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Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective

The circular economy (CE) proposes an economic framework, restorative and regenerative by intention and design, based on circular flows of products and materials. Transition towards a CE is underway, therefore understanding the nature and state of this transition is important for creating effective policies and business strategies. Some studies, having attempted to measure the implementation of the CE, have focused on specific contexts and pockets of good practice. This exploratory, survey-based study of 77 companies investigates the shift towards the CE using a taxonomy of practices and barriers. Results show that firms favour practices related to resource and energy utilisation efficiency, while practices related to investment recovery, green purchasing and customer cooperation are less prevalent. Eco-design and internal environmental management practices have a medium level of implementation. The significant up-front investment cost, lack of awareness or sense of urgency were identified as implementation barriers. Results suggest the CE is driven by economic not environmental considerations, and the deployment of practices remains within a firm rather than across the supply chain.

Keywords: Circular Economy, Exploratory, Practices, Barriers, Awareness

1. Introduction

The last 20 years have seen a rapid increase in awareness of the environmental impact of industrialisation. The first "green" solutions reshaped specific components of the broader economic framework, creating a trade-off between economic and environmental objectives (Chien and Shih 2007; Pagell and Shevchenko 2014). Examples of these solutions are cleaner production technologies (Vieira and Amaral 2016) or industrial eco-parks (Gibbs and Deutz 2007), focused on the technology level and the industrial network level of the broader economic framework.

Over the last decade, macro-economic changes and customers' new behaviours are increasingly challenging the effectiveness of traditional "green" solutions. Newly developing economies have significantly increased the consumption of natural resources and the production of waste (Ellen MacArthur Foundation 2013, 2014). Consumers are increasingly concerned about the environment, although they are not consistently displaying such concerns in their purchasing patterns (Gleim et al. 2013). There is evidence for the shift from a goods dominant logic to a service dominant logic (Neely et al. 2011). This is driven by changes in production systems, regulation, and the pressures of societal and environmental challenges (Gallouj et al. 2015).

The Circular Economy (CE) concept is gaining increasing attention as a solution to these challenges (Ellen MacArthur Foundation 2013, 2014). The CE proposes the creation of an entire economic framework that is restorative and regenerative by intention and design (Ellen MacArthur Foundation 2013).

From the perspective of a focal firm, the transition to a CE implies a change at the strategic level of business model innovation, with modifications in terms of product design, supply chain design and commercial strategy (Bocken et al. 2016). A focal firm is defined as a firm that rules or governs the supply chain, provides the direct contact to the customer, and designs the product or service offered (see Handfield and Nichols

[1999] and Schary and Skjøtt-Larsen [2001] cited in Seuring and Müller [2008]). Relevant practices from the perspective of a focal firm are recycling, refurbishing, remanufacturing or selling to secondary markets.

The CE is a promising solution for a variety of reasons. First, the adoption of circular flows of products and materials stops the depletion of natural resources and the creation of waste. Second, circular supply chains can allow focal firms to keep control of their products and materials over an entire life cycle. Therefore, focal firms involved in a circular supply chain can solve their issues of raw material availability and can potentially keep ownership of the physical product while offering it as a service to the final customer (Bocken et al. 2016).

Preliminary research suggests that a transition towards a more CE is already in motion (Ellen MacArthur Foundation 2014). Understanding the nature and state of this transition is important for the creation of effective policies and organisational strategies. As a result, several surveys have attempted to analyse the current state of transition towards a CE, taking into account Government officials' awareness and firms' behaviours. These surveys represent an important first step in developing an understanding of this transition. They focus either on a specific context or on a specific set of practices, thus neglecting the fact that a transition towards a more CE can imply modifications at the strategic level of business model innovation, with changes in terms of value proposition, value creation and delivery, and value capture (Bocken et al. 2016). The aim of this study is to address this gap by conducting an empirical study that investigates the implementation of practices aligned with CE principles at a focal firm level. It studies the practices both within the focal firm and across the broader supply chain (upstream and downstream), together with the barriers hindering the implementation of these practices.

The paper is structured as follows. Section two presents an overview of current literature on the CE. Section three outlines the research methodology. Section four presents and discusses the results of the empirical work. Finally, Section five concludes the study and suggests some future research directions.

2. Literature review

2.1. What is Circular Economy?

The concept of CE, originally introduced by Boulding (1966) and Pearce and Turner (1990), is rooted in diverse theoretical backgrounds such as environmental economics, industrial ecology, ecological economics (Ghisellini et al. 2016), and 'cradle-to-cradle' (Braungart et al. 2007). The key principle of the CE is the creation of circular loops of materials, energy, and waste flows; this key principle is combined with others, such as the minimisation of energy and raw material inputs into production systems and the mimesis of natural systems. All these principles are the core of different conceptual antecedents of the CE, and a first original feature of the CE is the way in which it combines principles from different conceptual antecedents. Table 1 summarises the key principles of the CE and the corresponding conceptual antecedents.

