Investigating the barriers and opportunities of circular economy in the manufacturing sector

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Abstract

In recent years Circular Economy (CE) has come to prominence as an alternative to the classic approach of "make-use-dispose". How companies can exploit the opportunities of CE to position themselves better are not well articulated in literature. This paper therefore aims to identify the barriers and opportunities of CE in the manufacturing sector through a socio-political, economic and environmental lens. The study reports the findings based on 64 responses from a survey questionnaire. The study identifies a number of barriers to CE implementation as well as a number of opportunities that it presents from socio-political, economic and environmental lens.

Keywords: Circular Economy, Barriers, Opportunities

Introduction

Growing environmental awareness, environmental legislation and the need for social responsibility has led manufacturing companies to look for new ways to do their business. In recent years Circular Economy (CE) has come to prominence as an alternative to the classic approach of "make-use-dispose" which is based on the circular flow of materials and energy (Gregson et al. 2015). CE has the potential to pave the way for eliminating environmental waste in manufacturing and regaining used materials into the material flow by encouraging the use of renewable energy sources and new manufacturing methods to achieve the sustainability (Ciani, Gambardella, and Pociovalisteanu, 2016; Yuan, Bi, & Moriguichi, 2006). Although CE is considered as a new concept on economic development, its roots date back to 1960s. Firstly, in 1965, Kenneth Boulding (1965) suggested that earth is a unique system similar to the space

and to have a constant reproduction in the earth, there should be cyclical ecological system. After that, there were two concepts emerged in parallel to CE which are Industrial Ecology (IE) and extended product life (Gregson et al., 2015). To visualise, IE was revealed as a concept which was based on the formation of new analogies by taking material and energy flows into account. By this system, it is aimed to recycle residual wastes and by-products to create an industrial symbiosis and reach sustainable development. As a result, IE offers to minimise the use of virgin resources and promotes cleaner production technologies. On the other hand, extending product life refers to the prevention of waste generation and embedding sustainable production and consumption techniques (Andersen, 2007; Gregson et al., 2015). These ideas and concepts paved the way for the emergence of the term, CE.

Circular economy definitions

Over the years a number of definitions of circular economy have been proposed. For example, Murray et al. (2015) defines CE as 'The Circular Economy represents an attempt to conceptualise the integration of economic activity and environmental wellbeing in a sustainable way'. Whereas, Hu et al. (2011) states that 'CE advocates that economy system should be constructed on base of material and energy flow and changes linear throughput flow to round put flow of matter and energy'. Based on the review of definitions**,** Circular Economy (CE) can be defined as an economic growth and development system which unifies economy with natural resources and environment. It is based on the circular flow of material and energy and turns traditional linear take-make-dispose model to circular resource-product-regenerated resource model (Li et al., 2010). By this way, CE aims to reduce the consumption of virgin resources, wastes and pollution generated and paves the way for resource recovery and efficiency (Hu et al., 2011). Although CE has these benefits to the nature, it is an economic strategy instead of an environmental strategy. As the main objective, CE targets to ensure the sustainability and continuous development of the economy (Yuan et al., 2006). To do this, it introduces more advance technologies, improves equipment and machinery, organises the structures of industries, strengthens managements and correspondingly formulates a sustainable eco-industrial system. In other words, whilst supporting the development of economies as the base of the concept, CE also takes into account the environment and contributes its sustainability.

Circular economy implementation

The implementation of CE has several practical aspects. Horizontally, it includes industries, urban infrastructure, cultural environment and social consumption systems. When it comes to vertical implementation, CE consists of enterprise (micro), industrial parks (meso) and cities and regions (macro) levels (Zhijun & Nailing, 2007). To be able to successfully implement CE, the process should start from micro level with enterprises. Then, macro level should be embedded and then the process is concluded with implementation of macro level since each level forms a basis for the following level and makes it possible to develop a sustainable economic growth and development. To clarify, at the micro level, companies are promoted to adopt cleaner production (CP) and eco-design. CP is a concept which studies how pollution is generated and refers to the significance of efficient use of resources throughout the production processes (Su et al., 2013). On the other hand, eco-design aims to create awareness against environment and its protection during the design stage of production and formation of the final product. It supports companies to build more efficient, sustainable and integrated production processes to minimise the pollution generated (Negny et al., 2012). By

