



Corporate-entrepreneur collaborations to advance a circular economy

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ABSTRACT

This paper examines the role of small entrepreneurial companies and their partnerships with large corporations to advance the circular economy (CE). The authors provide insights from a U.S.-based empirical study that involved 12 companies and examined the emerging drivers, current challenges and future opportunities for advancing waste repurposing and product reuse. Many large companies fail to incorporate CE principles into their business strategy due to lack of mandates, costs, logistical hurdles and inertia. This presents an opportunity for entrepreneurial companies with innovative business models to fill the gap and provide critical links for corporations in reverse supply chains while creating new business opportunities with social benefits. The study found that despite the lack of federal regulations in the U.S. a growing number of corporations are partnering with entrepreneurs to reduce waste and advance product reuse. Key drivers for such trends include sustainability commitments and zero waste goals by companies and municipalities, European Union and U.S. state mandates, reputation and the growing focus on local sourcing. Technology, knowledge, and strategic partnerships between entrepreneurs and corporations play a critical role in reducing financial costs, time, energy, environmental impacts and resources, thus helping establish viable business models. The authors propose a new framework for corporate-entrepreneur collaborations to advance a CE. The study contributes to the research on the relationship between entrepreneurial innovation and the development of CE principles within corporate supply chains, a field that is still in its infant stage.

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1. Introduction

The circular economy (CE) has recently been gaining traction in developed nations as an alternative to the dominant “take-make-waste” model of production and as a strategy to decouple economic growth from resource depletion. The European Union has led this movement by launching a national CE strategy and action plan with concrete waste reduction goals and measures of success (EC, 2017; Murray et al., 2017). It is estimated that the circular economy will provide an economic opportunity of over \$1 trillion as well as significant social and environmental benefits (WEF, 2016). This new economic paradigm requires innovation and new business models to advance zero waste production, product design, reuse and remanufacturing.

Most research to date has focused on original equipment manufacturers (OEMs) taking back and remanufacturing old products.

This option however is often not financially viable for many companies with global supply chains due to a lack of mandates, upfront costs, logistical hurdles that include transportation and technical recovery challenges, and the inertia of ‘business as usual’. Moreover, manufacturers often do not want to offer lower cost products as they would erode profit margins from new product sales (Matsumoto, 2009; Guide and Jiayi, 2010; Veleva et al., 2013). This presents an opportunity for entrepreneurial companies with innovative business models to fill the market gap and provide critical links for corporations in reverse supply chains while creating new business opportunities with social benefits.

The role of entrepreneurs however is still underexplored (Heshmati, 2015). At the same time, entrepreneurs are critically important for solving complex problems that involve high uncertainty and risks because they are able “to produce value out of uncertainty” (York and Venkataraman, 2010). Transitioning to a circular economy will require “massive innovation and mind-set changes that cannot be anticipated” thus presenting a “tremendous entrepreneurial opportunity”. The opportunity will bring both social and economic benefits and new ways of living that

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established market players are unable to provide due to strong “inertial forces”, according to research by York and Venkataram (2010). Entrepreneurs are also better positioned to deliver social value, an area still missing in the current CE frameworks and research (Murray et al., 2017). They are however constrained by their limited scalability and resources, thus establishing strategic partnerships with incumbent market players is advantageous for delivering their value proposition, creating new markets and transforming industries (Hockerts and Wustenhagen, 2010).

This study aims to examine the emerging business models for CE and how value is created from collaborations between small entrepreneurial players and large, well-established companies with sustainability commitments, an area where research is still scant (Wijk et al., 2013; Schaltegger et al., 2016). According to Planing (2015), transitioning to a circular economy requires attention in four fundamental business areas: a) materials and product design; b) new business models; c) global reverse networks, and d) enabling conditions. This paper focuses on the second and fourth building blocks and has the following **main goals**: a) to examine the emerging drivers for product and waste reuse in the U.S. in the absence of federal regulation; b) to examine the role of entrepreneurs in launching innovative CE business models; c) to analyze collaborations between entrepreneurs and corporations and propose a new framework for understanding value creation between these players in a CE, and d) to identify current challenges and future opportunities for scaling up CE initiatives.