Table 1. Principles of the Circular Economy and related antecedents

Characteristics of the Circular Economy	Environmental Economics	Industrial Ecology	Ecological economy	Cradle-to-Cradle	References
Circularity necessary for sustaining human activities	X				Ghisellini et al. 2016
Four economic functions of the environment	X				Andersen 2007
Closed loops of materials, energy, and waste flows	X	X		X	Geng and Doberstein 2008; Geng et al. 2009; Ellen MacArthur Foundation 2013; Bocken et al. 2016; Ghisellini et al 2016; Genovese et al. 2017

Concern of minimising energy and raw material inputs into production systems	X	X			Geng et al. 2009; Genovese et al. 2017
Mimicking natural systems		X			Ellen MacArthur Foundation 2013
Interdependence between economic and environmental systems		X	X		Naustdalslid 2014; Ghisellini et al. 2016; Heshmati 2016
Waste as an input		X	X		Ellen MacArthur Foundation 2013; Ghisellini et al. 2016
Reusing and recycling residual waste materials		X	X		Andersen 2007; Gregson et al. 2015; Heshmati 2016
Recognising the limits of planetary energy, materials and resources			X		Liu et al. 2009; Gregson et al. 2015; Bocken et al. 2016
Integrating circularity concerns into the early stages of the production process (eco-design)				X	Ellen MacArthur Foundation 2013; Gregson et al. 2015
Distinguishing between biological and technical nutrients				X	Ellen MacArthur Foundation 2013; Kok et al. 2013

CE goes beyond its conceptual antecedents by proposing a radical change in all aspects of economic and social activities (Bonciu 2014). Scholars have diverging ideas regarding the nature and scope of the CE (Bocken et al. 2016). Table 2 lists the existing definitions of CE and shows how scholars perceive the CE as a new label for old concepts (see e.g. Geng and Doberstein [2008] or Ying and Li-jun [2012]), a combination of established concepts (Gregson et al. 2015), or a new set of guiding principles for economic activity.

Table 2. An overview of existing definitions

Reference	Definition
Ying and Li-jun 2012, 1683	'Circular economy is essentially an ecological economy, which requires human economic activities in line with 3R principle, namely Reduce, Reuse and Recycle.'
Geng and Doberstein 2008, 232	'A circular economy approach encourages the organisation of economic activities with feedback processes which mimic natural ecosystems through a process of "natural resources → transformation into manufactures products → by-products of manufacturing used as resources for other industries". (…) In essence, the circular economy approach is the same as the more familiar terms EID and "industrial ecology." '
Gregson et al. 2015, 3–5	'The circular economy (…) is a diverse bundle of ideas which have collectively taken hold.' '…is located in the allied but distinctive fields of ecological and environmental economics.'
Sarkis and Zhu 2008, 5	'CE was developed in China as a strategy for reducing its economy's demand for natural resources as well as ecological damage.'
Zhijun and Nailing 2007, 95	'A mode of economic development based on ecological circulation of natural materials.'
Murray et al. 2017, 377	'A true circular economy would demonstrate new concepts of system, economy, value, production and consumption, leading to sustainable development of the economy, environment and society.'
Giurco et al. 2014, 432	'The concept of the circular economy proposes new patterns of production, consumption and use, based on circular flows of resources.'

Ellen MacArthur Foundation 2013, 7	'An industrial system (…) restorative by intention and design' that 'relies on renewable energy' and 'eliminates the use of toxic chemicals' aiming for 'the elimination of waste through the superior design of materials, products, systems, and (…) business models'

When analysing the practical implementation of the principles of CE, researchers generally identify three levels of initiatives (see e.g. Yuan et al. [2006]): the micro-level of firms, the meso-level of networks and the macro-level of policy and regulations.

The micro-level relates to firm-specific initiatives (Geng and Doberstein, 2008) that can be classified based on the 3R principles – reduce, reuse, recycle (Ying and Li-jun, 2012). Examples of these initiatives include improvements in energy and material efficiency (Cagno and Trianni 2013) and recycling (Zhu et al. 2010).

The meso-level, i.e. the inter-firm level, includes the creation of eco-industrial parks and networks (Geng and Doberstein 2008), cross-chain and cross-sector collaborations (Ellen MacArthur Foundation 2013) to use resources more efficiently (Naustdalslid 2014). Appendix A provides a taxonomy of CE practices at the micro- and meso-levels, which are the ones relevant from a focal firm perspective and therefore the ones investigated in this study.