benefiting from CP and eco-design, companies form ecological industrial chains which consist of circular flows of materials and energy within themselves. Thus, they can restrict pollution, waste and toxic substance emission whilst boosting resource efficiency (Zhijun & Nailing, 2007). Furthermore, the application of green labelling in public disclosure systems should be provided. To do this, local organisations should be established which monitors companies according to their levels of environmental protection. All businesses should be classified as green, blue, yellow, red and black from good to bad, in response to their performance. As a result of this classification, it becomes easier to identify and eliminate outdated technologies and decrease resource consumption and pollution generation. This is a crucial procedure since it enables to make companies to more environmentally friendly (Yuan et al., 2006).

Additionally, at the meso level, eco-industrial parks and eco-agricultural systems should be developed to redesign the material and energy flows. Within an industrial park, businesses utilise a common infrastructure and services. They can easily share their energy, water and waste materials which decline their dependency to outside providers. Besides, by the help of eco-agricultural systems, an industrial symbiosis can be created and utilisation of wastes and resources can be maximised within these systems (Su et al., 2013). At the meso level, a circulating system is provided. Companies can trade their wastes and by-products with a closed-loop and waste of a company transforms to the resource of another one. Thereby, the utilisation of products are maximised, discharge of wastes and costs are minimised and resources and energy is preserved for further use (Zhijun & Nailing, 2007; Naustdalslid, 2014).

Ultimately, the third level is named as the macro level and the development of eco-cities and eco-regions are encouraged hereby. At cities and regions level, eco-activities which are structured in micro and meso levels should be associated with 3Rs principles of CE and it is aimed to organise them at a higher level. The implementation of CE in cities and regions level includes redesigning of four major systems which are industrial system, infrastructure system, the cultural framework and social system (Ghisellini et al., 2016). Those systems gather a range of legal, social, economic and environmental factors. To make a successful implementation, those systems should be rearranged by considering the regional characteristics. As a consequence, an appropriate legal framework can be formulated, the responsibility can be shared over the society, risks can be minimised and more advanced eco-technology can be provided.

In short, CE provides a circular flow of materials and energy and gives importance to higher utilisation of resources. To do this, it serves reduce-reuse-recycle principles to set a course of action for companies. By starting its implementation from enterprise level and moving on industrial park and regional levels, CE offers a better future for companies, industries and societies.

Barriers to circular economy

CE offers many opportunities, yet, the level of awareness on public against CE is quite poor (Su et al., 2013; Naustdalslid, 2014; Benton et al., 2015; Winans et al., 2017). CE is a new concept and there is still lack of awareness of what it can bring to daily life and environment. Many people are still unaware of the term, CE and there is a lack of understanding of its principles (Benton et al., 2015). For these reasons, an extensive public education should be provided via different channels. There should be advertisements on TVs, magazines, newspapers and billboards. Also, governments should arrange trainings to present the opportunities of CE and encourage the society to take a part since the public involvement is the key for the success of CE (Geng & Doberstein, 2008). The human and institutional capabilities are generally poor which

limits the availability of public education. Because of lack of qualified personnel on CE, institutions and governments cannot become successful enough to promote the society (Benton et al., 2015; Su et al., 2013; Li & Yu, 2011).

Generally, most people care more about the appearance of products whilst purchasing. They do not pay attention to their sustainability and environmental effects and prefer the one with a better look instead of manufactured from scrap (Pomponi & Moncaster, 2017; Naustdalslid, 2014). This reduces the demand of remanufactured products and low customer acceptance makes it difficult to maintain CE strategies. Moreover, to circulate the loops continuously, there should be a regular flow of materials so that old products and parts can be utilised in remanufacturing operations. To do this, companies make contracts with customers to limit their usage and ensure the return. However, many people want to use their products beyond their contracts and reluctant to replace their old products (Park et al., 2010). These circumstances result with the interruption of the smooth flow of materials and increase the waste creation.

