Circular Economy to Enhance Sustainability of Small and Medium sized Enterprises

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Abstract

The circular economy (CE) represents a major paradigm shift of moving from the concepts of linear to circular supply chains across multiple industries. Although some aspects of CE adoption within industrial supply chains have been researched extensively (particularly addressing challenges of design, implementation and operations), the research that relates CE practices with sustainability performance to reveal the current state of CE practices within small and medium sized enterprises (SMEs) is scant. The aim of this research is to facilitate SMEs to achieve greater sustainability through CE implementation. This research addresses three research questions – How are CE fields of action related to sustainability perfornace, what are the issues, challenges and opportunities of adopting circular economy in SMEs, and what key strategies, resources, and competences facilitate effective implementation of CE in SMEs? This study adopts a mixed method approach (qualitative and quantitative) using survey research, focus group and case studies. 130 randomly selected SMEs within the Midlands of the UK has been surveyed and the responses are analysed using statistical tools along with findings from focus groups and case studies. The study reveals that all circular economy fields of action (*take, make, distribute, use and recover*) of SMEs are correlated to economic performance but only *make* and *use* are related to *environmental and social performance*. The study further derives strategies, resources and competences for achieving sustainability across all the CE field of actions. Additionally, this research reveals the issues and challenges, strategies, resources and competences required for implementing CE in SMEs.

Key Words: Circular economy, small and medium sized enterprises, environmental and social practices, sustainability performance, structural equation modelling

Abbriviation used in this paper:

3PL	Third Party Logistics
3R	Reduce, Reuse and Recycle
AGFI	Adjusted Goodness-Of-Fit Index
CE	Circular Economy
CEO	Chief Executive Officer
CLSC	Closed Loop Supply Chain
CPS	Coating and Painting Solutions
CSR	Corporate Social Responsibility
EJ	Exajoules
ESCC	Environmental-Oriented Supply Chain Cooperation
EU	European Union
GDP	Gross Domestic Product
GFI	Goodness-Of-Fit Index
JLR	Jaguar Land Rover
MDF	Medium-Density Fibreboard
MPL	Metal Pressing Limited
OEM	original equipment manufacturer
PGFI	parsimonious goodness-of-fit index
PSU	Public Sector Undertaking
RL	Reverse Logistics
SEM	Structural Equation Modelling
SME	Small and Medium-sized Enterprise
SOI	Sustainable Oriented Innovation
UK	United Kingdom

1. Introduction

Small and medium sized enterprises (SMEs) make up around 90% of the world's businesses and they employ 50-60% of the world's population (Organisation for Economic Co-operation and Development Staff, 2000). The total number of SMEs in the UK is 5.7 million, and they employ approximately 15.8 million people, contributing close to 20% in the GDP. SMEs in the UK are likely to contribute £250 billion by 2025, which is 19% more than the current figure. While SMEs contribution to GDP is beyond doubt, their cumulative negative contribution to environmental degradation is also alarming. SMEs are responsible for more than 70% of the industrial pollution (Hillary, 2000). As per the UK environmental agency report, 8 out of 10 pollution incidents are caused by SMEs (Anon, 2019). Recent survey reveals that SMEs consume more than 13% of total global energy demand (around 74 exajoules (EJ)). Cost-effective energy efficiency measures could shave off as much as 30% of their consumption, namely 22 EJ, which is more energy than Japan and Korea combined consume per year (IEA, 2016). These facts show the significance of achieving SMEs' sustainability for making entire ecosystem sustainable. Sustainability (right combination of economic, environmental and social factors) is the major issue of SMEs' business today as SMEs need to be economy focused due to uncertainty in both demand and supply sides along with numerous competitions (Dey et al., 2019). Adhering to desired environmental and social goals as per local regulations and global needs becomes increasingly difficult for the SMEs along with remaining competitive as many environmental and social projects are cost intensive (Dey et al., 2018; Malesios et al., 2018).

Lean has been adopted across industries in the past decades to reduce waste all through the supply chains, which is both efficiency focused as well as environment friendly for many cases (Dey et al., 2019). Recently closed loop supply chain (CLSC) (Battini et al., 2017), reverse logistics (RL) (Govindan and Soleimani, 2017), environmental-oriented supply chain cooperation (ESCC) (Zhu et al., 2010) and sustainable oriented innovation (SOI) (Klewitz and Hansen, 2014) have been adopted in manufacturing, process and construction industries to achieve sustainability across the industry supply chains. Although lean approach is philosophically efficiency oriented, CLSC, RL, ESCC and SOI are responsive focused. They are often cost intensive as higher enviormental and social performances are emphasized over economic. CE came up as a newer philosophy that optimises economic, environmental and social factors of the businesses to transform the entire society towards becoming more sustainable through the involvement of all the concerned stakeholders. The CE is defined as "an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitates sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels (Geissdoerfer et al., 2017). Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes" (Prieto-Sandoval et al., 2018).

It has been argued that industry can achieve circular economy through five phases – *take*, *make*, *distribute*, *use* and *recover* i.e. converting their linear business processes (take, make and distribute) to circular (Prieto-Sandoval et al., 2018). Circular economy is a concept widely studied in China and the European Union, the adoption of the latter driven by legislation, but there is a big scope for analysis beyond those countries (Zhu et al., 2010; Katz-Gerro, 2017). Moreover, although there is research in larger organisations (Zhu et al., 2010; Kumar et al., 2019), study on SMEs adoption of circular economy is scant. Only recently, research has been undertaken to facilitate implementation of CE in SMEs covering

awareness, strategies, policy, barriers and challenges, benefits and business models. However, according to the authors' knowledge there is limited work that holistically enables implementation of CE within SMEs through revealing current state of practicing CE, identifying issues and challenges and deriving enablers. This research bridges this critical research and practice (knowledge) gap. The overarching aim is to facilitate SMEs to achieve greater sustainability through circular economy approach addressing the following three research questions (RQs):

RQ1: How are CE fields of action related to sustainability perfornace,
RQ2: What are the issues and challenges, and opportunities of adopting circular economy in SMEs, and
RQ3: What key strategies, resources, and competence and capability facilitate effective implementation of circular economy in SMEs?

These questions are answered through empirical research within SMEs in the West Midlands region of the UK.

This study adopts mixed method – both qualitative and quantitative using case studies, interviews, and survey. Responses from 130 SMEs in the West Midlands of the UK were analysed to reveal the answers to the research questions. The responses were processed through structural equation modelling (SEM) using AMOS software (Arbuckle, 2014). Additionally, a focus group was organised involving all the relevant stakeholders of SMEs in order to capture current issues and challenges of CE implementation. Finally, a few case studies were undertaken to derive case specific strategies, resources and competences needed to support CE implementation and validate the entire results / findings.

The paper has been organised as follows – Section 2 provides literature review on the topic, Section 3 demonstrates the methodological steps, Section 4 presents the proposed model, Section 5 analyses the data and demonstrates results and findings, and finally, last two sections are for discussion and conclusion respectively.

2. Literature Review

Many countries including the UK have taken pledge to become carbon neutral by 2050 to keep the global temperature rise within 1.5 degree centigrade till end of this century. Circular economy has evolved as a newer paradigm to make entire society responsible to achieve this uphill targets. Recently, Kirchherr et al. (2017) after reviewing 114 CE definitions define CE as "an economic system that is based on business models which replace the 'end of life' concept with reducing, alternately reusing, recycling and recovering materials in production / distribution and consumption processes, thus operating at the micro level (products, companies and consumers), meso level (eco-industrial parks) and macro level (city, region, national and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations".

CE is based on the 'reduce reuse and recycle' principle, which could deliver through five field of actions – *take, make, distribute, use* and *recover* (Ormazabal et al., 2016). *Take* is related to how industry gets raw materials in their system. *Make* is conversion of raw materials to finished products. *Distributes* relates to making the finished products available to

users. *Use* allows the consumers to get benefit from the utility of the products. *Recover* facilitates manage the end of life state of the product through reuse and recycle. These fields of actions should be supported in micro, meson and macro levels. At the micro level, firms produce sustainable goods and services in separate units. Then the integration of firms makes it possible to build the meso level, where industry and business associations, clusters, and eco-industrial parks may interact and stimulate industrial symbiosis (Ormazabal et al., 2016) and considerably improve their environmental performance indicators (Daddi and Iraldo, 2016). Finally, at the macro level, policymakers facilitate adopting CE through most appropriate regulatory framework.

SMEs' business orientation is different from larger organisations due to numerous competitions, demand side uncertainties, cash flow issues, lack of standardised business practices, skill shortage and higher employee turnover. Therefore, SMEs emphasize more on their economic performance over environmental and social ones. SMEs' adoption of CE is constrained by their budget and pressure from their customers and policymakers. As indicated in the relevant research (Prieto-Sandoval et al., 2018) there are several barriers to adopt CE with SMEs' businesses. They are lack of financial support, inadequate information management system, lack of proper technology, lack of technical resources, lack of financial resources, lack of consumer interest in the environment, lack of support from public institutions, lack of qualified professionals in environmental management, and lack of commitment on the organisational management (Rizos et al., 2016; Ritzen and Sandstrom, 2017; Ormazabal et al., 2016).