The paper is structured as follows: it begins with a literature review, illustrating the consensus about the role of companies (and entrepreneurs in particular) in advancing CE strategies. The authors then introduce the research methods and companies involved in the study and propose a new framework for corporate-entrepreneur collaboration to advance a CE. The study results are presented next with a discussion of the key findings. Finally, the paper concludes with discussion of the lessons learned and implications for companies, policymakers and researchers.

2. Literature review

2.1. Circular economy – origin, current challenges and opportunities

The CE traces its origin to the concepts of “industrial ecology”, “cradle-to-cradle”, “biomimicry” and “natural capitalism” introduced by sustainability thought leaders in the late 20th century. It is often described as an economy-scaled version of industrial ecology (which aims to optimize industrial systems and eliminate waste) that attempts to decouple economic growth from resource consumption (Ghisellini et al., 2016). It emphasizes redesigning products and processes to ensure continuous reuse of resources. The end result is an effective, self-sustaining system that mimics natural processes.

The circular economy is based on several main principles, including a) “designing out” waste, b) separating the biological from technical nutrients¹ where the former are returned back to the biosphere, and the latter are reused indefinitely, and c) using renewable energy to reduce dependence on finite resources and develop sustainable systems (WEF, 2014). The European Union is currently leading global efforts to enact policies, establish targets and measure progress towards the CE with China, Canada and Japan

following suit (EC, 2017; Murray et al., 2017).

Such an economy is critically important for addressing climate change. For instance, 42% of U.S. greenhouse gas emissions are related to materials management (U.S. EPA, 2009). A study of five European countries found that a shift to a circular economy could reduce each nation’s greenhouse gas emissions by up to 70% and increase its workforce by 4% (Wijkman and Kristian, 2016). Lastly, the CE can promote social benefits such as jobs, access to resources and technology, inter/intra-generational equity, and educational/career opportunities for disadvantaged populations (Murray et al., 2017).

Making the transition to a CE however, is challenging due to the economic stake and complexity of the current production system, antiquated policies (e.g., taxation of labor rather than resources), a lack of effective measurement, tools and reporting, and less attention to waste management from policymakers and other stakeholders compared to climate change and water. According to the U.S. Environmental Protection Agency (EPA), approximately 7.6 billion tons of industrial solid waste are generated and disposed of each year in the U.S. (EPA, 2016). This waste is not only endangering human health and the environment but also represents a double penalty for business – it demonstrates inefficient production processes and increases disposal costs. In addition, not forecasting proper waste disposal can pose business risks related to the development of new waste regulations or liability risks from accidental exposure or release of harmful material (Veleva et al., 2017).

The implementation of eco-industrial parks (EIPs)² in the U.S. has also been problematic. Some of the challenges include a) attempting to plan parks around a narrow definition of waste, energy and byproduct exchanges, b) focusing on technical analysis when attention is needed on the role of social interactions, culture and institutions, c) a lack of commonly accepted criteria and indicators to assess progress, and d) a lack of expertise (Veleva et al., 2015). Even when including a diverse group of stakeholders such as small companies, NGOs, academic institutions and policymakers, EIPs are mostly focused on recycling and waste repurposing rather than following the waste reduction hierarchy of reduce, reuse, recycle, recover and landfill (Dorn and MacWhirter, 2016). Ghisellini et al. (2016) also demonstrates that this is a significant problem as the CE economy is often identified with the recycling principle.

2.2. The barriers of business to advance a CE

A growing number of companies including GM, Honda, Unilever, P&G, Biogen and Dell have recognized the business benefits of transitioning to a CE. Such benefits include reduction in disposal costs and risks, improved brand reputation, diversified revenue streams, and the ability to attract and retain talent (Hermes, 2014; Veleva et al., 2017). Research has found that environmental strategies can also leverage a) access to new markets, b) product differentiation, c) lower material, energy and service costs, d) lower cost of capital and labor, and e) better risk management and relations with external stakeholders (Ambec and Lanoie, 2008).

Most research on the role of business in advancing the CE to date has focused on large companies such as OEMs exchanging waste and materials or taking back and remanufacturing old products (Chertow and Lombardi, 2005; Yuan and Shi, 2009; Hall et al., 2010; Veleva et al., 2013). Established market players, however, are subject to significant internal and external inertial forces, which make it difficult to change their strategy (York and Venkataraman, 2010).