On the other hand, governmental policies play significant roles for companies to shape their future steps. In most regions, there are fragmented regulation systems. Governments' and local authorities' responsibilities are not clear on the implementation of CE. This complex structure results with poor accountability of local governments and leads to the creation of an inadequate legal system (Benton et al., 2015; Geng & Doberstein, 2008; Su et al., 2013; Li & Yu, 2011; Naustdalslid, 2014; Winans et al., 2017). Therefore, necessary systematic laws and regulations on CE cannot be created. Poor enforcement ability of legislations due fragmented system and correspondingly, lack of policy support make it difficult to apply CE by businesses. As a result, companies prefer to go for their existing strategies rather than taking risks and the spread of CE is restricted. Besides, many governments lack a sophisticated understanding of CE practices (Geng & Doberstein, 2008; Benton et al., 2015; Naustdalslid, 2014). Since they are not completely aware of the benefits of CE, they remain incapable to take the lead, guide companies and make appropriate laws. Correspondingly, they cannot specify a clear vision, goals, objectives, targets and indicators (Pan et al., 2015). Lack of sophisticated knowledge of policy makers on CE prevents the formulation of standard system for performance assessment, data collection, calculation and submission and punishment (Su et al., 2013). Furthermore, taxes and charges specified by governments reveal as another barrier. Current tax regulations does not promote the implementation of CE in most regions, instead, they discourage the companies due to its financial burden (Geng & Doberstein, 2008; Benton et al., 2015; Naustdalslid, 2014).

There are many economic barriers to CE in the manufacturing sector. CE is a costly process and it requires a considerable amount of upfront investment (Liu & Bai, 2014). However, it does not pay back instantly, instead, it has a long-term economic return. Having term limits imposed on managers leads to hesitation over investing on CE and uses the same amount in other business operations (Liu & Bai, 2014; Benton et al., 2015; Park et al., 2010). The lack of financial support mechanisms and tax incentives built into the budgetary systems from banks and governments further cause companies to avoid the implementation of CE although they are willing to do (Geng & Doberstein, 2008; Liu & Bai, 2014; Su et al., 2013). It is an expensive process and except huge companies, it is not possible to cope with it financially. Governmental support is a must to convert the existing linear economy model to the closed loop and it is governments' responsibility to create a convenient environment for the implementation of CE. CE also requires collaborative business models to have a regular flow of materials and satisfy customers. Yet, because of lack of reliable information (Su et al., 2013; Pomponi &

Moncaster, 2017; Winans et al., 2017; Pan et al., 2015) and high cost of establishing eco-industrial chains (Liu & Bai, 2014), companies cannot formulate a quicker feedback mechanism to adjust themselves. On the contrary, they take unsuitable actions which decline their profitability. Furthermore, high costs and uncertainties are embodied within CE can impact on companies financial conditions. These uncertainties cause companies to avoid remanufacturing processes due to the questions on its future sustainability and profitability.

CE also faces several environmental barriers as there are not enough environmental management programs and facilities available both under government bodies and at academic institutions whereas the existing ones are rather dysfunctional (Su et al., 2013; Geng & Doberstein, 2008). The available incentives to promote greener activities and save water, energy and materials cannot measure up to the desired level (Geng et al., 2009; Su et al., 2013). Many companies use old technology machinery and equipment since they are not powerful enough to replace them with higher technology ones on their own. Hence, the level of energy consumption and pollution generation is much higher in those machinery and equipment which treats the environment wastes (Geng & Doberstein, 2008; Naustdalslid, 2014). Many of the areas performing landfilling and incineration activities lack adequate technologies (Gregson et al., 2015). As a consequence, these activities cause huge environmental losses which cannot be reverted back. Additionally, scavenger and decomposer companies lack capacity to create new fields due to existing policies (Geng & Doberstein, 2008). Governments do not provide adequate subsidies and tax reductions to promote waste recovery. Ultimately, the amount of materials recovered remains incapable to meet the demand of companies in remanufacturing business and lead them to use virgin materials.

