but – also- with a significant number looking past potential problems for local landfills that may be caused by their products. In general, results for this pillar were expected, as environmental impact has been at the forefront on its own for a long time, while people are only just realizing the financial potential that is related an environmental approach such as CE. As a result, it is encouraging to see how far ahead firms are going and how far they are moving towards in their

attempt to minimize their environmental impact. Despite of that fact, critics suggest that this aspect is “low-hanging fruit” when it comes to CE and measuring its success (Ghosh & Morrison, 2017).

4.3.4 Relationships between Pillars

One of the key objectives of this study was to validate the framework proposed by Lieder & Rashid (2016), which identifies the three pillars of CE (economic benefit, environmental impact, resource scarcity). The survey questionnaire first aimed at investigating the connection between the environmental impact and the economic benefits of the firm. Respondents were asked how the implementation of CE was affected by the incentives offered by the environmental legislation on the firm’s economic benefits (Figure 5). While there was a significant number of firms already taking advantage of them (22%) and some looking into such possibility (29%), another important part of the sample declared that they were not considering that relationship at all (34%). One of the reasons might be the nuisance of the initiatives that promote this combination and another being the lack of an effective legislative environment to support CE. When asked about the level at which end-of-life products were perceived to be resources and how this affected the environmental impact produced through the firm’s activities, nearly 45% of them reported that they were not considering this aspect.

[Insert Figure 5 here]

The survey then asked questions to explore the relationship between resource scarcity and the environmental impact of the firms’ activities. When asked whether their firms were taking speed of depletion of their resources into account and its relationship with the environmental impact of the firms’ activities, the majority of the respondents (Figure 6) claimed their firms to be omitting that connection. On the other hand, another significant part also claimed to have tracked that relationship and considering it or implementing it successfully, in order to better understand their processes and improve their environmental issues. On the other hand, the situation regarding the connection between the speed of waste generation as a result of environmental policies and the scarcity of resources seems to be a rather niche territory for firms, since most of them are either unaware or have just started plans to look into it (Figure 7). As explained before, this might be connected to the current state of resource scarcity and the lack of long-term strategic planning on the part of the firm. Despite that fact, if resource scarcity issues occur as they are expected to do so in the following years, it is expected that those relationships will become stronger.

[Insert Figure 6 and 7 here]

The final relationship concerns the pillars of resource scarcity and economic benefits. First of all, the connection between the financial targets set by the firm and its dependency on resources that might become scarce was put into question. Again, when resource scarcity is being mentioned, a pattern seems to occur, with firms disregarding that possibility in their current plans. As it is evident (Figure 8), almost half (44%) admitted their firm is doing nothing in that regard, while

33% are either planning to consider or are considering that option at the moment. As a result, this aspect can be declared to still be a nuisance for manufacturing firms. In addition to that, the effects of price volatility due to scarcity of resources were also investigated. As discussed earlier, this aspect and relationship is not really being considered by firms, presumably due to the lack of effective strategic decision-making processes.

[Insert Figure 8 here]

In order to further validate the relationship between the three pillars of CE from Lieder & Rashid's (2016) model, a correlation analysis was carried out (Table 2). The findings showed a significant correlation ($P < .01$) between the pillars of CE, recognizing trends and verifying the quality of the results (Gliem & Gliem, 2003; Tavakol & Dennick, 2011). This interdependency between the three pillars of the CE is a strong point towards the validation of the model. In addition to that, it can be argued that it adds to the existing literature significantly, as well as helps to meet one of the research objectives. Arguably, these numbers suggest that there is a significant dependence leading to the assumption that one aspect of the model is directly correlated to another. Furthermore, it suggests that once a firm considers one of them they consider all three as part of CE.

[Insert Table 2 here]

4.3.5 Importance of a collaborative approach

The last part of the study focused on investigating the implementation strategy of CE. Firstly, we tried to assess the importance of a national (or governing body) effort in the firms' decisions to implement CE. As it is evident from Figure 9, the majority of the firms that were looking into a CE were disregarding the importance of such effort on the part of the government, despite of the recent efforts of the government in the UK, EU and other countries. However, it is also interesting to see that those efforts may have, in fact, put the wheels in motion for some of the firms in question, as another 40% of the firms were at an early stage of planning or considering that aspect. Finally, it is also interesting to see how only 10% of those firms had been influenced by the acts of the government in its effort to implement CE. When looking into the importance of an individual firm's effort, it appears that the trend is somewhat different. While the number of firms overlooking that importance is similar to the previous one (about 38%), it is interesting to see the number of firms implementing that philosophy successfully being almost double from the previous one. What this means, in essence, is that firms are more inclined to trust their own initiatives in making a transition towards a CE rather than laying their plans and aspirations depending on the efforts of the government.