However, there are several benefits and opportunities (Prieto-Sandoval et al., 2018) for the SMEs – increased image, cost reduction, business growth, higher productivity, recovery of environment through reduced CO2 emission, and greater sustainability. Prieto-Sandoval et al. (2018) reveal strategies across field of actions (take, make, distribute, use, and recover) of CE. In the *take* field the strategies are related to raw material selection along with supplier selection with green image. Avoidance of the use of toxic materials, process and product transparency, embrace the use of sustainable materials, and use of sustainable and fully recoverable materials are the key strategies for materials selection in CE. In the *make* field of action, the strategies are training of employees in sustainability issues, minimizing the environmental impact by resource optimisation, the use of sustainable energy sources, prevention of environmental damage, eco-design, and zero waste production processes are the key strategies. In the *distribute* field of action, optimisation of stock, routes, and space for both forward and reverse logistics through collaborative initiatives from all the concerned stakeholders form the right strategy to adopt CE. Strategies for the *use* field of action are focused on communicating to customers on eco-labelling and zero waste certification along with green marketing strategy, market segmentation and product system services implementation. Finally, in the *recover* field of action most appropriate reuse and recycle strategies will make effective adoption of CE. These need appropriate synergy among all the stakeholders across the supply chain including policymakers.

Successful implementation of CE will depend on a number of internal and external factors. External factors include public policy, market conditions, technological development, and stakeholders, whereas internal factors are the firm's resources, capabilities and competencies (Prieto-Sandoval et al., 2018). In the *take* field, the resources are procurement department, materials database, design and creativity, human resource department, and competences are abilities for eco-design and to attract talents with environmental values. In the *make* field, the resources are machineries and equipment, design, production technology, and competences

are production and project management. In the *distribute* field, traceability systems is the resource and competences are ability to perform reverse logistics, manage traceability, and share logistics operations with other organisations. In the *use* field, the resources are business intelligence for market analysis, maintenance services platform, and communication channels, and competences are green marketing initiatives, including consumer in product design, and maintenance services offer. In the *recover* field, the resources are reusable and recyclable products and materials, and competences is the ability of designing circular processes and products.

Many large organisations have adopted CE and recently started encouraging their supply chain to adopt CE also. However, uptake of CE in SMEs is very slow due to the reasons as stipulated in the above paragraphs. Research by Katz-Gerro and Sintas (2018) demonstrates CE activities across 11000 SMEs in EU-28 member states. They reveal that the CE activities that SMEs in the EU are likely to undertake is waste minimisation, replanning of energy use, redesigning products and services, using renewable energy, and water usage in descending order. Another research (Prieto-Sandoval et al., 2018) demonstrates key strategies, resources, and capabilities for implementing CE within Spanish SMEs across their *take, make, distribute, use* and *recover* field of actions. Prieto-Sandoval et al. (2018) in their study present challenges and opportunities of adopting CE in Spanish SMEs. The study reveals that the most motivating aspect of CE adoption is cost saving compared to aspects of image building and regulatory pressure. Kircherr et al. (2018) identify cultural barriers such as lack of consumers' interest and awareness, which alongwith a hesitant company culture are considered as main barriers to adopt CE. They further reveal that these are driven by market barriers, which in turn are induced by a lack of Governmental interventions. Rizos et al. (2016) present business models for adopting CE within SMEs' businesses and reveal that despite the various policy interventions many barriers act as obstacles to implement CE. The study recommends to emphasize on company culture, consumer preference and company's green business model. Prieto-Sandoval et al. (2019) demonstrate key strategies, resources, and capabilities for implementing CE in SMEs. Graces-Ayerbe et al. (2019) analyse the CE practices of EU SMEs for facilititaing implementation. They also came out with barriers to CE implementation such as administrative processes, regulations and lack of trained human resources. Unal et al. (2019) develop business models for designing CE using a case of an Italian SME in office supply industry.

In summary, three factors are associated in adopting CE within SMEs – material provision, resource reutilisation and financial advantage. As demonstrated above, there is inadequate work on SMEs adoption of CE and the studies are not conclusive. Additionally, although there are a few studies that facilitate implementation of CE within SMEs, they are limited researching on barriers and enablers, strategies and resources, and business models development for CE implementation. However, in order to implement CE, one needs to first know the current state of CE within a system. This is possible through studying the correlation between CE fields of action (e.g. *take, make, distribution, use and recover*) and sustainability performance (economic, environmental, and social). This will clearly identify various issues and challenges that need to address for successful implementation of CE through most appropriate strategy formulation, resource identification and development of competences. This research undertakes a holistic approach to analyse current state of CE practices, identifies issues and challenges, derives strategies, resources and competences of SMEs in the UK for effective implementation of CE. Although the study has been undertaken in the UK only, covering SMEs located in the West Midland County in manufacturing sector, the findings are applicable for any geographical location and industry.

3. Methodology

This study adopts a mixed method approach (qualitative and quantitative) using literature review, survey, focus group and case studies. First, the constructs and sub-constructs are identified for analysing the three research questions through review of secondary information (academic papers and reports) and an analytical framework is developed. Second, to reveal the current state of CE practices in the UK SMEs, a few hypotheses are developed relating CE field of actions with sustainability (economic, environmental and social) performance, data is collected through a survey instrument in line with the proposed hypotheses, and the correlations among the CE field of actions and sustainability performance are determined through statistical analysis. Third, a focus group is organised with the involvement of the participants of SMEs, their customers and suppliers, policymakers and researchers in order to identify issues and challenges, and derive opportunities for implementing CE. Forth, three case studies are undertaken to derive strategies, resources and competences for CE within SMEs and validate the overall findings of the research questions. Focus group approach is selected to derive issues and challenges, and opportunities of adopting CE in SMEs as we need to gather perspectives of all the concerned stakeholders. The statistical analysis could provide only the perspectives of SMEs' representatives. Similarly, as strategies, resources, and competencies of SMEs to implement CE need to be specific to individual SMEs, we decide to pursue case study method for revealing the answer to our third research question.

The survey responses were received from 130 manufacturing SMEs' representatives from the West Midlands, UK. The responses were analysed to estimate the relationship of the variables within the model using structural equation modelling (Bollen, 1989; Hussey and Eagan, 2007) by running the AMOS software. SEM models can be seen as a means to capture complex and dynamic relationships among a set of observed variables and unobserved constructs in the form of a regression equations system. The distinguishing feature is that variables here – in contrast to typical regression analysis techniques – can be either directly observed or latent (i.e. not directly measurable item) or a mixture of both of these. Hence, SEM provides a distinctive superior characteristic of being able to regress latent variables on other latent variables, such as the latent constructs analyzed in our paper. SEM modeling additionally allows fitting more complex model structures in comparison to typical regression analysis formulations. This type of modelling is deemed the most suitable for testing hypotheses and establishing correlations in our paper.

SEM model was fitted utilizing a covariance-based modelling approach, whereas the parameter estimation method chosen was the method of weighted least squares (Jöreskog, 1994), which is the most suitable method for the type of non-normal data gathered by the questionnaire, instead of utilizing maximum likelihood approaches that assume the data to be normally distributed (see, e.g., Bollen, 1989; Jöreskog, 1994). The covariance-based SEM approach has been selected due to the confirmatory nature of hypotheses posed under this research (Hair et al., 2011). Regarding the fit assessment of the fitted SEM model, we test its validity by using several alternative fit statistics (Marsh and Balla, 1994), such as the GFI (goodness-of-fit index), the AGFI (adjusted goodness-of-fit index) and the PGFI (parsimonious goodness-of-fit index), with AGFI adjusting the GFI for the complexity of the fitted model. Typically, for a good fit the indices should be above 0.9, however this cut-off threshold has been often criticized.

The demography of the sampled SMEs is listed in table 1.

Table 1. Demography of the participating SMEs

Title	**Number**
Owner	23
Production manager	41
Marketing manager	15
Supply chain manager	8
Purchasing manager	14
Quality manager	10
Maintenance manager	19
Total	**130**
Industry category	
Primary metal manufacturing	35
Fabricated metal product manufacturing	17
Machinery manufacturing	13
Electrical equipment and components manufacturing	23
Chemical manufacturing	10
Food and beverage manufacturing	17
Apparel manufacturing	10
Wood product manufacturing	5
Total	**130**

The focus group is undertaken with the involvement of representatives of SMEs, their customers and suppliers, policymakers, and researchers. Three manufacturing SMEs from West Midlands are selected on the basis of business performance and environmental practices for pursuing the case studies.