Finally, macro-level initiatives are the ones that are undertaken by governments and policy makers. Indeed, countries are becoming increasingly aware of the need to adopt a new industrial system based on CE principles (Bonciu 2014). For instance, in 1996 Germany enacted a law that provides a framework for encouraging closed cycle waste management (Guide et al. 2000). In 2002, Japan moved towards a circular industrial system through quantitative targets for recycling (Morioka et al. 2005). The European Commission committed to a more circular industrial model by developing an action plan for the transition to a resource-efficient Europe. Since 2008, the Chinese central government has adopted the CE as a national regulatory policy priority (Geng et al. 2012).

The three levels are related and inter-dependent; for instance, macro-level initiatives can result in disturbances at the micro-level and reduced levels of environmental performance (see e.g. White et al. [2015]). However, this study aims to analyse the implementation of the practices and not their performance, therefore the analysis will neglect the interactions between the three levels.

Contextual factors play a key role in the transition to a CE. Several researchers (see e.g. Xue et al. [2010]) have highlighted how a complex set of financial, institutional, infrastructural, societal, and technological factors can hinder or foster the transition to a CE. These obstacles are essentially overlapping with the ones detected for resource and energy efficiency (Chai and Yeo 2012) or for the implementation of socially sustainable practices (Masi and Cagno 2015). Similarly to the studies on practices, many studies on barriers to the CE tend to focus on specific factors (Geng et al. 2012). The present study, aimed at a comprehensive analysis of the barriers to the implementation of the CE, adopts the taxonomy proposed by Kok et al. (2013). This taxonomy is shown in Table 3 and covers all the key aspects relevant for the implementation of the CE from a focal firm perpective.

Table 3. Barriers to a CE transition (adapted from the taxonomy of Kok et al. [2013])

Financial	Major up-front investment cost
	Environmental costs (externalities) are not taken into account
	Shareholders with short-term agenda dominate corporate governance
	Recycled materials are often still more expensive than virgin raw materials
	Higher costs for management and planning
Institutional	Uneven playing field created by current institutions
	Financial governmental incentives support the linear economy
	Circularity is not effectively integrated in innovation policies
	Competition legislation inhibits collaboration between companies
	Recycling policies are ineffective to obtain high quality recycling
	Governance issues concerning responsibilities, liabilities and ownership
Infrastructural	Limited application of new sustainable business models
	Lack of an information exchange system between different stakeholders
	Confidentiality and trust issues hamper exchange of information
	Exchange of materials is limited by capacity of reverse logistics
	Lack of clear, standardized, quantitative measurement and goals
Societal	Lack of awareness and sense of urgency, also in businesses

	GDP does not show the real progress or decline of our society
	Resistance from powerful stakeholders with large interests in the *status quo*
Technological	Limited attention to end-of-life phase in current product designs
	Limited availability and quality of recycling material
	New challenges to separate the bio- from the techno-cycle
	Linear technologies are deeply rooted

2.2. Current survey studies on Circular Economy

Understanding the nature and state of the ongoing transition to a CE is essential for the development of more effective regulation and business strategies. Accordingly, researchers have started to analyse the transition to a CE from various perspectives. The focus of the preliminary studies on the transition to a CE varies and includes awareness, attitudes, behaviours and practices at individual, organisational, and regional levels. The results of various survey studies published in peer-reviewed scientific journals and identified by the authors through a review of the literature are summarised in Table 4.

An analysis of the studies suggests three key limitations. First, all were carried out in a specific context, i.e. China. This is not surprising as China is the only country whose central government has adopted the CE as a national policy priority.

Second, there is a scarcity of survey studies at firm level published in high quality peer reviewed journals; indeed, only two of the reviewed surveys focus on firms (Zhu et al. 2010; Liu and Bai 2014).

Third, a comparison between the practices and barriers measured in the existing survey studies, compared to the literature, show that previous studies have focused on specific practices and barriers. An understanding of the transitions to a CE at a firm level requires a comprehensive analysis of all the practices and barriers listed in Appendix A and Table 3.

In the light of these gaps, this paper presents the results from a survey-based study from the perspective of 77 focal firms. It explores the practices aligned to a shift towards

CE principles and its corresponding barriers. The international sample used for this survey overcomes the geographical bias of previous studies.