[Insert Figure 9 here]

When asked about the importance of a collective effort from both government and individual firms, less than 30% of firms seem to have been omitting that importance when faced with the

strategic decision to implement CE. In addition to that, another 40% seems to have been in the process of consideration or planning. Finally, it is also very encouraging to see that more than 20% of the respondents declared that importance to be not only considered but implemented, meaning that firms had been trying to take advantage of what is offered by governing bodies as incentives into making CE more attractive.

5. Conclusions

This study provides a holistic review of the literature around the current state of CE practices. The study also reviewed and critically examined the existing CE models/frameworks that make an attempt at encapsulating CE. Specifically, the most widely accepted models found in the literature were analysed. The model proposed by Lieder & Rashid (2016) was benchmarked and tested through survey. The results of the survey proved the effectiveness of the model in describing the concept of CE far better than other models and taking all aspects considered by manufacturing firms into account. This is important, as so far, no model of CE had ever been tested and proven. Our study provides a better understanding of the levels of awareness of the concept of CE in the European continent. Our findings show a very encouraging 70% awareness levels, which is constantly improving. The results of the survey suggested that, as far as employees in manufacturing firms are concerned, the consideration of their firms' environmental impact is greater than the potential economic benefits or resource scarcity. Despite of that fact, all of those aspects are interdependent, meaning that one cannot think about CE without thinking on all three elements of the pillars of CE. This study therefore adds to the limited empirical literature on CE awareness and practices in manufacturing firms. The paper also provides empirical validation of the CE model proposed by Lieder & Rashid (2016) thus, providing a valuable contribution to the knowledge and understanding of the CE.

5.1 Key Contributions

This study provides a valuable contribution to the area of CE practices among manufacturing firms. Some of the key contributions of this study are listed below;

- The study provides a comprehensive review of the literature around the current state of CE practices.
- Our study adds to the limited empirical literature on CE awareness and practices in manufacturing firms and shows that awareness towards CE is constantly improving.
- This study is also one of the first studies to review the existing CE models, cross-examine an earlier CE model proposed by Lieder & Rashid (2016) and empirically validate it.
- Our study confirms the interdependency between the three pillars (environmental impact, resource scarcity and economic benefits) of the CE.

5.2 Practical Implications

This study provides an important contribution to practice as it suggests firms should consider all three pillars of CE. Through understanding the importance of the three pillars (environmental impact, resource scarcity and economic benefits) of CE and its awareness, more manufacturing firms will be able to use this model as a guide to plan for an efficient strategy around CE implementation. Our findings will also help managers to get a complete understanding of the state of CE among manufacturing firms, whether that is their competitors or firms within their supply chain network. Moreover, our study adds to the existing efforts towards raising awareness on CE practices among all the relevant stakeholders.

5.3 Limitations and Future Research

As is the case with all studies, this study is based on the findings from a limited 103 survey responses from manufacturing firms. Moreover, majority of the responses came from UK, EU or North America, while manufacturing is shifting towards Asia/South Asian countries. Future research studies hence should aim to get a larger number of responses to generalize the findings across the sector and extending the geographical coverage beyond developed economies. Furthermore, data collection from other sectors beyond manufacturing would also help firms to understand the complexity and benefits of CE implementation. Combining the quantitative survey based approach with expert opinion or qualitative interviews would further shed some more light on the practicalities of CE in firms. Additionally, use of more robust statistical analysis techniques can further add to the credibility of the findings. One thing that can be argued is that the field of CE is one of the key emerging areas around the globe and offers multiple opportunities for researchers to delve into as well as for firms to take advantage of. As a result, this study can be a starting ground for future researchers who might look for ways to take this field further, helping businesses to achieve improved financial performance while having the mind set of an environmentally-responsible firm –a much needed concept in today's manufacturing world.

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