¹ Biological nutrients are inputs that living organisms can use to synthesize life processes and can biodegrade safely (e.g., food waste, bio-based plastics). Technical nutrients are non-organic/synthetic inputs that cannot biodegrade but can be reused repeatedly (e.g., metals, petroleum-based plastics, glass).

² A co-located group of different companies pursuing exchanges of waste, byproducts or any used materials or have a shared supply chain infrastructure.

These forces can include capital costs tied in plants, equipment and personnel, legal barriers to market exit or entry, loss of legitimacy, and relationships with other organizations along the supply chain. Collecting old products, for example, is a major challenge due to its unpredictability and unreliability, making it difficult for companies to plan for capacity (Linder and Williander, 2015). Furthermore, extending the supply chain to include remanufacturing, recycling, repair and refurbishing creates an additional level of complexity, leading to potentially negative impacts in quality, cost, and delivery times. Moreover, in the current economic system, where profits are linked to the point of sale, companies selling products often face an inherent conflict of interest as revenues are maximized by selling more products, a dynamic known as planned obsolescence (Bartl, 2014).

Research has recently outlined the emerging opportunities for entrepreneurs with innovative business models to advance product end-of-life management and circular economy (Veleva and Bodkin, 2017). Yet both corporations and entrepreneurs face a “lack of channel control” and the necessary understanding and incentives for key partners like retailers and suppliers, to support their business. As such, it is difficult to lower pricing or offer credit and promotional programs. One potential solution is to develop multiple channels, however this comes with its own set of challenges (Frazier, 1999). Another challenge faced by both entrepreneurs and corporations is the lack of effective indicators to measure and communicate impacts, a lack of reliable data and information, which results in a lack of customer awareness and demand. Veleva et al. (2017) demonstrate that current corporate practices to advance zero waste lack effective indicators for measuring impacts and informing employees and as result lead to recycling and waste-to-energy disposal methods instead of product reuse or remanufacturing. Su et al. (2013) also report the lack of reliable data, information and standards to assess CE performance, which leads to lack of public awareness and demand for sustainable products (Heshmanti, 2015).

Entrepreneurs face numerous additional barriers including limited access to funding, mentors, networks, government support, reliable data and tools to measure and communicate their value proposition (Rizos et al., 2015). In cases of complex equipment they may lack the expertise and knowledge to repair or remanufacture the products.

Finally, the lack of supporting policies and the taxation of labor rather than raw materials has also been identified as a major barrier for business to advance CE practices (Kuo et al., 2010; Stahel, 2016). Furthermore, government policies such as the recent Chinese National Sword that restricts the import of 24 categories of solid waste can act as barriers to the CE (Staub, 2017).

2.3. Business drivers to advance a CE

Sanchez et al. (2004) identifies four conditions that can be used to frame the CE within companies – company conditions, product conditions, product chain conditions and society/market conditions. Ghisellini et al. (2016) further outlines the need for research to understand why consumers replace used but functional products with new ones, or when and why products lose their value for consumers.

A transition to a circular economy requires addressing four fundamental business blocks: a) *materials and product design*, b) *new business models*, c) *global reverse networks*, and d) *enabling conditions* (Planing, 2015). Addressing the first business block requires the adoption of cleaner production and eco-design so the resulting products and waste can be properly reused and repurposed without creating negative environmental and public health impacts (Ghisellini et al., 2016). Research has demonstrated that

initial product design “has a great influence on the degree to which a product can be reused, remanufactured, recycled, incinerated or disposed of” (Linton et al., 2007).

Lewandowski (2016) proposes a circular business canvas model and outlines the main challenges to overcome in the transition from a linear to a circular business model, including shifting the value proposition for consumers. Building on Osterwalder and Pigneur (2010) business canvas model, Lewandowski adds two more dimensions for CE models – *take-back system* (including channels and customer relations) and *adoption factors* (organizational capabilities and external factors). He identifies three main challenges that need to be overcome in order to enable the transition from a linear to a circular business model: a) between the value proposition and the customer segment; b) between the cost structure and revenue streams, and c) between the implemented changes and adaptation factors, which may hinder this process (Lewandowski, 2016).