4. Analytical Framework for this research

The proposed analytical framework has three steps – undertaking diagnostic to reveal the current state of SMEs' CE practices; identifying issues, challenges and opportunities; and deriving strategies, resources and competences for effective implementation of CE. Figure 1 depicts the proposed framework for answering all the research questions.

Insert Figure 1 here

In step I, current state of SMEs' CE practices is revealed through establishing correlations among CE field of actions (e.g. take, make, distribute, use and recover) with sustainability (economic, environmental and social) performance. The subconstructs of the variables are shown in table 2 along with their reference sources.

Table 2. Constructs and subconstructs to reveal state of CE practices within SMEs

State of CE practices	*Constructs*	*Subconstructs*	*Sources (References)*
CE field of actions	Take	Materials selection	Unal et al. 2019; Kumar et al. 2019; Prieto-Sandoval et al., 2018; Prieto-
		Source selection	
		Inbound storage	

		Inbound transportation	Sandoval et al., 2018; Katz-Gerro and Sintas, 2018; Zhu et al. 2010; Sassanelli et al. 2019; Geissdoerfer et al. 2017; Dey et al. 2019; Dey et al. 2018; Malesios et al. 2018, De et al. 2018
	Make	Eco-design	
		Lean practices	
		Energy consumption	
		Use of renewable energy	
		Social wellbeing and equality	
	Distribute	Outbound storage	
		Outbound transportation	
	Use	After sales service	
		Repair	
		Reuse	
		Carbon offsetting / corporate social responsibility	
	Recover	Recycle	
		Reverse logistics	
Sustainability performance	Economic performance	Productivity	
		Turnover	
		Cost reduction	
		Business Growth	
	Environmental performance	Energy efficiency	
		Waste reduction	
		Resource efficiency	
	Social performance	Employee turnover	
		Accident reduction	
		Carbon offsetting/ CSR investment	

Figure 2 shows the theorised model relating CE field of actions with sustainability performance.

Insert Figure 2 here

Materials sourcing, supplier selection and inbound logistics contribute to economic, environmental and social performance. In general, SMEs emphasize on economic performance over environmental and social on sourcing decisions unless customers emphasize on specific requirement related to quality or there are regulatory requirements (Gupta et al., 2017). SMEs often emphasize on scale economy in procurement and order in bulk that results higher inventory. This is not a good practice from over all sustainability performance (Lee et al., 2008) perspective. Although in the past, supplier selection was governed by time, cost and quality factors, more recently, organisations are adopting environmental, social and risk taking ability of suppliers in to consideration for strategic sourcing (Dey et al., 2015; Ho et al., 2011; Ho et al., 2010; Scott et al., 2015). In many industires, suppliers without ISO14000 are not eligible for international biddings (Dey et al., 2018). SA8000 is also becoming popular for supplier selection (Malesios et al., 2019). There are several articles (Lee et al., 2008; Kumar et al., 2019) on green procurement that study the role of sourcing and in-bound logistics in achieving sustainability (Blome et al., 2014; Testa

et al., 2016). Therefore, for a group of SMEs in a specific region deriving the relationship of *take* and sustainability performance reveals current state of CE practices.

Accordingly, the first three hypotheses are formed:

H1: *Take* is positively correlated to *economic performance*.
H2: *Take* is positively correlated to *environmental performance.*
H3: *Take* is positively correlated to *social performance.*

Eco-design, lean practices, energy efficiency, use of renewable energy, and social wellbeing and equality help achieve sustainability. Energy efficiency and use of renewable energy help enhancing environmental performance and in turn firm's economic performance (Liu et al., 2017; Tseng et al., 2016; Zhu et al., 2007) as it helps in the operational performance. However, eco-design and lean practices may not help achieve higher economic performance (Tseng et al., 2018; De et al., 2018), although quite likely to contribute to higher environmental performance. Very few researches reveal direct relationship between social wellbeing and economic performance and environmental performance (Tseng et al., 2018). However, environment friendly SMEs are likely to have sarisfied employees with higher economic performance (Dey et al., 2019; 2020). While *lean practices* and *energy efficiency* measures help achieve both *economic and environmental performance*, *eco-design, use of renewable energy and social wellbeing* are capital intensive (Dey et al., 2019). *Social wellbeing* helps achieve higher *social performance* but may not have direct relationship with *environmental performance in SMEs*. However, there are contradictory findings by many researchers (Asif and Searcy, 2014; Morioka and Carvalho, 2016). Researches also look into the drivers for adopting energy efficiency measures and their role for achieving sustainability performance (Cagno and Trianni, 2013). Therefore, the following hypotheses need to be tested for SMEs in the midlands in order to derive current state of CE practices of the SMEs in the region.

H4: *Make* is positively correlated to *economic performance*.
H5: *Make* is positively correlated to *environmental performance.*
H6: *Make* is positively correlated to *social performance.*

Outbound logistics (warehousing and transportation) contribute substantially to profitability through customers' satisfaction (e.g. on time delivery) (Kumar et al., 2012) and efficiency (e.g. consolidating capacity) (Perotti et al., 2012). Optimal logistics in one hand could contribute reducing carbon footprint and on other hand, helps achieve customers' satisfaction in terms of quality and timeliness. Green innovation in logistics services enhances environmental performance (Jumadi et al., 2010). The search for solutions that are both efficient and ecologically sound (eco-efficient) have become topics of great interest. However, companies seeking to develop supply chain solutions that are eco-efficient may need to draw on external support from logistics service providers (LSPs). Research by Rossi et al. (2013) aims to explore the innovative strategies undertaken by LSPs to achieve eco-efficiency in supply chains. Environmental sustainability within logistics and transportation are fewer and relatively more recent (Marchet et al., 2014). Piecyk and Bjorklund (2015) demonstrate corporate social responsibility (CSR) activities of LSPs. Accordingly, hypotheses 7 – 9 are proposed.

H7: *Distribute* is positively correlated to *economic performance*.
H8: *Distribute* is positively correlated to *environmental performance.*

H9: *Distribute* is positively correlated to *social performance.*

Use in CE field action help extending products' life through effective after sales service, repair and reuse. Although these help enhance overall sustainability, better economic performance is not assured. However, there are contradictory findings from previous research, where extension of product life helps achieve efficiency through engagement with varied customers in different tier (Grenchus et al., 2001; Zhang et al., 2015). Carbon offsetting through corporate social responsibility projects are common to many large organisations. SMEs are also adopting this due to pressure from customers and / or policymakers. Although they are capital intensive, their long term economic benefits are also not assured. However, many research argued that CSR projects help achieve sustainability (Fisher et al., 2009) as they are been implemented to make the society carbon neutral. Customer driven initiatives drive SMEs to adopt green initiatives that help achieve environmental performance and competitive (Laari et al. 2016). Accordingly, hypotheses H10 – H12 are introduced.

H10: *Use* is positively correlated to *economic performance*.
H11: *Use* is positively correlated to *environmental performance.*
H12: *Use* is positively correlated to *social performance.*

Recover closes the forward logistic through reverse logistics and recycle (Zhang et al., 2015). Reverse logistics forms circular economy through closing the loop. Recently, there are many studies that relate reverse logistics and circular economy performance of industry supply chain (Bernon et al., 2018). Although both reverse logistics and recycle have economic model, they may not always be profitable to the company concerned (Grenchus et al., 2001). Waste management through reduce, reuse and recycle enhances environmental performance (Eltayeb et al., 2011; Theyel, 2000; Zhu and Sarkis, 2004). However, there are evidences also that effective waste management enhance both social and economic performance (Gyan, 2017). Sarkis et al. (2010) first reveal the positive correlation between reverse logistics and sustainability. Disposition decision needs proper analysis using triple bottom line approach (Agrawal and Singh, 2019). Accordingly, the following hypotheses are introduced.

H13: *Recover* is positively correlated to *economic performance*.
H14: *Recover* is positively correlated to *environmental performance.*
H15: *Recover* is positively correlated to *social performance.*

A questionnaire (appendix A) is developed to gather perceptions of the SMEs' representatives to reveal the current state of SMEs' CE practices and performances.

In step II, through focus group both external and internal issues and challenges are identified along with various opportunities for adopting CE practices within SMEs' businesses. Table 3 shows various issues and challenges and table 4 presents opportunities to adopt CE from prior research. A focus group template (appendix B) is developed to engage the participants and gather desired information.