Table 4. Survey studies published in peer-reviewed scientific journals on the implementation of CE

Reference	Unit of analysis	Context	Results
Xue et al. 2010	Awareness and attitudes regarding the CE of municipal government officials	China	· Government officials were more aware of the CE than the public · Lack of public awareness and of financial support were the main barriers to the CE · Positive attitude toward garbage sorting by government officials · Gap between policy-making and practical actions hampering the development of the CE in China
Liu et al. 2009	Public awareness and behaviour in the promotion of a CE	Tianjin, China	· Low awareness and understanding of the CE · Economical consumption behaviours rather than conservation-conscious behaviours
Liu and Bai 2014	Firms' awareness and behaviour in the development of the CE	Manufacturing clusters in China	· Good understanding and a high willingness of firms to move to a CE · Only a few CE practices implemented · Reasons for the gap between awareness and behaviour were structural, contextual and cultural.
Zhu et al. 2010	Impact of environmental-oriented supply chain on the implementation of CE practices	China	· Supply chain cooperation enhanced CE-targeted performance and practices

3. Research Methodology

The authors selected a survey-based questionnaire as their strategy to collect primary data as it enables both reach and breadth. The research process included three different phases: survey design, data collection and data analysis. Sections 3.1 and 3.2 outline the choices made for the survey design and data collection.

3.1 Survey design

The questionnaire was divided into three sections, namely: demographic information for statistic reference, firms' circular practices and barriers, and firms' awareness of the CE. Given the holistic nature of the CE concept, richness is lost if specific practices or contextual factors are considered in isolation. Therefore, the authors performed a review of the literature with the objective of defining a comprehensive taxonomy of practices and barriers regarding the CE.

In order to locate the relevant studies, three search engines were chosen: Scopus, ProQuest, and Web of Science. The search string used was 'Circular Econom*' in the Article Title. This choice was made to ensure that papers were explicitly focused on the CE, instead of incidentally mentioning the term while the main spotlight was on another topic. The search was made in July 2015 and limited to scholarly journals in English with no time restrictions. The resultant number of papers was 154 (Scopus), 114 (ProQuest), and 75 (Web of Science). Given the relative immaturity and fragmentation of the CE concept, the titles, journals, and abstracts of the papers were reviewed for selection. The selection criteria used to reduce the number of articles were the relevance to the review questions and the journal type, including only papers published in double-blind peer reviewed journals. Application of these criteria reduced the resultant number of full papers for analysis and synthesis to 54.

The analysis of the 54 references clarified the key types of practices aligned with the CE principles and the key barriers. Since the studies analysed the practices and barriers with varying degrees of granularity, the authors added other eight papers and four reports from the analysis of the references, thus obtaining taxonomies of practices and barriers with the same level of detail. All the practices and barriers with the corresponding references are summarised in Appendix A and Table 3.

The last section assessing firms' awareness of the CE was deliberately located at the end of the questionnaire, so that a low understanding of the CE did not affect the answers in previous sections. To measure awareness, the respondents were asked to tick the main principles of CE established on the basis of the existing literature (Ellen MacArthur Foundation 2013).

Following the questionnaire approach of Binti Aminuddin et al. (2015), questions were specifically designed to obtain both nominal and ordinal data. The questionnaire used a precise scale for the answers to capture the varying degrees of implementation across firms: 'not considering it', 'planning to consider it', 'considering it currently', 'initiating implementation', 'implementing successfully', coherently with the scale used in previous studies on the CE (Xue et al. 2010; Zhu et al. 2005, 2010).

To ensure the validity and reliability of the questionnaire (Crowther and Lancaster 2008), a pilot study was conducted as suggested by Robson (2011). Therefore, the questionnaire was distributed to 10 professionals, which included academic and industrial experts in a variety of fields. As a result, the questionnaire was amended and improved to eliminate common threats such as subject or participant error, subject or participant bias, observer error and observer bias (Robson 2011).

3.2 Data collection

As this was an exploratory study, the questionnaire was distributed to respondents working in various industrial sectors worldwide. It was mainly circulated using the business/professional-oriented social networking site LinkedIn. LinkedIn is now increasingly becoming a reliable platform for the fast collection of research data (Papacharissi 2009). In this case, 200 professionals from LinkedIn group societies related to relevant subject areas such as sustainability, green practices, circular economy, manufacturing, business excellence and operations management were identified and directly contacted through personal messages to request their contributions to the research by completing the questionnaire. In addition, the questionnaire was publically shared in the same LinkedIn group societies, alongside a covering letter that described the research and its objectives, as well as forwarded via e-mail to personal contacts of the authors. Personal contacts were also requested to distribute the questionnaire among their own professional networks, which created a 'snowballing sampling technique' that contributed to broadening the pool of respondents (Horwitz et al. 2006).

In total, 81 responses were received from various respondents across the world, out of which four were incomplete and hence were ignored and excluded from the analysis. Therefore, the final sample size included 77 fully completed survey responses. Although the total number of responses obtained may be considered slightly lower than other survey-based studies in CE (Liu et al. 2009; Xue et al. 2010), it still provided sufficient data for an initial and general exploratory analysis of the awareness, practices, and barriers in the implementation of CE.