Planing (2015) sees three major changes that are driving companies’ shift towards CE practices: a) increasingly volatile commodity prices; b) information technology that enables new business models and innovation, and c) changing consumer behavior toward performance and away from ownership. Linder and Williander (2015) summarize the key drivers for implementing circular business models, including cost savings, differentiation, improved customer relations, improved margins, reduced environmental impacts and increased brand protection. Sharma et al. (2010) reports that an important driver for product reuse and remanufacturing is the growing segment of marginal customers who cannot afford new products but are interested in buying.

The growing movement to source locally can be seen as an important driver and enabler for smaller companies that are focused on product reuse and waste repurposing. Such practices are critically important for the CE as they help reduce packaging, transportation costs and greenhouse gas emissions (Ghisellini et al., 2016). The idea was originated by Schumacher (1973) who emphasized that “locally adaptive solutions have less environmental impact than large scale global solutions”.

Business model innovation is increasingly seen as essential for advancing CE principles and broadening social and environmental practices (Bocken et al., 2014). In this paper we define “business model” using three main elements: *the value proposition*, *value creation* and *value capture*. There is still limited research on these three elements, and particularly on value creation and value capture between corporations and entrepreneurs. Laubscher and Marinelli (2014) further propose six strategies for integrating CE principles into the business model based:

- *Sales model* - shifting from selling volumes of products to selling services and taking back products at the end of their useful life);
- *Product design/material composition* – designing products for high quality reuse of product, component and material;
- *IT/data management* – leveraging IT to keep track of products, components and materials in order to optimize resources, including logistics of reverse supply chain;
- *Supply loops* – working with suppliers and customers to recover used product, component and materials and incorporate in new products;
- *Strategic sourcing* – building long-term partnerships with customers and suppliers to enable take back and value co-creation;
- *HR/incentives* – developing incentives and training for culture shift towards adoption of circular business models (e.g., awards and bonuses linked to CE objectives).

Bocken et al. (2014) introduced eight sustainable business model archetypes, described as businesses that a) maximize

material and energy efficiency, b) create value from waste, c) substitute with renewables and natural processes, d) deliver functionality rather than ownership e) adopt a stewardship role, f) encourage sufficiency, g) re-purpose the business for society/environment, and h) develop scale-up solutions. Fig. 1 presents Bocken et al. (2014) framework for creating value from waste. The study authors argue that in a CE “value is no longer created by firms acting autonomously, but by firms acting together with parties external to the firm through informal arrangements or formal alliances”. This is confirmed by Ghisellini et al. (2016) who found that successful CE strategies “come from the involvement of all actors of the society and their capacity to link and create suitable collaboration and exchange patterns”. Similar findings have been reported in the industrial ecology literature by Lowitt (2013) and Veleva et al. (2015). Bocken et al. (2014) has proposed viewing such collaborations as a new business model and a new unit of analysis for business.

2.4. Entrepreneurs and corporations - strategic partners for creating value in a Circular Economy

Transitioning to a CE paradigm will require a fundamental shift in the *purpose* of business and how *value* is defined by companies and society. It will require new innovative actors who serve as intermediaries between large corporations and consumers and help solve environmental and social challenges (Ghisellini et al., 2016; Veleva et al., 2017). However, CE research to date has done little to articulate the social impacts and contributions of such an economy with a focus on optimizing resource use and reducing environmental impacts. As Murray et al. (2017) finds, “the circular economy is virtually silent on the social dimension. It is unclear how the concept of the CE will lead to greater social equality, in terms of inter- and intra-generational equity, gender, racial and religious equality and other diversity, financial equality, or in terms of equality of social opportunity.” The study also discerns that a truly sustainable future requires “system-based thinking that involves in equal measure, society, environment and economics” (Murray et al., 2017). York and Venkataraman (2010) believe that by creating new markets, products, information sources and institutions, environmental entrepreneurs can create new opportunities and societal change.