Table 3. Issues and challenges of adopting CE in SMEs' businesses

Issues and challenges		*References*
External issues and challenges	Lack of financial support Lack of customers' support Lack of technology Lack of public institutional support Lack of professional in environmental management	Prieto-Sandoval et al., 2018; Ormazabal et al. 2016; Rizos et al., 2016; Ritzen and Sandstrom, 2017; Preston, 2012
Internal issues and challenges	Lack of information system Lack of technical & financial resources Lack of management commitment	Prieto-Sandoval et al., 2018; Ormazabal et al. 2016; Rizos et al., 2016; Ritzen and Sandstrom, 2017; Preston, 2012

Table 4. Opportunities of adopting CE within SMEs' business

Opportunities	*References*
Increased image	Del Rio et al. 2016; Rizos et al. 2016
Cost reduction	Ritzen and Sandstrom, 2017; Preston, 2012
Business growth	Dey et al. 2018; Malesios et al. 2018; De et al. 2019
Emission reduction	Ellen MacArthur Foundation, 2015
Productivity	Dey et al. 2018; Dey et al. 2019; Malesios et al. 2018; De et al. 2018
Sustainability	Moore and Manring, 2009; Dey et al. 2019; Malesios et al. 2018; De et al. 2018
Social wellbeing	Dey et al. 2019; Dey et al. 2018; Malesios et al. 2018; De et al. 2018

In step III, strategies, resources and competences of SMEs are derived across CE field of actions (i.e. *take, make, distribute, use,* and *recover*) to establish derive critical success factors for CE implementation. Table 5 and 6 depict strategies, and resources and competences respectively from prior research (Prieto-Sandoval et al., 2018).

Table 5. Strategies for adopting CE in SMEs' businesses (adapted from Prieto-Sandoval et al. 2018)

CE fields of action	*Sustainability performance*		
	Economic performance	*Environmental performance*	*Social Performance*
Take	Sourcing locally, Green procurement, material traceability, process and product transparency	Using regenerative materials, avoidance of the use of toxic materials, embrace the use of sustainable materials	Carbon offsetting / CSR projects
Make	Company digitisation	Minimising	Training employees in

	toward Industry 4.0, Design of circular and sustainable products, collaborative product design, ecological modernisation	environmental impact through resource optimisation, use of renewable energy sources, prevention of environmental damage, zero waste	sustainability issues,
Distribute	Optimisation of inventory, routes and space, Local market promotion, use of third party logistics, Use of telematic	Collaborative reverse logistics, promoting bio fuel in logistics,	Carbon offsetting / CSR projects (e.g. alternative materials for road construction)
Use	Product service system implementation, communication of environmental initiatives, Green marketing strategy, Market segregation	Ecolabelling	Addressing consumers' request on environmental issues
Recover	Implementing reverse logistics	Waste management across the supply chain, Valorisation of waste and energy	Transforming the entire system including manpower to adopt reverse logistic philosophy

Table 6. Resources and competences of SMEs' businesses (adapted from Prieto-Sandoval et al. 2018)

CE field of actions	*Resources*	*Competences*
Take	Procurement department Materials and suppliers database Design and creativity Human resource management	Develop successful, green, and circular products or services Fostering environmental friendly atmosphere across the supply chain
Make	Design Machineries and equipment Facilities Processes	Products / services management Process management Project management
Distribute	Facilities and equipment Traceability system Processes	Ability to optimise logistics operations across supply chain Promoting renewable sources of energy
Use	Market analysts and business intelligence After sales services Communication channel	Incorporate customers' feedback in products / services design Provide effective after sales services

		Integrate marketing and reverse logistic operations
Recover	Reduce, reuse and recycle (3R) philosophy across the supply chain	Practice 3R philosophy across the supply chain

A case study template is depicted in Appendix C.

5. Data analysis and results

This section describes responses to three research questions – correlation between CE fields of action and sustainability performance, issues and challenges, and opportunities of implementing CE; and strategies, resources and competenecies of SMEs that are desired to implement CE. The first research question is answered using survey method within 130 manufacturing SMEs in the West Midlands County. The second one uses focus group involving all the concerned stakeholdwers of SMEs using structured approach. The third research question adopts case study method through involving three manufacturing SMEs in the same region. The following paragraphs demonstrate the results of each research question.

Correlation between CE fields of action and sustainability performance :

Prior to SEM analysis, observed items from the questionnaire were checked for reliability and validity. Hence, statistics for testing reliability and validity of the constructs and latent variables utilized for the SEM analysis are described below (Table 7), i.e. the Cronbach's α values (Bollen, 1989) and the percentage of variance of the selected items explained by each of the latent factors.

Table 7. Reliability and validity analysis results for the constructs used for SEM modelling (CE and sustainability constructs)

Constructs	Latent variables	Cronbach's α	% of explained variance
Economic Performance	Productivity	0.598	48.92
	Turnover		
	Cost reduction		
	Business Growth		
Environmental Performance	Energy efficiency	0.592	53.34
	Waste reduction		
	Resource efficiency		
Social Performance	Employee turnover	0.634	55.41
	Accident reduction		
	Carbon offsetting/ CSR investment		
Take	Materials selection	0.944	90.47
	Source selection		
	Inbound logistics		
Make	Eco-design	0.691	52.62
	Lean practices		

	Energy consumption		
	Use of renewable energy		
	Social wellbeing and equality		
Use	After sales service	0.637	57.25
	Repair		
	Reuse		
	Carbon offsetting / corporate social responsibility		
Recover	Recycle	0.987	98.45
	Reverse logistics		

As we observe, the constructs utilized for the SEM analysis are adequately addressing the reliability and validity requirements. In addition, the collected data do not seem to suffer from Common Method Bias, since that the total percentage of variance explained by each single factor is much higher than 50% in almost all cases.

Next table (Table 8) shows the correlations between the eight constructs used for subsequent analysis.

Table 8. Pearson's correlation coefficients for the constructs used for SEM modelling (CE and sustainability constructs)

	Take	Make	Distribute	Use	Recover	Econ	Environ	Social
Take	1							
Make	0.35*	1						
Distribute	0.92*	0.29*	1					
Use	0.75*	0.41*	0.77*	1				
Recover	0.92*	0.29*	0.97*	0.77*	1			
Economic Performance	0.33*	0.64*	0.32*	0.47*	0.32*	1		
Environmental Performance	n.s.	0.44*	n.s.	0.62*	n.s.	0.41*	1	
Social Performance	n.s.	0.53*	n.s.	0.49*	n.s.	0.38*	0.77*	1

(*) Correlation is statistical significant at the 1% significance level.

The higher correlations between the examined constructs are observed between the CE constructs, and especially between *take* and *distribute*, *take* and *recover* and *distribute* and *recover*. Nevertheless, these results (in accordance with the reliability and validity results) do not provide evidence for the presence of common method bias, since that majority of correlation coefficients do not exceed 0.9 value (Lowry & Gaskin, 2014).

Regarding the fit of the SEM model using the UK SME data, as depicted in Figure 2, the results of fit statistics for assessing the model fit are presented in the following Table (Table 9).

Table 9. Values of goodness-of-fit measures for assessing SEM model fit

	Fit statistics				
	PGFI	**GFI**	**AGFI**	**RMSEA**	**SRMR**
SEM MODEL	0.687	0.897	0.865	0.029	0.0078

Goodness-of-fit (GoF) statistics for all the examined models show that the path analysis structures tested provided a moderate to good fit, since that most of the values are above the acceptable limits or at the borderlines (see Table 9). The GoF values are generally acceptable for the robustness of the SEM model and the obtained results.

Next, we turn our attention on the estimates of the fitted SEM model. Figure 3 shows the correlations between CE fields of action and sustainability performance (in the form of standardised regression estimates) and table 10 depicts standardised coefficients of sub-constructs of CE fields of action (*take, make, distribute, use and recover*) and sustainability performance criteria (economic, environmental and social performance).

Insert Figure 3 here

SEM results in the form of standardized path coefficients are displayed in Figure 3 and corresponding significances along with support for the four direct hypotheses (H1-H15) are summarized in Table 10 below.

Table 10. Standardised regression coefficients between CE and sustainability performance constructs

CE constructs	**Sustainability performance constructs**	**Standardised regression coefficient**
Take	Economic Performance	0.471**
Take	Social Performance	n.s.
Take	Environmental Performance	n.s.
Make	Economic Performance	0.922***
Make	Social Performance	0.83***
Make	Environmental Performance	0.95***
Distribute	Economic Performance	0.438**
Distribute	Social Performance	n.s.
Distribute	Environmental Performance	n.s.
Use	Economic Performance	0.503**
Use	Social Performance	0.717***
Use	Environmental Performance	0.975***
Recover	Economic Performance	0.434**
Recover	Social Performance	n.s.
Recover	Environmental Performance	n.s.

(*) p-value < 0.05; (**) p-value < 0.01; (***) p-value < 0.001; (n.s.): non-significant.

Results of SEM modelling show that most strong (positive) associations are between "Make" and "Economic performance" (beta coefficient = 0.922; p-value<0.001), "Make" and "Environmental performance" (beta coefficient = 0.95; p-value<0.001), "Use" and "Environmental performance" (beta coefficient = 0.975; p-value<0.001), "Make" and "Social performance" (beta coefficient = 0.83; p-value<0.001) and "Use" and "Social performance" (beta coefficient = 0.717; p-value<0.001).

No statistical significant association has been detected for the relationship between "Take" and "Social performance", "Take" and "Environmental performance", "Distribute" and "Social performance", "Distribute" and "Environmental performance", "Recover" with "Social performance" and "Recover" and "Environmental performance".