4. Findings and Discussion

The survey data showed that most respondents were acting as managers/supervisors (42%) and working in operations, quality, production, process improvement and general

managerial roles. These were followed by engineers (25%), whereas around 21% of respondents classified themselves as 'others'. These included professions such as consultants, business developers, architects, and procurement specialists. The majority of the responses were also from the manufacturing sector (43%) and from organisations employing more than 250 employees (55%). With regard to respondents' experience in industry, around 40% had 5-10 years of experience, followed by 10-25 years (22%), 2-5 years (21%), and less than 2 years (14%) of experience. Respondents identified themselves from various countries around the world, with the majority of them being based in the UK, Vietnam, Turkey, Denmark, Italy, India, South Korea, Indonesia, Germany, Russia, Malawi and France.

The second part of the survey included questions aimed at investigating the current organisational practices and barriers encountered. This part was further subdivided into six parts: i) resources and energy utilization efficiency; ii) investment recovery; iii) eco-design; iv) green purchasing; v) customer cooperation; and vi) internal environmental management. The results for the practices are summarised in Table 5 while the results for the barriers are summarised in Table 6.

Table 5. Results: Practices

		Not considering it	Planning to consider it	Considering it currently	Initiating implementation	Implementing successfully
Resource and Energy Utilisation Efficiency	Reducing energy			░	░	░
	Reducing material consumption			░	░	░
	Reducing pollutant emissions	░		░	░	░
	Reducing wastes				░	░
Investment Recovery	Taking back products from consumers after the end of their functional life	█				
	Taking back products from consumers after the end of their usage	█				
	Remanufacturing products	▓				
	Recycling materials	░				░
	Refurbishing products	░				░
	Reusing energy and/or water across the value chain	░				
	Cascading use of components and materials	░	░			
Eco-design	Designing products for reduced consumption of material/energy	░				░
	Designing products for reuse, recycle and/or recovery of material/component	░				
	Designing process for minimisation of waste	░		░		░
Green Purchasing	Selecting suppliers using environmental criteria	░		░		
	Using renewable energy/material in the production process	░		░		
	Cooperating with other firms to establish eco-industrial chains	▓				
Customer Cooperation	Adopting a leasing or service-based marketing strategy	▓				░
	Targeting "green" segments of the market	▓				
	Green packaging	▓	░			
Internal Environmental Management	Including environmental factors in the internal performance evaluation system	░				░
	Environmental auditing programmes such as ISO 14000 certification	░				░
	Cross-functional cooperation for environmental improvements	░		░	░	
	Eco-labelling of products	░				
	Special training for workers on environmental issues	░			░	░

	Frequency <20%
░	20 ≤ Frequency < 40
▓	40 ≤ Frequency < 60
█	60 ≤ Frequency

Table 6. Results: Barriers

Legend: ■ = 60% ≤ Frequency; ▓ = 40% ≤ Frequency < 50%; ░ = 30% ≤ Frequency < 40%; (blank) = Frequency < 30%

Category	Barrier	Res. Eff.	Inv. Rec.	Eco-d	Green Purch	Cust Coop	Env. Mgmt
Financial	Major up-front investment cost	■	■	■	▓	▓	░
Financial	Environmental costs (externalities) are not taken into account						
Financial	Shareholders with short-term agenda dominate corporate governance						
Financial	Recycled materials are often still more expensive than virgin raw materials	░			░		
Financial	Higher costs for management and planning	■	▓	░		▓	■
Institutional	Uneven playing field created by current institutions					░	
Institutional	Financial governmental incentives support the linear economy	░	░		░	░	
Institutional	Circularity is not effectively integrated in innovation policies	░	░	░			
Institutional	Competition legislation inhibits collaboration between companies						
Institutional	Recycling policies are ineffective to obtain high quality recycling	▓	░	░	░		
Institutional	Governance issues concerning responsibilities, liabilities and ownership				░		░
Infrastructural	Limited application of new sustainable business models	▓	▓	▓	▓	░	▓
Infrastructural	Lack of an information exchange system between different stakeholders	░				░	░
Infrastructural	Confidentiality and trust issues hamper exchange of information						
Infrastructural	Exchange of materials is limited by capacity of reverse logistics	░					
Infrastructural	Lack of clear, standardized, quantitative measurement and goals	■	▓	▓	▓	▓	▓
Societal	Lack of awareness and sense of urgency, also in businesses	■	■	■	■	■	■
Societal	GDP does not show the real progress or decline of our society						
Societal	Resistance from powerful stakeholders with large interests in *status quo*	░		░		░	
Technological	Limited attention to end-of-life phase in current product designs	■	■	■	■	■	■
Technological	Limited availability and quality of recycling material	▓	▓	▓	░		░
Technological	New challenges to separate the bio- from the techno-cycle						
Technological	Linear technologies are deeply rooted	░		░	░		░