Entrepreneurs are critically important for launching innovative business models and filling the gaps in reverse supply chains, yet their role is still underexplored (Heshmati, 2015). Entrepreneurship is defined as “the process of starting a business, a startup company or an organization by developing a business plan and securing the necessary resources.” While large companies can also be entrepreneurial, small companies are often seen as “major drivers for

economic growth, breakthrough innovations and job creation” (Heshmati, 2015). They typically launch a business to address social or environmental problems. They are less concerned with profits (at least initially) and are better positioned to innovate and take risks. According to York and Venkataraman (2010), entrepreneurs are best positioned to solve complex problems and turn uncertainty into business opportunity with social and environmental benefits. While startup businesses may not be economically viable initially, this can change over time as a result of regulatory action or changes in the market (Bocken et al., 2014). In addition, research has demonstrated that while entrepreneurs have limited resources and reach, their ability to foster strategic partnerships with large players can stimulate disruptive innovation, leading to industry transformations in sustainable development (Hockerts and Wustenhagen, 2010).

This is particularly important for advancing a CE, which requires the focus to shift from individual technologies towards *creating new systems that are based on collaborations between accountable stakeholders*. A recent report by the World Business Council for Sustainable Development found that in a sustainable value network, “there are no longer up and down streams but rather a network of interactions and value exchanges ... blurring the lines between production and consumption” (WBCSD, 2011). Rizzi et al. (2013) affirms that a systems-based approach benefits stakeholders via collaborations that can only be captured if a company can build long-term relationships with key suppliers. Allee (2000) further reports that “the key to reconfiguring business models for the knowledge economy lies in understanding the new currencies of value: a) goods, services and revenue, b) knowledge, and c) intangible benefits.” This is in line with Zott et al. (2011) findings that the business model is emerging as a new unit of analysis, which “explains how value is created, not just how it is captured” and “occurs in a value network including suppliers, partners, distribution channels, and coalitions that extend the company’s resources.” The study also points out that value creation can refer to different forms of value (economic or social).

While research has reported some examples of co-evolution of small companies and large incumbents (Hockerts and Wustenhagen, 2010; Schaltegger and Wagner, 2011; Schaltegger et al., 2016) there is still limited understanding of how these players develop mutually beneficial collaborations to deliver new products or services, create a new market or transform existing market practices (Hockerts and Wustenhagen, 2010). Most research to date has described their relationship as competitive, with entrepreneurs as new entrants disrupting existing large players (incumbents) to bring market transformation. The present study aims to fill this gap and propose a new framework for corporate-entrepreneurial collaboration in a CE economy, based on



Fig. 1. Sustainable business model based on creating value from waste; adapted from Bocken et al. (2014).

establishing mutually beneficial partnerships between entrepreneurs and corporations, who recognize emerging drivers and are leveraging technology, knowledge and intangible benefits to offer innovative products or services.

3. Study design and method

To conduct the study, the researchers selected twelve U.S.-based companies – six entrepreneurs focused on product reuse or waste repurposing, and six large companies with commitments to zero waste and/or circular business practices. The goal of the study design was to select a diverse group of companies in order to examine whether there are common drivers, barriers and future opportunities with CE adoption. The entrepreneurs included **Circular Blu**, **The Furniture Trust**, **Seeding Labs**, **Save That Stuff**, **Preserve** and **RISE Products**. They represent both for-profit and non-profit organizations from diverse sectors and at different stages of development (from 1 year to 26 years old). Participating corporations were also selected from diverse sectors and included **Biogen**, **Raytheon**, **First Solar**, **Dell**, **PerkinElmer** and **Waste Management**. With the exception of Dell, all companies are publicly traded with annual revenues between \$2.1 billion and \$56.9 billion (see Appendix A). While not intentionally planned, some of the participating companies are business partners (see Fig. 2). For instance, Biogen provides surplus furniture to the Furniture Trust and surplus biotech equipment to Seeding Labs; Save That Stuff sends collected blue wrap from hospitals to Circular Blu and collected compost to Waste Management. This was a result of the study recruitment strategy – the authors leveraged their contacts with some companies to recruit additional participants who in some cases were their business partners.