Opportunities of Circular Economy

CE offers a variety of social and political opportunities. Basically, it strengthens the connection between the society and industry. By closing the loop, all participants within supply chains, included the public and companies, are required to have an extended collaboration (Geng et al., 2012; MacArthur, 2013b). When the end-of-life of a product is come, it should be regained since the value chain does not end up with consumers anymore. This positioning results with a better alignment between businesses and customers (MacArthur, 2013b). Thereby, companies can understand the needs and expectations of the public in a better way and manufacture products accordingly. In turn, they can satisfy their customers and attract many others.

Moreover, the implementation of CE has the potential to create many employment opportunities to local communities (Park et al., 2010; Geng et al., 2012; MacArthur, 2013b; Yuan et al., 2006). The development of recovery firms also bring investments and create many job opportunities to local people. CE also paves the way for the improvement of public health and environmental awareness (Geng et al., 2012; Park et al., 2010). People become more conscious about hazardous materials and prefer more environmentally friendly and safe products. In addition, CE promotes rental models in all sectors (MacArthur, 2013b) which help companies to collect insight information about customers, provide more customised and personalised products according to customers' requirements with cheaper prices. Thus, the social value is advanced and the quality of life is improved.

Politically, CE enables companies to operate in accordance with regulations (Park et al., 2010). CE helps to create an organisational legitimacy and improve companies' environmental consciousness. Therefore, they are able to obey the requirements of laws and decrease the social pressure.

CE helps companies to save money and enhance their profitability. It enables to reduce the costs through sustainable supply chain and end-of-life managements, lower input prices and minimising environmental penalties and waste generation (Park et al., 2010; Geng et al., 2012; MacArthur, 2013b). By the help of the closed loop model of supply chains, companies can sell their wastes instead of disposing them and make additional profits. Therefore, wastes can be turned to raw materials for other companies, decline their material costs and eliminate their price volatility. Besides, CE opens new markets for recycling and remanufacturing. These new markets and new revenue channels boost the profits of existing firms and provide competitive advantage to them among their rivals (MacArthur, 2013b; Park et al., 2010; Geng et al., 2012). In addition to companies, local governments and public can cut down their costs (MacArthur, 2013b). Municipalities can make additional profits from the amount that they collect and sell them to recycling businesses. The public can benefit from CE as well since the amount that they are required to pay for waste disposal is minimised. As a result, a financially mutualist relationship can be formulated.

By the developments in environmental sciences and technologies, there are many new concepts occurred which aims to protect the nature, namely, eco-design, eco-label, cleaner production and life cycle assessment (Geng & Doberstein, 2008; Liu & Bai, 2014). As a result, the amounts of environmentally friendly and green products, which have minimum negative effects on environment, become more common and preferred. Those products save energy and natural resources and decline the pollution generation (Zhu & Tian, 2016). Such environmentally sound management practices offer organisational and supply chain resiliency and make it easier to penetrate into new markets and grow the business operations (Park et al., 2010). As well as, by CE, the utilisation of waste is improved and waste streams advance the availability of materials and enable to protect natural resources, water, energy and minerals. Correspondingly, the productivity of materials is increased by rework and recycling, their life cycles are extended and the need for landfill sites are reduced (Geng et al., 2012; Park et al., 2010; MacArthur, 2013b). Moreover, by the help of CE applications, the need for energy, chemical fertilisers and soil amendments are declined. They result with a reduction on the consumption of fossil fuel, the emission of greenhouse gases and toxic substances (MacArthur, 2013b; Geng et al., 2012). Therefore, the effects of climate change can be mitigated as well.