■	60% ≤ Frequency
▓	40% ≤ Frequency < 50%
░	30% ≤ Frequency < 40%
	Frequency <30%

4.1 Resource and Energy Utilisation Practices

The results of the study illustrated in Table 5 indicate that practices related to 'resource and energy utilisation efficiency' tend to be more commonly implemented than other practices. This is valid for both current implementation and for the intention of implementing such practices. In this case, the majority of the participant companies indicated the implementation of these practices, with 28.57% of companies focusing on reducing material consumption and 33.77% focusing on reducing waste. The high levels of implementation of 'resource and energy utilisation efficiency' practices may be explained by their fast return on investment, in line with previous findings reported in the academic literature that have highlighted how the implementation of CE and sustainability-based models is mostly driven by economical consumption behaviours rather than conservation-conscious behaviours (Liu et al. 2009). In addition, the synergy between productivity and environmental conservation created by these practices may be another factor for companies to be attracted to their implementation. The major barrier to the deployment of 'resource and energy utilisation efficiency' practices was found to be a 'lack of awareness and sense of urgency' (77.33%). Garza-Reyes (2015) suggests that environmental concerns and pressures have contributed to organisations being more environmentally aware and 'greening' their operations; however, this does not appear to be the case for the participant organisations. Thus, the results of this study suggest that even though environmental awareness and sense of urgency to become more sustainable may have increased around the world, the lack of awareness and sense of urgency are still acting as important barriers which impede the adoption of sustainable practices. Other barriers to the implementation of 'resource and energy utilisation efficiency' practices include 'major up-front investment cost' (65.33%), 'lack of clear, standardized, quantitative measurement and goals for assessing the performance of a circular

sustainable development model' (61.33%), 'life phase in current product designs' (60.56%) and 'higher costs for management and planning' (60.01%). Economic barriers are still significant for most of the CE practices investigated, showing that it may still be expensive for an organisation to initially adopt, for example, energy efficiency practices, such as new energy-saving equipment (e.g. solar panels) that need to be bought and installed.

4.2 Investment Recovery Practices

According to the results of the study, 'investment recovery' practices such as 'taking back products from consumers', 'remanufacturing', and 'recycling' do not only tend to be less common but also a relatively low number of firms were currently considering their implementation. These practices are close to the core principles of CE and show that, despite a transition towards this economic model occurring, most businesses still have practices related to linear economy models. Practices such as 'taking back products from consumers after the end of their functional life', 'taking back products from consumers after the end of their usage', and 'remanufacturing products' are those that are less likely to be implemented by companies according to our study's results. For example, the vast majority of companies are not considering 'taking back products from consumers after the end of their functional life' (67.11%) or 'after the end of their usage' (64.47%) or 'remanufacturing products' (55.26%). These types of CE practice require a significant capital investment and a full alignment with corporate goals. This makes the implementation of 'investment recovery' practices more complex and risky, and, unlike 'resource and energy utilisation efficiency', they must be part of the strategic vision of organisations. The most perceived barriers to the implementation of 'investment recovery' practices were found to be 'lack of awareness and sense of urgency' (81.69%), 'major up-front investment cost' (70.83%), 'limited attention to end-of-life phase in

current product designs' (61.97%), 'lack of clear performance measurements' (59.15%) and 'limited availability and quality of recycling material' (59.15%). Indeed, 'major up-front investment costs' have been indicated as a barrier in the majority of the CE practices investigated in this research, in line with previous sustainability related studies (Masi and Cagno 2015; Masi et al. 2014).

4.3 Eco-design Practices

In terms of 'eco-design' practices, the results of the study indicate that these are equally split between companies not considering them and those that have implemented them successfully. However, 'designing products for reuse or recycle' is an exception, as the majority of the surveyed organisations (38.16%) were not considering its implementation. Once more, there is a marked difference between those practices that generate an economic return in the short-term and those that produce it in the longer term. 'Product design for reuse, recycle and/or recovery' is less adopted than practices with short-term returns such as 'waste minimisation and material efficiency'. Another interesting observation is whether the implementation of some practices requires the involvement of the supply chain. Indeed, the practices that can be implemented at firm level seem to be more successful than practices involving supply chains. This is easy to understand as the implementation of practices relating to other organisations (e.g. suppliers, wholesalers, customers, etc.) is significantly more complex than when simply implemented within the internal operations of an organisation. The result is in line with supply chain theory that highlights the difficulty of implementing supply chain practices characterised by broader arcs of integration (Frohlich and Westbrook 2001). Moreover, the success of some specific product design practices seems to be crucially dependent upon alignment with corresponding supply chain configurations. The relationship between product design and supply chain design has been widely discussed in the literature, and several authors (see

e.g. Van Hoek and Chapman [2007] and Pero et al. [2010]) have highlighted the need for aligning product design and supply chain design. This seems particularly relevant for the transition to a CE. In relation to the barriers to the implementation of 'eco-design' practices, they were found to be: 'lack of awareness and sense of urgency, also in businesses' (80.00%), 'major up-front investment cost' (71.23%), 'limited attention to end-of-life phase in current product designs' (64.29%), and 'lack of clear performance measurement' (59.15%).