Data for each company was collected between October 2016 and March 2017 using two main sources: a) publicly available information from websites, annual/sustainability reports and other publications, and b) in-depth, semi-structured interviews with senior managers or founders in the case of entrepreneurs. Each company participated in one interview in person or by phone. The interview protocol was developed using two CE frameworks: a) the Sanchez et al. (2004) framework, which examined the feasibility of circular economic business strategies, and b) the Levandowski (2016) framework for integration of CE principles into business models. All interviews were audio-recorded and transcribed for

accuracy. The empirical data was managed through cross-case analyses using the methodology described in Eisenhardt (1989). All collected data and information was aggregated and summarized in a table format to enable further analysis (see Appendix A). To ensure the validity and reliability of the qualitative analysis, we invited each participating company to review and provide feedback to the transcribed interviews and data analysis. The authors focused primarily on B2B collaborations between large corporations and entrepreneurs as these relationships provide valuable insights into inter-company dynamics by which a broader value network is defined, which can help articulate new business models.

4. Proposed framework for corporate-entrepreneur collaboration in a CE

Based on the present research, the authors propose a *new framework for corporate-entrepreneur collaboration in a CE*, based on developing strategic, mutually beneficial collaborations between entrepreneurs and large companies focused on product reuse, remanufacturing or waste repurposing (see Fig. 3). Once an idea for a novel product or service has emerged from another company's used product, packaging, or waste stream, the next step involves identifying strategic partners who can help in developing an adequate supply chain. Products and waste can be either reused, upcycled (converting into materials or products of better quality or environmental value) or downcycled (recycling into a material with inferior properties compared to the virgin material). Corporations or other large organizations (e.g., hospitals, universities, or nonprofit organizations) become suppliers to entrepreneurs as they generate significant amounts of old products, packaging or waste. Driven by their sustainability commitments, state or EU mandates, cost saving opportunities, reputational or other intangible benefits, these organizations recognize the value in establishing long-term partnerships. Leveraging their knowledge and relationships with materials processors, distributors or other partners, entrepreneurs develop their new CE products and services, which they then seek to sell to corporations, nonprofits, entrepreneurs or individual consumers. A range of factors such as cost savings, better service or product quality, environmental and social benefits, or reputational benefits, often drive the purchasing decision of these customers.

The strategic long-term partnerships between entrepreneurs and corporations, IT and knowledge (about the supply chain, product or customer needs) are key enablers for establishing viable CE business models, which confirms previous research by Allee (2000). Entrepreneurs and corporations developing CE products or services must address two challenges in order to establish viable business models: a) create an attractive value proposition for owners of waste and surplus products, and b) identify customers for their CE product or service. Being able to balance these two challenges is critical for reducing costs and generating profits. The framework also demonstrates that in a CE, value creation results from collaborations rather than competition between entrepreneurs and large companies. These symbiotic, mutually dependent partnerships benefit both sides and lead to job creation and social benefits. They are based on developing trust and close relationships, confirming previous research by Lowitt (2008).

In the next section, the authors detail the main findings from the study of entrepreneurial firms and corporations employing CE practices. The section begins with an analysis of business models and partnerships that focuses on value creation and value capture (section 5.1). Next, the authors analyze the drivers and enablers of the circular business strategies implemented by the participating companies (section 5.2). Section 5.3 examines the main challenges faced by the study participants. Finally, in section 5.4, the authors report the key future opportunities for scaling up CE practices

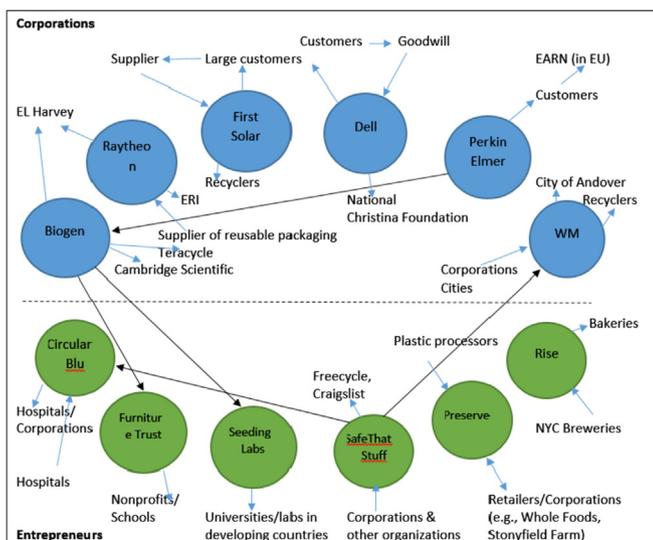


Fig. 2. Entrepreneurs and corporations participating in the study.