Next, Table 11 shows the corresponding standardised coefficients between constructs and sub-constructs, along with statistical significances.

Here, most important associations are observed between the CE constructs of "Take" and "Recover" and their sub-constructs (observed items). Sustainability performance constructs are shown to be less correlated with their respective sub-constructs, as revealed by the results of Table 11.

Table 11. Factor loading of sub-constructs of CE fields of action

CE fields of action	*Constructs*	*Subconstructs*	*Standardised regression coefficient*
CE field of actions	Take	Materials selection	0.859***
		Source selection	0.98***
		Inbound logistics	0.853***
	Make	Eco-design	0.23*
		Lean practices	0.74***
		Energy consumption	0.739***
		Use of renewable energy	0.397**
		Social wellbeing and equality	0.452**
	Distribute	Outbound logistics	---
	Use	After sales service	0.57**
		Repair	0.515**
		Reuse	0.421**
		Carbon offsetting / corporate social responsibility	0.452**
	Recover	Recycle	0.948***
		Reverse logistics	0.963***
Sustainability performance	Economic performance	Productivity	0.195*
		Turnover	0.523**
		Cost reduction	0.466**
		Business Growth	0.390**
	Environmental performance	Energy efficiency	0.589***
		Waste reduction	0.353**
		Resource efficiency	0.37**
	Social performance	Employee turnover	0.758***
		Accident reduction	0.487**
		Carbon offsetting/ CSR investment	0.428**

(*) p-value < 0.05; (**) p-value < 0.01; (***) p-value < 0.001.

Currently, CE field of actions *take* is moderately related to economic performance, but not correlated to environmental and social performance. In the contrary, both *make and use* are strongly correlated to economic, environmental and social performance. *Distribute* and *recover* are moderately correlated to economic performance but not related to both environmental and social performance. This means that SMEs in the UK make decisions on *take,* CE field of action considering economic factors only without environmental and social factors. Similarly, every decision related to *make* and *use* is undertaken with the consideration of all the economic, environmental, and social factors. In line with *take*, both *distribute* and *recover* consider only economic factors but completely ignore environmental and social factors.

Further, factor loading of CE field of actions reveal that all *material selection, supplier selection* and *in-bound logistics* are emphasized in *take*, whereas only *lean practices* and *energy consumption* are prioritised in *make*. In *use*, *aftersales service* and *repair* and in *recover*, both *recycle* and *reverse logistics* are considered important. Therefore, the UK SMEs' managers currently focus on a few selected subconstructs among every CE field of action. This reveals various issues and challenges across the CE field of actions.

Issues and Challenges, and Opportunities of SMEs for implementing CE:

A focus group of 26 people (with the involvement of SMEs' managers and owners, their customers and suppliers, policymakers and researchers using focus group protocol - Appendix B) is organised to identify number of issues and challenges, and opportunities that currently exist across CE field of actions. Table 12 shows the issues and challenges, and opportunities of SMEs in the region to enhance their sustainability.

Table 12. Issues and challenges, and opportunities of CE adopting of SMEs in the UK

CE Field of actions (constructs and subconstructs)	*Issues and challenges*	*Opportunities*
Take (materials selection, source selection, and inbound logistics)	Regenerative materials selection due to lack of innovation and management commitment, sourcing locally without sacrificing economic performance due to lack of supply chain integration led by client companies, specifications provided by client organisations keep limited scope to alter procurment strategies including material selection	Scope for improving environmental and social aspects to enhance sustainability
Make (Eco-design, lean practices, energy consumption, use of renewable energy, wellbeing	Eco-design across products, processes, facilities and supply chain, scale economy hinders adopting lean	Huge scope of carbon footprint reduction and enhancing social wellbeing, which in turn likely to

and equality)	approach, adopting renewable energy sources is challenging due to lack of financial resources and support, social wellbeing lacks due to lack of public intuitions and policymakers' support	enhance productivity and sustainability
Distribute (Outbound storage and transportation)	Distribution network is designed on economic performance basis; Use of technology and information system could help improving environmental performance substantially, social wellbeing of people in logistics sector lacks due lack of integration of supply chain across the industry	Substantial emission reduction and social inequality
Use (after sales services, repair, reuse, carbon offsetting / CSR)	Lack of understanding of the benefit of extending products and facilities life due to management commitment, technical and financial resources, carbon offsetting / CSR activities are policy driven	There is scope of improving sustainability through working with customers closely
Recover (Recycle and Reverse logistics)	Lack of formal recycle and reverse logistics approach due to technical, financial support, management commitment and availability of consultants	Emission reduction through *recover* needs highest attention across SMEs

The findings have synergy with the results of statistical analysis on state of current practices of CE in SMEs.

Strategies, resources, and competences of SMEs for CE implementation:

Strategies, resources, and competences of SMEs for CE implementation for facilitating CE adoption are revealed through case studies in three companies. Companies are randomly selected on the basis of their economic and environmental performance. A template (Appendix C) is designed to gather standardised information from all the case study SMEs. Information from each SME was gathered through meeting with CEO / owner of the company. The following paragrpahs demonstrate three case studies (anonymous) covering the company details, their CE field of actions, issues and challenges, and strategies, resources and competences.

Case study I:

The first company is a major supplier of Medium-density fibreboard (MDF) and timber products to construction industries. The company is closed to 100 years old. The products are manufactured from raw materials. They are also manufacturing a few tools that gives them enough flexibity to customise their products as per customers' requirements. The delivery schedule for their timber products are 5 – 7 days and for all MDF products within 3 days, which is benchmarked for the industry. The company's experience stems from being a major supplier of fire rated and regular doors, door sets, pullets, cladding, packing and cases.

Current state of *take* field of action

Company's products are completely recyclable. The industry is quite regulated through Timber regulation body, UK and EU timber federation. Raw materials are imported and third-party logistics are deployed. Carbon offsetting activities are undertaken with the suppliers in order to maintain the ecosystem. Supplier selections are done with the consideration of environmental factors.

Current state of *make* field of action

The company uses materials that are regulated and mould them to make the final product following eco-design principle. They intend to implement lean manufacturing. There is scope for investigating in reduction of energy consumption. The industry currently works on the principle of replace than repair. That causes serious issue of waste management. Industry should understand that a fine scratch is not a defect. More work needs to be done to repair than replace (e.g. repairing elements of a door). However, the logistics connected to this needs consideration. Supply chain carbon footprint needs to be measured and means for reducing should be implemented. Optimum usage of resources in manufacturing, implementation of waste minimisation, minimising energy usage, self-generated own heat are a few good practices implemented in recent years. Human resource department is responsible for wellbeing measures.

Current state of *distribute* field of action

Both inbound and outbound logistics incur considerable cost. Delivering products to customers- ensuring it arrives scratch free with quality and on time are one of the critical success factors of the company. Dealing with rejects / returns products depends on fitters' competency. Strategies and policies need to be aligned with customers satisfaction and management commitment to environmental and social regulations. Insurance companies also play major role in deciding company's actions on dealing with defective products. Packaging of the products (materials, cost, reusability and recyclability) is also to be considered as a sustainability strategy.

Current state of *use* field of action

In the use phase, the objective is to enhance product life as much as possible through reuse and repair. Recycle follows subsequently if reuse and repair fail. Currently the company emphasizes on replacing over repairing.

Current state of *recover* field of action

As the products are 100% recyclable the company uses third party to get rid of the returned products that are repairable along with raw materials and in process materials. Developing on line connections with major customers for collecting their non-repairable products at the end of life cycle could reduce their carbon print substantially.

Case study II:

The second company is in business to provide a friendly, service driven, cost effective, high quality component powder coating & paint spraying solution. Since 1879 the company has always strived to be at the forefront of the finishing industry, utilising the latest processes and tools to maximise production for our customers. Their clients include JLR, Aston Martin, BMW, Ford, Mitsubishi, HP and Siemens to name but a few.

Current state of *take* field of action

They use water-based paints, which is eco-friendly. Customers' specification is strictly followed along with educating customers on new development. Supplier selection is done on the basis of quality and logistics consideration.

Current state of *make* field of action

They have ISO 9001 and ISO14001 accreditation and employs Six Sigma techniques to focus and develop continual improvement philosophy. Environmental aspects of the business have equal priority and importance to the business issues and are controlled within the management systems of the company. Energy consumption is monitored and reduction measures are implemented successfully. There is emphasis on paint waste reduction too. Employee wellbeing and equality are also given priority.

Current state of *distribute* field of action

Same packaging is used for inbound and outbound. Full truck loads are used as much as possible.

Current state of *use* field of action

Paint and coating materials are designed to enhance product life as much as possible. Packagings are reused.

Current state of *recover* field of action

Packaging is reused and recycled as much as possible.