4.4 Green Purchasing Practices

Similarly to the 'investment recovery' and 'eco-design' practices, 'green purchasing' practices, such as 'selecting suppliers using environmental criteria' and 'cooperating with other firms to establish eco-industrial chains', tend to be uncommon. This is linked to the previous idea that internally implemented practices are less complex than those implemented throughout the supply chain of organisations, and hence they are less commonly practised by organisations. This complexity is reflected in the percentage of companies that are not considering their implementation, with 30.67% for 'selecting suppliers using environmental criteria', 30.67% for 'using renewable energy/ material in the production process', and 41.33% for 'cooperating with other firms to establish eco-industrial chains'. The preference of companies intervening at a firm level rather than a supply chain level is further confirmed by this relative comparison between the 'green purchasing' practices, where 'cooperating with other firms to establish eco-industrial chains' is less frequently adopted than the 'selection of suppliers using environmental criteria', since this second activity relies more on the firm than on the supply chain. The result is, again, explained by supply chain theory highlighting the difficulty of implementing supply chains' practices characterised by broader arcs of integration (Frohlich and Westbrook 2001). The most perceived barriers to this type of practice are

'major up-front investment cost' (55.07%), 'lack of clear, standardized, quantitative measurement and goals for assessing the performance of a circular sustainable development model' (57.14%), 'lack of awareness and sense of urgency, also in businesses' (81.69%), and 'limited attention to end-of-life phase in current product designs' (62.86%). It is interesting to observe how financially related barriers have less importance in this case, and this can be explained both by the actual lower cost and the perception of the relative importance of these costs for the firm.

4.5 Customer Cooperation Practices

In the case of 'customer cooperation' practices, such as 'adopting a leasing or service-based marketing strategy' or 'targeting "green" segments of the market', these practices were found not to be commonly followed among the participant organisations. For instance, the results of the study indicate that only 45.33% of the companies that participated in the study had adopted a 'leasing or service-based marketing strategy', whereas 41.33% had 'targeted "green" segments of the market', and only 40.00% had adopted 'green packaging practices'. After 'investment recovery', 'customer cooperation' practices were those least commonly adopted by organisations. Apart from emphasising again how the implementation of CE practices tends to be characterised by narrow arcs of integration (Frolich and Westbrook 2001), the result highlights how practices for the upstream side of the supply chain are more common than CE practices adopted in the downstream side of the supply chain. One possible explanation for this phenomenon is that customer integration could be relatively more difficult to achieve if compared to supplier integration, since suppliers can easily be influenced if focal companies use their bargaining power (Crook and Combs 2007).

Barriers to the implementation of 'customer cooperation' practices included 'lack of awareness and sense of urgency, also in businesses' (76.47%), 'limited attention to end-

of-life phase in current product designs' (64.71%), 'lack of clear, standardized, quantitative measurement and goals for assessing the performance of a circular sustainable development model' (56.72%), and 'higher costs for management and planning' (56.52%). Similarly, as in the case of 'green purchasing', financial barriers seem to be less significant to adopt than 'customer cooperation' practices. This can be related to the fact that the costs to manage the downstream side of the supply chain are lower, or to the fact that practitioners are not aware of the costs needed to perform this kind of activity. It is interesting to observe the importance of the 'lack of clear, standardized, quantitative measurement and goals for assessing the performance of a circular sustainable development model', in line with previous supply chain management studies (Wong et al. 2012) highlighting how a proper business performance management system is a key enabler for supply chain alignment.

4.6 Internal Environmental Management Practices

'Internal environmental management' practices, such as 'including environmental factors in internal performance evaluation systems', appear to have a "medium" level of adoption among the participant organisations (i.e. these practices were equally split between companies not considering them and companies that had implemented them in their operations).

In terms of barriers to the implementation of 'internal environmental management' practices, the most commonly perceived were 'lack of awareness and sense of urgency, also in businesses' (75.36%), 'limited attention to end-of-life phase in current product designs' (61.19%) and 'higher costs for management and planning' (60.61%).