It is evident from these discussions that CE can be considered as a new concept and this characteristic of it means that there are a limited number of published materials. Although CE has been in existence for last a number pf years, there is still a huge gap in theory and also in the implementation process. The data published is generally superficial and does not consider different sectors and regions separately. There are also many companies who have started to implement CE or who are intended to do however, they face several barriers in the implementation process of CE and often struggle to mitigate their effects. Many companies are also not well aware of the potential opportunities that CE presents (MacArthur, 2013). At this point, there is a lack of literature presenting existing barriers and potential opportunities of CE which can help companies to position themselves better (Masi et al. 2018). This paper therefore aims to fill this gap by identifying the barriers and opportunities of CE in the manufacturing sector through a socio-political, economic and environmental lens (Winans, Kendall, & Deng, 2017; Benton, Hazell, and Hill, 2015; Li & Yu, 2011).

Methodology

The study adopts a survey questionnaire based approach for data collection. The first step involved a comprehensive review of the literature to identify barriers and opportunities among different industries and sizes of companies from different locations and classifying them from socio-political, economic and environmental perspectives. An online survey questionnaire was designed based on the review of literature using the Qualtrics platform and circulated to more than 350+ companies identified through FAME database as well as the social networking platforms 'LinkedIn' and 'Facebook'. The link of the questionnaire was also posted in 18 LinkedIn and 3 Facebook groups on CE. The initial set of survey questions were aimed at sorting the profile of respondents filling the survey. Although the questionnaire reached to sufficient number of potential participants, only 80 people responded to the questionnaire over the period of two weeks. After screening the survey responses, only 63 usable responses formed the final sample size for this study. The data was then analysed using SPSS. Particular attention was paid on the reliability and validity of the data. Reliability was achieved by the triangulation of the literature, questionnaires and interviews in this research. They were directed to the companies in manufacturing sector which has implemented the circular economy or intended to do it. The participants mainly composed of supply chain manager or senior executives since they are the ones who have the most critical roles in the implementation of the circular economy to their organisations. A participant information leaflet and a participant consent form were created and given to the participants. They showed that the participants have completed the questionnaire with their own consent and they have the right to withdraw in any part of them. As a consequence, in these ways, the reliability and validity were kept high throughout this research.