Case study III:

The third company is recognised as a world-leading manufacturer of precision metal pressings and metal stampings and since last 50 years provides value-adding, end-to-end solutions through closely working with their customers. They tailor around customer requirements to oversee tooling design and production, the manufacture of pressings and stampings, welding, finishing and assembly. Their 57,000 square foot facility contains some of the latest state-of-the-art manufacturing plant. This enables them to provide metal formed components and welded assemblies to a high specification at competitive prices, highest quality and on time. APS is an international leader in precision pressings, automotive presswork, welded assemblies and metal flow forming technologies. They produce a wide variety of products and work in partnership with customers representing the following markets: automotive, construction, consumer, mining, DIY, and bathroom products.

They have developed the expertise to undertake a complete range of processes to offer customers a single source solution for stampings, pressed components and pressed assemblies. Through complex pressing, welding, deburring, assembly and finishing operations, tooling, and presswork they have also overcome most of the challenges that are likely to be encountered and can oversee the most demanding projects with confidence.

Current state of *take* field of action

As they mainly manufacture customised products, materials selection is not their discretion. Therefore, they have very little room to contribute selecting regenerative materials. However, as metal is completely recyclable material selection does not contribute negatively in their effectiveness of sustainability practices. They have generally long-term relationship with their suppliers (steel manufacturers and retailers).

Current state of *make* field of action

They provide professional product development support through state of art project management approach that makes things simple for customers and provides them with the assurance of knowing that pressings and stampings will be engineered to the most exacting standards following eco-design principle using optimal resources.

They have a dedicated production management team that meets daily to program customer schedules and optimise production equipment. This helps to ensure pressed products, stampings and welded assemblies are delivered on time, every time.

Due to a company policy of continuous investment in modern manufacturing plant, MPL is able to provide high quality products at competitive prices.

As a TS16949 & ISO 14001/9001 accredited company, MPL is committed to delivering quality assured technical pressings, stampings and welded assemblies. Quality Department supports all elements of the business from daily production to the forward planning of new projects. A small team also dedicated to maintaining and improving quality systems, and liaising with accreditation bodies including environmental and social requirements.

There is no dedicated effort to reduce energy consumption, and enhance resource efficiency.

Current state of *distribute* field of action

Their own, in-house fleet of trucks provides complete control and flexibility to ensure that on-time deliveries directly to their mainland UK based customers. Where customers prefer to collect pressed products from them on an ex-works basis, timed collections are arranged by the production control team. Carbon saving and cost cutting through third party logistic hasn't been explored.

Current state of *use* field of action

Due to mostly long-term relationship with customers and characteristics of the products (e.g. customised components) there is no aspiration from customers for after sales services. Customers' feedback mechanism exists, which helps in new product development along with service improvement.

Current state of *recover* field of action

The products are 100% recyclable. Wastes from raw materials, work in progress and finished products within plant premises are recycled through third party. However, the end products remain at the discretion of the customers.

Inventory of equipment and machineries are appropriately managed through formal approach. Equipment and machineries are replaced on the basis of economic measures. Environmental (energy efficiency) and social factors are less emphasized.

The findings through case studies on current state of CE fields of action and their relationship with sustainability performance are aligned with the empirical findings from the statistical analysis of 130 SMEs data from the West Midlands region. Additionally, the issues and challenges that are identified from previous researches match with the case studies companies.

The researchers brainstormed with the company representatives of each participating SME and derived strategies, resources and competences for implementing CE. Table 12, 13, and 14 describe the strategies, resources and competences respectively across CE field of actions that the case study companies have planned to undertake for adopting circular economy.

Table 12. Strategies across the CE field of actions for adopting circular economy in each case study company

CE field of actions	**Case study 1**	**Case study 2**	**Case study 3**
Take	-Develop long term relationship with suppliers	-Communicate paint quality and customers' requirements to suppliers for product development	-Select materials with the consideration of manufacturing processes including tooling. -Work in collaboration with suppliers and

			customers
Make	-Adopt Industry 4.0 for advanced data management -Undertake ecological modernisation with suppliers -Train employees to adopt sustainability practices -Adopt renewable energy	-Adopt Industry 4.0 for advanced data management -Train employees to adopt sustainability practices -Adopt renewable energy	-Adopt Industry 4.0 for advanced data management -Design product in collaboration with customers in order to design most effective manufacturing process -Train employees to adopt sustainability practices including energy efficiency and waste management -Adopt renewable energy
Distribute	-Use third party logistics -Use technology to optimise logistics -Promote biofuel		
Use	-Implement product service system -Adopt ecolabelling -Communicating environmental and social measures to customers		
Recover	-Train employees for practicing reduce, reuse and recycle philosophy across the supply chain		

Table 13. Resources for adopting circular economy in each company

CE field of actions	**Case study 1**	**Case study 2**	**Case study 3**
Take	-Regenerative and biodegradable raw materials -Competent suppliers -Warehouse	-Use of environment friendly paint products	-Use of recyclable products -Competent and committed suppliers
Make	-State of art technology -Standardised processes -Trained manpower -required facilities	-State of art technology -Standardised processes -Trained manpower -required facilities	-State of art technology -Standardised processes -Trained manpower -required facilities
Distribute	-Availability of third-party logistics providers	-Availability of resources and technology	-Distribution network in place
Use	-communication infrastructure	-Long term relationship with customers	-Long term relationship with customers
Recover	-committed and competent manpower	-Entire business process is conducive for reduce, reuse and recycle	-Trained employees and committed management

Table 14. Competences for adopting circular economy in each company

CE field of actions	**Case study 1**	**Case study 2**	**Case study 3**
Take	-Expertise in working in regulatory framework in closed collaboration with suppliers -Carbon offsetting activities with suppliers -Communication with suppliers	-Standardised procurement processes	-Strong collaboration with suppliers and customers that helps to source materials optimally
Make	-Extending product life through repair -Emphasize on waste reduction across supply chain philosophy -Reduction of energy consumption -Ability to design products with less packaging	-ISO 9001 and ISO 14001, and six sigma approach in business processes -Emphasize on waste reduction through resource optimisation, energy reduction, waste reduction	-Accreditation of ISO9001 and 14001 help practicing standardised approach all through the organisational value chain -Continues improvement philosophy in place -Expertise in project management to facilitate new product development
Distribute	-Management is committed to reduce carbon footprint in logistics along with cost reduction	-Optimisation approach in place	-Distribution mechanism with the consideration of cost and quality (delivery time) in place
Use	Initiated dialogue with customers on sustainability practices in to extend product life, reduce packaging, and recycling of used products	-Long term relationship with customers -Effective communication to achieve greater sustainability across supply chain	Long term relationship through communication
Recover	-Company is committed to reduce waste of production using lean approach, which works in reduce, reuse and recycle philosophy	-ISO 14001 has been adopted -Six sigma in place -Sustainability is practiced across the supply chain in collaboration with suppliers and customers	-ISO 14001 in place -Cost reduction philosophy across the supply chain helps adopting sustainability approach through waste reduction.

Although there are similarities and differences on strategies, resources and competences that are required to implement CE within the case study organisations, they match in general with the previous studies. The case studies further reveal that the SMEs' approach to CE

implementation is currently economy focused. Cost effective measures for improving environmental and social performance are implemented without any external pressure, although SMEs need support to undertake diagnostic to identify and prioritise means for improvement through business development. However, unless there is pressure from customers, suppliers and policymnakers cost intensive measures are not implemented. These completely match with the findings from the statistical analysis and focus group.

Although the case studies have been primarily undertaken to reveal the answer to the research question 3 (strategies, resources and competences that are required to implement CE), these also help to validate findings of research questions 1 and 2 (current state of CE practices, and issues and challenges of implementing CE).

6. Discussion

The UK pledges to become carbon neutral by 2050 to keep the global warming within the acceptable limit (1.5 degree celcius). Although larger organisations initiated several means for achieving their carbon neutral targets, very less work has been undertaken to make SMEs' carbon footprint lower. In one hand, SMEs contribute to GDP and employment generation but affect environment negatively due to the characteristics of their businesses, which emphasize on economic performance over environmental and social. Circular economy emerges as a new philosophy for achieving sustainability in micro (enterprises), meso (regions) and macro (national) levels through transforming today's linear supply chain (*make, use* and *dispose*) to circular (*take, make, distribute, use* and *recover*) (Geissdoerfer et al., 2017). This research demonstrates how CE could be implemented within SMEs in the UK to reduce carbon footprint substantially with higher productivity. This study addresses three research questions – how the CE fields of action are related to sustainability performance, what are the issues and challenges, and opportunities of implementing circular economy in SMEs, and what key strategies, resources, and competences facilitate effective implementation of circular economy in SMEs?

A holistic analytical framework (figure 1) is developed to answer the above three questions, which uses statistical analysis, focus group and case study approaches respectively in order to reveal answers to the research questions. While statistical analysis reveals current state of CE implementation through deriving the correlation between CE fields of action and sustainability performances, focus group identifies issues and challenges, and derive opportunities of SMEs to implement CE, and finally the case study approach determines strategies, resources and competences of SMEs to implement CE.