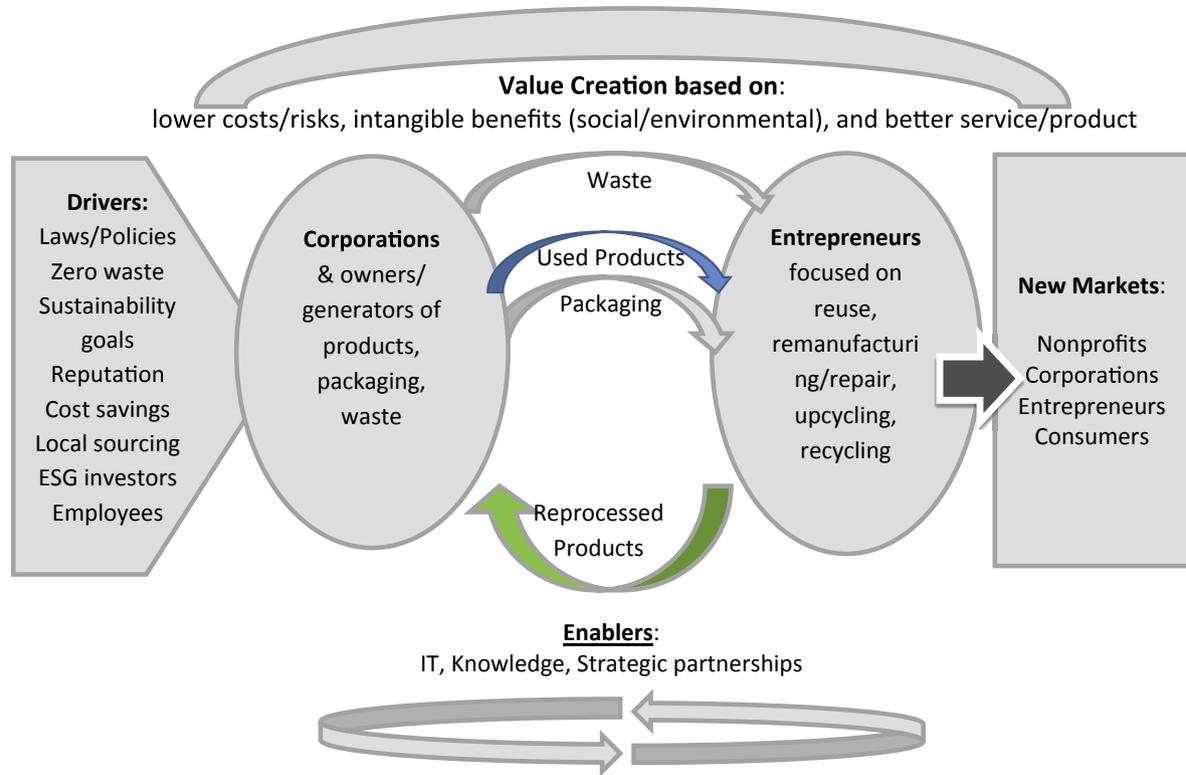


Fig. 3. Framework for corporate-entrepreneur collaboration in a circular economy.

identified in the study.

5. Results and discussion

Appendix A provides information about each of the 12 companies participating in the study and summarizes the key findings from the interviews and the online research in four areas: a) circular business model and partnerships, b) top drivers and enablers for CE strategy, c) key challenges to expanding CE strategy, and d) future opportunities for scaling up CE practices.