The results again highlight the relevance of metrics and planning for the implementation of the CE, in line with supply chain theory (Wong et al. 2012; Skipworth et al. 2015) and highlight how this is true at both internal operational and supply chain

levels. Hence, organisations must strive to adopt planning and environmental metrics in their performance measurement systems to make sure that a higher performance in this area is enabled.

4.7 Awareness

Finally, it is interesting to observe that 65.33% of the participant organisations declared they were aware of the CE concept, while 34.67% were not. In this context, the result of this study shows a discrepancy between awareness and practices, as previously observed by Liu and Bai (2014).

5. Conclusions

Unique, when compared to previous CE researches, the present survey-based study investigated the implementation of practices aligned with the CE at a firm level through a comprehensive taxonomy of practices and barriers. The results show that the implementation of CE-related practices seems driven by economic rather than environmentally conscious behaviours, with a marked preference for those practices that generate an economic return in the shorter term. The results also highlight the preference of companies for practices at firm level instead of supply chain level, in line with supply chain management theory.

The paper contributes to knowledge in the field of CE by proposing an empirically validated taxonomy of practices and barriers related to the deployment of the CE at a firm level. Such a taxonomy creates a background for the contextualisation of other studies with a narrow focus on specific contexts or on pockets of good practice.

Despite the exploratory nature of the present study, its results are also beneficial for organisations of any sector that aims to tackle the sustainability challenges of the current scenario through the principles of the CE. An understanding of the current trends in the

transition to a CE allows firms to differentiate their strategies and gain competitive advantage. Similarly, an analysis of current biases and barriers can foster the design of more balanced strategies for firms trying to align their practices to the CE principles. This is extremely important in a macro-economic context, where legislation is increasingly stringent in terms of protection of the environment. Moreover, the insights into the practices that can play a significant role in the transition to a CE may encourage organisations not currently committed to sustainability to contemplate its potential benefits.

In terms of research limitations, the size of the sample considered in this study is a constraint factor that implies the exploratory nature of the results. Therefore, further research can build on current results while involving a broader set of companies. Building on a clear understanding of the main trends, in terms of practices and barriers, further studies can investigate the effect of specific industry sectors and geographical contexts, a key gap that prompted the current study. Finally, while the current study analysed the implementation of practices aligned with the CE principles, researchers could also investigate the factors triggering the adoption of these practices.

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Appendix A

Measurement items	Carter et al. 1998	Chien and Shih 2007	Ellen MacArthur F. 2013, 2013, 2014	Geng et al. 2012	Geng and Song 2014	Li et al. 2010	Liu 2009	Liu and Bai 2014	May et al. 2012	Vachon and Klassen 2006	Xue et al. 2010	Zailani et al. 2012	Zheng and Zheng 2011	Zhu et al. 2010	Zhu et al. 2005	Zsidisin and Hendrick 1998
A- Resource and energy utilisation efficiency			X			X	X	X				X				
1) Reducing energy (i.e. electricity, coal, gas) consumption		X	X	X		X						X	X		X	
2) Reducing material (i.e. raw material and/or water) consumption		X	X	X	X	X						X	X	X	X	X
3) Reducing pollutant emissions		X	X		X	X	X							X	X	
4) Reducing wastes	X	X	X			X		X				X	X	X	X	
B- Investment recovery														X	X	X
5) Taking back products from consumers after the end of their functional life			X									X				
6) Taking back products from consumers after the end of their usage			X											X		
7) Remanufacturing products			X													
8) Recycling materials			X	X	X			X					X			X

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
9) Refurbishing products (i.e. returning them to good working condition by replacing or repairing major faulty components)			X														
10) Reusing energy and/or water across the value chain			X										X				
11) Cascading use (i.e. multiple usages/applications) of components and materials			X														
C- Eco-design		X	X						X	X				X	X	X	X
12) Designing products for reduced consumption of material/energy														X	X		
13) Designing products for reuse, recycle and/or recovery of material and/or component parts	X											X		X	X	X	X
14) Designing process for minimisation of waste														X	X		
D- Green-purchasing	X						X			X		X		X	X		
15) Selecting suppliers using environmental criteria	X						X			X		X		X	X		
16) Using renewable energy/materials in the production process			X														
17) Cooperating with other firms to establish eco-industrial chains								X						X			X
E- Customer cooperation										X				X	X		
18) Adopting a leasing or service-based marketing strategy														X			
19) Targeting "green" segments of the market										X							
20) Green packaging	X											X		X	X		

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
F- Internal environmental management														X	X	
21) Including environmental factors in the internal performance evaluation system	X													X		
22) Environmental auditing programmes such as ISO 14000 certification							X							X		X
23) Cross-functional cooperation for environmental improvements														X	X	
24) Eco-labelling of products												X		X	X	
25) Special training for workers on environmental issues	X						X							X	X	