This study considers *take, make, distribute, use* and *recover* as CE fields of action, out of which only *make* and *use* contribute to all economic, environmental and social performance, as the current research reveals. This is in line with the findings of the previous studies (Calabrese et al., 2012; Egels-Zandén & Rosén, 2015; Tseng, 2017). However, each CE field of action is designed to contribute to economic performance of SMEs in the UK, whereas *take, distribute* and *recover* do not contribute to environmental and social performance. This is aligned with the findings of Tseng et al. (2016). Therefore, in order to effectively implement CE in the UK SMEs, social and environmental aspects of *take, distribute* and *recover* need strengthening, which will result in greater sustainability (right combination of economic, environmental and social performance) across SMEs' supply chain (Engert and

Baumgartner ,2016). Table 15 shows the list of previous studies that matches and differes with the findings of this research.

The study further reveals that *turnover, cost reduction* and *business growth* moderately contribute to *economic performance* of the UK SMEs (aligned with the study by Wijethilake, 2017). *Environmental performance* is strongly affected by *energy efficiency* and moderately by *waste reduction* and *resource efficiency.* This is in line with the previous studies ((Liu et al., 2017; Tseng et al., 2016; Zhu, Sarkis, & Lai, 2007). *Employee turnover* contributes strongly to social performance, whereas *accident reduction* and *CSR investment* are moderately connected to social performance. Studies done by a few researchers ((Bonn & Fisher, 2011; Liu et al., 2017; Szekely & Knirsch, 2005) also reveal similar results.

The UK SMEs need improvement in eco-design, lean practices, renewable energy adoption, and employee wellbeing and equality within *make* CE field of action, which is aligned with the findings of couple of recent researches (Bonn & Fisher, 2011; Liu et al., 2017; Szekely & Knirsch, 2005). Logistic optimisation and use of telematic within *distribute* need attention. Carbon offsetting / CSR investment and reuse need improvement in *use* category of CE field of action.

The focus group identifies several issues and challenges of the UK SMEs for implementing CE across their supply chains. SMEs have very little scope to contribute in materials selection as design and specification for the products are done by the clients / customers without any consultation with the suppliers. SMEs can affort to undertake eco-design only if it's economically feasible due to intense competition in SMEs business. Although lean practices are philosophically efficiency oriented, however they are perceived as capital intensive by the UK SMEs (Tseng et al., 2018), which calls for financial support from local Government and / or clients (Bocken and Short's, 2016). Although switching to renewable energy usage is considered to be the preferred approach to become carbon neutral for the UK SMEs due to likely reduced energy cost, financial support is still needed to install the facilities (Perez-Batres, et al., 2012). SMEs also lagging behind in social wellbeing of their employees due to lack of support from public institutions. SMEs have least concern on the logistic carbon footprint as this is being perceived as third party's discretion, although for many industries in SMEs business 20 – 30% cost is tied up in logistic and there is huge scope for both cost and carbion footprint reduction. SMEs are generally not responsible for their products after they are delivered to their customers. Additionally, they work in the principle of *make, use* and *dispose* that is quite opposite to sustainability (Engert and Baumgartner, 2016). Therefore, there is huge opportunity for enhancing environmental and social performance of SMEs along with higher productivity.

Table 15. Comparing the findings of the study with the existing literature

Findings of the study			**Literature supporting findings of the study**	**Literature not supporting findings of the study**
CE fields of action	Relationship	Sustainability performance		
Take	Moderately Related	Economic	Engert and Baumgartner ,2016	
	Not Correlated	Environmental	Tseng et al.,2018,	

		Social	(Tseng et al., 2015).	
Make and Use	Strongly Correlated	Economic Environmental Social	Sehnem et al., 2019; Kumar et al.,2019, Calabrese, Costa, Menichini, & Rosati, 2012; Egels-Zandén & Rosén, 2015; Tseng, 2017	Engert and Baumgartner (2016)
Distribute and Recover	Moderately Correlated	Economic	Engert and Baumgartner ,2016	Kinnunen et al.,2019
	Not Related	Environmental Social	Tseng et al.,2018, ;Tseng et al., 2015, Engert and Baumgartner (2016)	

Subsequently, case studies analysis reveals strategies, resources and competences that are required to implement CE within the UK SMEs. The strategies for adopting CE are integrated approach to sourcing through communication across the supply chain including customers; design of products in collaboration with customers to optimise resource, minimise energy consumption, reduce packaging or use biodegradable packaging materials, and use 100% recyclable materials; adopt industry 4.0 for data management across the supply chain; train people; adopt renewable energy; use third party logistics (3PL), technology and promote biofuel for logistics operations; adopt product service system ecolabelling and emphasize on repair where possible; and train people and make management committed to practise reverse logistics effectively. The resources that facilitate SMEs to implement CE are availability of regenerative materials, competent suppliers, state of art technology and facilities, trained manpower, 3PL service providers, renewable energy sources, and communication infrastructure, facilities and technologies for reverse logistic. Competence wise SMEs in the UK need expertise in working in regulatory framework, standardised production and operations processes, ability to optimise resources, energy consumption and waste reduction, ability to communicate to customers and suppliers to enhance sustainability across the supply chain, and to adopt formal reverse logistic approach to make supply chain circular.

7. Theoretical and Practical Contribution, and limitations

This research contributes by introducing new knowledge on the current state of SMEs' circular economy implementation, various issues and challenges they face that hinder implementation of CE, and strategies, resources and competences they need in order to successfully implement CE. It reveals correlation between CE fields of action and sustainability performance that discloses current state of CE in a system. The study further reveals SMEs in the region are economy focused all across the CE fields of action (take, make, distribute, use and recover). They are concerned on environmental and social issues related to *make* and *use* CE fields of action. Therefore, there is huge scope of improving environmental and social contributions in the areas of *take, distribute and reorder* fields of action. This research suggests very practical pathway to implement CE within SME organisations through appropriate strategies, resource deployment and competence building.

Although the above findings are specific for the region covering West Midlands in the UK only, we can generalise these across the other counties of the UK because of synergies of business practices in manufacturing supply chains and Government policies. For further generalisation to other countries in the EU and other developed as well as emerging economies we suggest to undertake primary research following the proposed methodological framework. Analysing the current state of CE practices within a specific region through revealing correlation between CE fields of action and sustainability performance provides approapriate diagnostic to derive means for implementing CE objectively to enhance sustainability performance (targeting zero carbon emissions).

In this research, CE fields of action are considered to be *take, make, distribute, use* and *recover*. The study could have been done considering closed loop supply chain processes (e.g. design, procurement, manufacturing, distribution, use and reverse logistics) also. The subconstructs of CE field of actions may vary across the industries and geographical locations. This research has been undertaken using combined statistical analysis, focus group and case studies through data gathered from 130 SMEs for statistical analysis, focus group of around 26 people representing SMEs' managers / owners, their customers and suppliers, policymakers and researchers, and three case studies. Different methodology could result in slightly different outcomes. Although the study reveals current state of CE implementation within the UK SMEs and means of improving its uptake through strategies, resources and competences, the stakeholders play major role to implement CE, which has not been covered in this research and kept as scope for further research. Finally, energy efficiency measures, adopting renewable energy, and carbon offsetting through CSR projects are popular means for implementing CE across manufacturing supply chain. However, this study focuses on all CE fields of action and its relationship with sustainability performances in order to suggest the best way to achieve higher sustainability performance without emphasizing on specific mean for implementing CE.

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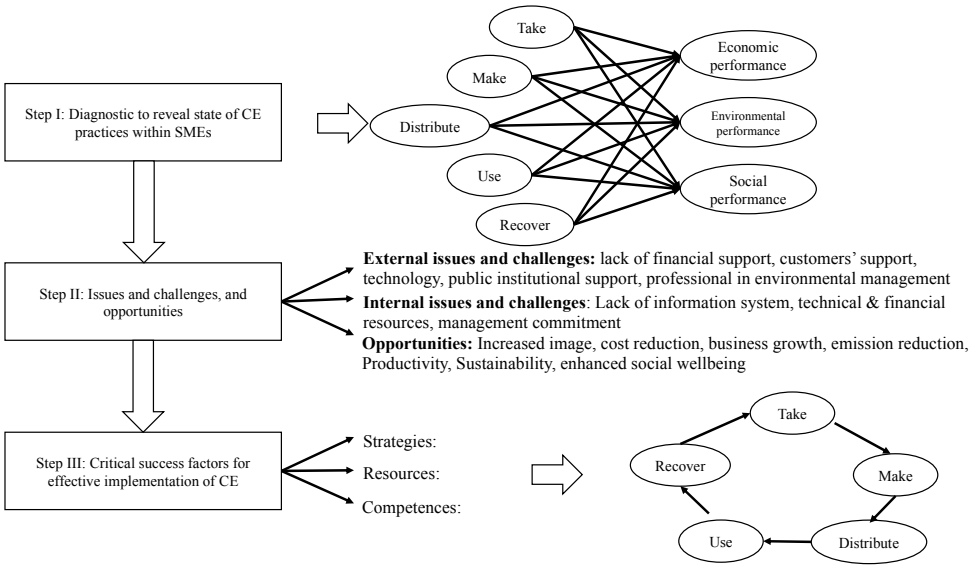