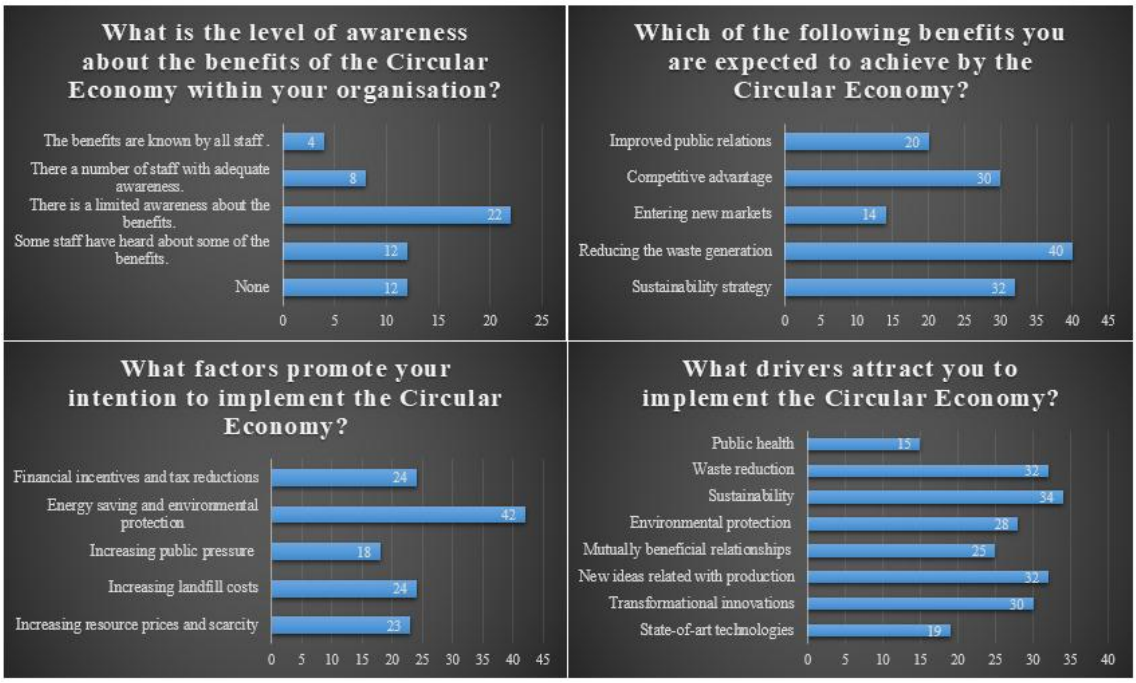

Figure 1: CE Opportunities

Findings

The first set of questions was focused on demography of the survey participants. The survey resulted in response from 13 supply chain managers and 8 senior executive from the overall 63 respondents. The next set of questions was aimed to identify the level of

awareness towards the CE concept. When asked whether they have heard this term before, around 35.9% of participants have chosen the alternative 'No, I have not heard of it' while the remaining 64.1% have stated that they have at least a basic knowledge on CE. This shows that there is still a significant lack of awareness around the CE. The other question further probed their understanding of the CE concept, 3Rs (Reduce – Reuse – Recycle) and their current implementation status. The responses show the low level of awareness among the respondents. The next set of questions was focused on the opportunities of CE (Figure 1). The results were very surprising as many respondents noted the limited awareness about the benefits of the CE whereas very few acknowledged that their staff were aware of the potential benefits. With regard to the benefits of CE, reducing waste generation was ranked first among the participants followed by sustainability strategy and competitive advantage. Energy savings and environmental protection opportunities appeared to be the top factors promoting intention to implement CE in most organisations which was followed by financial incentives and tax reduction. When asked about the drivers that attract CE implementation waste reduction, sustainability, environmental protection and new ideas related to production emerged as key drivers (see Figure 1).