Figure 1 Proposed analytical framework

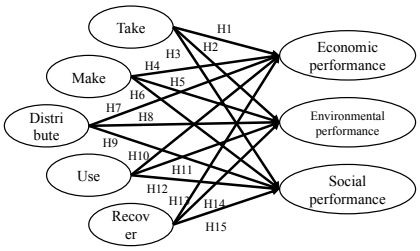

Figure 2 Diagnostic model to derive state of CE practices within SMEs

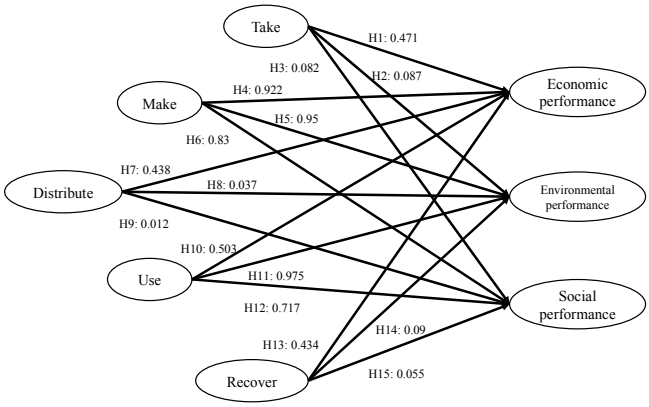

Figure 3 Correlation of CE fields of action with sustainability performance

Appendix A

TAKE	
Do you consider environmental factors in the raw materials/associated process materials/semi-manufactured goods-parts used in production?	1 2 3 4 5
Do you consider environmental factors while choosing suppliers?	1 2 3 4 5
Do you consider environmental factors while considering the storage in the production plant?	1 2 3 4 5
Do you consider environmental factors while transportation within production plant?	1 2 3 4 5
MAKE	
Do you consider eco design in production?	1 2 3 4 5
Do you practice lean?	1 2 3 4 5
Do you have developed conservation and efficiency initiatives in order to reduce energy consumption?	1 2 3 4 5
Do you use renewable source of energy?	1 2 3 4 5
How effective do you think is your social well being and equality?	1 2 3 4 5
DISTRIBUTE	
Do you consider environmental factors while considering the storage outside the production plant?	1 2 3 4 5
Do you consider environmental factors in logistics?	1 2 3 4 5
USE	
How effective is your after sales service?	1 2 3 4 5
Do you consider repair?	1 2 3 4 5
How you consider reuse of material in process/product/after sales?	1 2 3 4 5
How effective is your corporate social responsibility?	1 2 3 4 5
RECOVER	
How effective is recycle?	1 2 3 4 5
How effective is reverse logistics actions (e.g. remanufacturing, refurbishing)	1 2 3 4 5
SUSTAINABILITY PERFORMANCE	
ECONOMIC PERFORMANCE	
How effective is your productivity	1 2 3 4 5
ENVIRONMENTAL PERFORMANCE	
Do you have developed conservation and efficiency initiatives in order to reduce energy consumption?	1 2 3 4 5
Do you support recycling, reclaim and/or recovery of material from waste derived from your production processes?	1 2 3 4 5
SOCIAL PERFORMANCE	
Do you keep formal records of the hazardous and non-hazardous waste derived from your production processes?	1 2 3 4 5
How would you rate the resource efficiency of your company?	1 2 3 4 5
Do you have employee training programs to upgrade skills or, if not, do you support your employees in attending external training or education?	1 2 3 4 5

Please rate on a scale of 1 "very low ", and 5 "very high"

ECONOMIC PERFORMANCE

The previous financial year your total revenue was:

Up to 100000 £	More than 100000 and up to £ 500000	More than 500000 and up to £ 1 million	More than £ 1 million and up to £ 2 million	More than £ 2 million and up to £ 10 million	More than £ 10 million

The Turnover Growth % in two previous years was:

0% – 10%	11-20%	21% – 30%	32% – 50%	Above 50%

The cost reduction % in two previous years was:

0% – 2%	3% – 5%	6% – 8%	9% – 10%	Above 10%

The Turnover Growth % in two previous years was:

0% – 10%	11-20%	21% – 30%	32% – 50%	Above 50%

SOCIAL PERFORMANCE

What is the (approximate) amount invested in CSR activities by your company in the last year (last 5 years?)

Less than 5000 £	5001-10000 £	10001-25000 £	25001-50000 £	Above 50000 £

Appendix B

Focus Group Protocol

Participants: SMEs' owners and managers, Policymakers (e.g. people from city council, Local area enterprises), Managers of original equipment manufacturers (OEMs), retailers, and public sector units (PSUs), environmental consultants, researchers, academics

Each table will pick up one of the five fields (*take, make, distribute, use and recover*) of circular economy and discuss on its correlation with SMEs' sustainability performance (economic, environmental and social).

Take

- What are the major issues and challenges of 'material selection', 'supplier selection', and 'in-bound logistics' within SMEs for achieving sustainability performance?
- Is there any best practice within 'take' that you are aware of?
- What innovation you suggest in above areas to enhance sustainability performance?
- What role individual SME, SMEs consortium (e.g. federation of small businesses), customers (e.g. OEM, retails and PSU) and policymakers should play to adopt circular economy framework

Make

- What are the major issues and challenges of 'eco-design', 'lean practices', 'energy consumption', 'use of renewable sources of energy' and 'employee wellbeing and equality' within SMEs for achieving sustainability performance?
- Is there any best practice within 'Make' that you are aware of?
- What innovation you suggest in above areas to enhance sustainability? performance
- What role individual SME, SMEs consortium (e.g. federation of small businesses), customers (e.g. OEM, retails and PSU) and policymakers should play to adopt circular economy framework?

Distribute

- What are the major issues and challenges of 'Outbound logistics (transportation and ware housing)' within SMEs for achieving sustainability performance?
- Is there any best practice within 'Distribute' that you are aware of?
- What innovation you suggest in above areas to enhance sustainability performance?
- What role individual SME, SMEs consortium (e.g. Federation of Small Businesses), customers (e.g. OEM, retails and PSU) and policymakers should play to adopt circular economy framework?

Use

- What are the major issues and challenges of 'after sales services', 'reuse', 'repair', and 'corporate social responsibility', within SMEs for achieving sustainability performance?
- Is there any best practice within 'use' that you are aware of?
- What innovation you suggest in above areas to enhance sustainability performance?
- What role individual SME, SMEs consortium (e.g. Federation of Small Businesses), customers (e.g. OEM, retails and PSU) and policymakers should play to adopt circular economy framework?

Recover

- What are the major issues and challenges of 'recycle', and 'reverse logistics' within SMEs for achieving sustainability performance
- Is there any best practice within 'Recover' that you are aware of?
- What innovation you suggest in above areas to enhance sustainability performance
- What role individual SME, SMEs consortium (e.g. Federation of Small Businesses), customers (e.g. OEM, retails and PSU) and policymakers should play to adopt circular economy framework

Appendix C

Case study template

A. Small and medium sized enterprises detail:

1. Company name:
2. Website:
3. Industry: manufacturing / Processes / services / Construction
4. Company start year:
5. Family Owned Business: Yes / No
6. Annual Turnover:
7. Major products / services:
8. Major customers:
9. Major suppliers:
10. Any regulatory requirement: Yes / No
    If yes, give detail:

B. Current business performance (before our intervention):

1. Business Growth in last five years (in percentage):
2. Increase in profit margin in last five years (in percentage):
3. Cost reduction in last 5 years (in percentage):

C. Business processes (Current state and scope for improvement):

1. Materials selection
2. Procurement
3. Design
4. Manufacturing (including maintenance)
5. Distribution
6. Use
7. Reverse logistics

D. Resource efficiency (current state and scope for improvement)

1. Throughput
2. Inventory (raw materials)
3. Inventory (work in progress)

4. Inventory (finished products)
5. Capacity utilisation
6. Facilities
7. Plant layout
8. Base line carbon footprint

E. Energy efficiency (Current state and scope for improvement)

1. Energy sources: Renewable / non-renewable
2. Energy consumption (total)
3. Energy consumption (facilities)
4. Energy consumption (production and operations)
5. Base line carbon footprint

F. Waste management (current state and scope for improvement)

1. Reduce
2. Reuse
3. Recycle
4. Base line carbon footprint

G. Improvement measures

1. Describe the improvement project and business case

H. Overall performance enhancement (likely / Actual)

1. Business growth
2. Cost reduction
3. Throughout increase
4. Carbon footprint reduction
5. Job creation