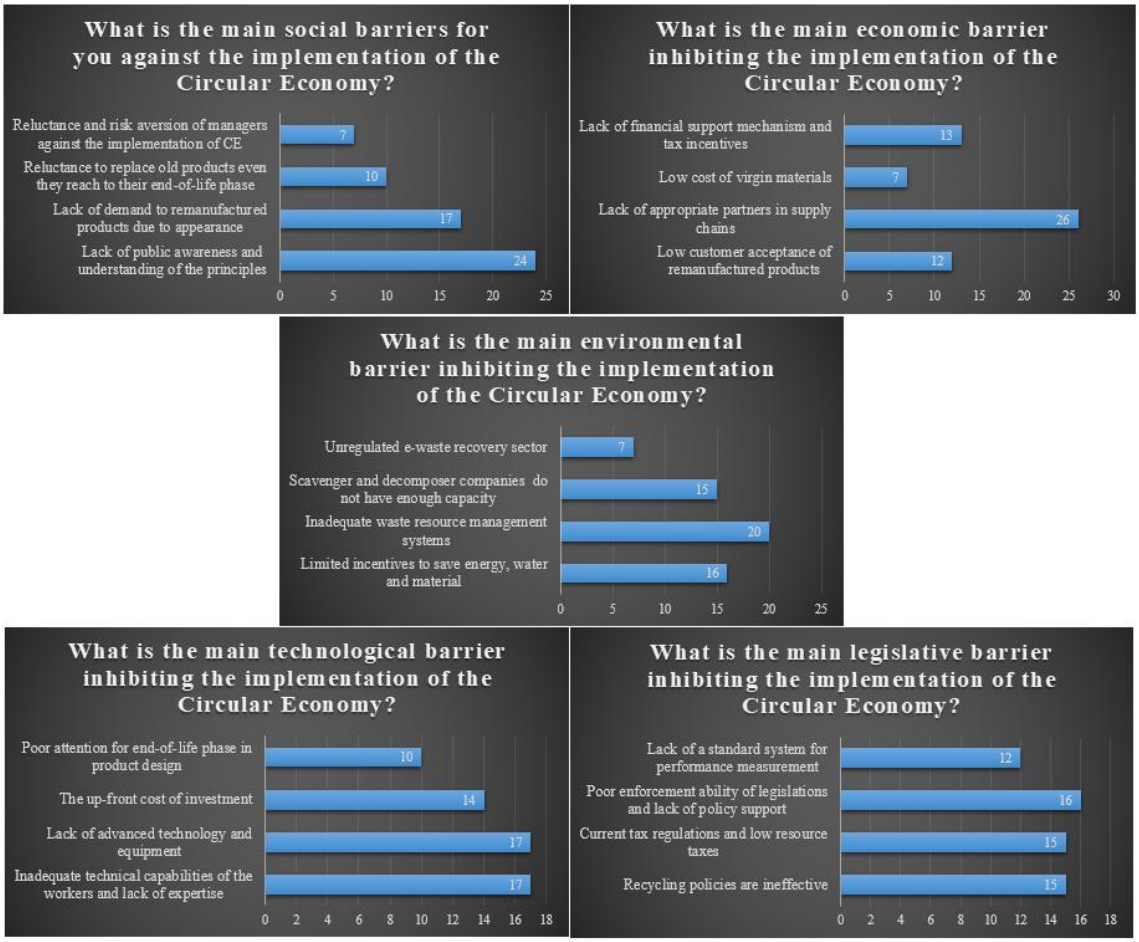

Figure 2: CE Barriers

Next section aimed to find out what prevents companies to implement CE and how they differ according to their social, economic, environmental, technological and legislative characteristics. Analysis reveals that governments remain incapable to promote CE. They cannot incentivise companies properly and provide adequate support as Geng & Doberstein (2008), Liu & Bai (2014), etc. have also pointed out in their

studies. Besides, the required up-front investment for advanced machinery, risk-averse profiles of management and lack of availability of experts on CE put barriers against the implementation of CE (see Figure 2). Moreover, the data presented shows that 41.4% of the participants have stated that lack of public awareness and understanding of its principles as the main social barrier to CE. When the literature is reviewed, it also emerges as one of the major issues so that many researchers such as Benton et al. (2015), Su et al. (2013), Naustdalslid (2014), Winans et al. (2017) and Geng et al. (2009) have also mentioned in detail about this weakness. From the economic barriers perspective the unavailability of appropriate partners in supply chains emerged as key barrier followed by lack of financial support mechanism as noted in the study of CE as Benton et al. (2015). From environmental barriers perspective, inadequate waste resource system emerged as key barrier which was followed by limited incentive to save energy, water and materials. As Li & Yu (2011) have mentioned, the existing systems are appropriate for linear economies and unable to satisfy the expectations of circular economy. Lack of advance technology and equipment and inadequate technical capabilities emerged as technical barriers. Finally, with regard to legal barriers, poor enforcement ability of legislations and lack of policy support emerged as a key barrier which was followed by ineffective recycling policies and current tax regulations. Our study adds to the limited empirical literature on CE by providing a comprehensive review of CE barriers and opportunities in the manufacturing sector. The study looks at these barriers and opportunities from socio-political, economic and environmental lens, thus adding valuable contribution to the CE literature from the theoretical perspective. The findings of this study will equip manufacturers with necessary understanding of the key barriers to address the challenges encountered during the implementation of CE.

Conclusions

In summary, the major socio-political barriers revealed as low level of public awareness on CE and lack of understanding of its principles. The main economic barrier was seen as lack of appropriate partners in supply chains which restricts the collaboration between companies. From the environment point of view, inadequate waste resource system arose as the biggest challenge in front companies which limits the utilisation of recovered materials. On the other hand, the study also shows the opportunities of CE in terms of the same characteristics. Socio-politically, the main expectations are opening up new employment opportunities and strengthened relations between the society and industry. When it comes to economic opportunities, companies are fundamentally looking for reduction of costs through sustainable supply chains and end-of-life management. Eventually, the participants have shown their interest for environmentally friendly and green products and reduction in environmental pollution.

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