5.1. CE business models and partnerships

Each of the entrepreneurial firms in the study had identified a market gap and opportunity often by serendipity and following their passion for environmental sustainability. For instance, while working for Practice Greenhealth, environmentally trained brothers Chris and Gavin Bodkin saw the large amounts of sterilization wrap from hospitals going to landfill which creates both environmental burden and financial burden for healthcare facilities. In 2015 they launched Blu2Green, later rebranded as **Circular Blu** to repurpose this high quality polypropylene material into tote bags. To create both environmental and social benefits they hired people with disabilities to make the bags through a partnership with a Worcester, Massachusetts based charity. Circular Blu sells the tote bags to the healthcare industry and thus helps “close the loop” for the material. The company’s value proposition involves reducing hospital costs for waste disposal, and helping large organizations meet their environmental and social goals. Its success is based on its partnership with hospitals and waste haulers to collect the waste product, and with healthcare organizations such as Halyard Health to sell the new products.

The **Furniture Trust** is a non-profit company founded in 2008

by Christine Mosholder, who had been managing commercial renovation projects for many years, and who noticed the large amounts of good quality furniture going to landfill during building renovations. She launched the company as a way to solve this environmental problem and create social benefits by donating surplus furniture to educational and other non-profit organizations in Massachusetts. Since it was founded, the Furniture Trust has increased its network from 20 to 150 organizations, including about 75 corporate contributors such as Adobe, Biogen, Vertex Pharmaceuticals and Reebok ([The Furniture Trust, 2017](#)). It also has a network of about 200 non-profit recipients, including Boy Scouts of America, United Way and Weymouth High School. The Furniture Trust offers value to corporations by helping them meet their sustainability goals around waste reduction, and achieve their social and community support goals. Between 2014 and 2017 the company diverted 2,393,759 pounds of furniture and supplies from landfill or incineration while helping non-profit organizations save money and educating high school students through their annual Eco-Carpentry Competition ([The Furniture Trust, 2017](#)).

For both entrepreneurs and large companies **establishing long-term partnerships** with key players in their supply chains is critical for **creating and capturing value** and for establishing a viable business strategy, which confirms previous research ([WBCSD, 2011](#); [Rizzi et al., 2013](#); [Bocken et al., 2014](#); [Ghisellini et al., 2016](#)). For example, to meet its closed-loop manufacturing goals **Dell** leverages its partnership with Goodwill® to ensure cost effective collection and a continuous supply of used electronics to build its closed loop program. **Biogen**’s partnership with Cambridge Scientific helps repurpose surplus R&D equipment while generating revenue from resale, reducing environmental impacts and meeting its “zero waste to landfill” goal. **First Solar** partners with its customers on end-of-life management of its panels by providing globalized cost-effective recycling solutions. The company is an

engaged supporter of a newly developed PV sustainability leadership standard (NSF 457), initiated by the NSF and the Green Electronics Council in collaboration with other stakeholders. The standard would help differentiate its products and strengthen market presence. For producer of recycled plastic products **Preserve**, partnerships with plastics processors ensure a continuous supply of raw material (pre and post-consumer polypropylene), where its partnerships with retailers such as Whole Foods and Target ensure a sales channel as well as low cost/high quality raw material through drop off programs. For non-profit company **Seeding Labs**, partnerships with pharmaceutical and biotech companies are critical for obtaining surplus R&D equipment, which is then sent to scientists in developing countries. It partners with third party logistics company Barrett Distribution Center to ensure flexibility and cost reduction when managing inventory. For **RISE Products**, a small startup in New York City, partnerships with local breweries ensure a constant supply of spent grain, which is converted to high-quality flour. Local bakeries are key to ensuring market access and the company is currently seeking partnerships with retailers such as Whole Foods and Target to increase demand. These collaborations confirm previous findings that in sustainable consumption systems there are no longer “up” or “down” streams but rather a network of interactions and value exchanges (WBCSD, 2011), which blurs the lines between production and consumption (e.g., users of products become suppliers to entrepreneurs who repurpose these products and sell them again).

In this process **technology** enables companies to optimize logistics, reduce the costs of storing and shipping (e.g., Seeding Labs, Furniture Trust, Rise), leverage low cost marketing (e.g., Preserve and the digital marketing firm ecosphere) and educate customers (Dell, Save That Stuff), confirming Planing (2015) findings. For example, RISE Products' mission is “to foster sustainability through technology” and as such, the company has created an online marketplace to connect breweries (generating 4.8 million tons of spent grain on an annual basis costing \$1.2 billion for disposal) with bakeries and retailers purchasing the high quality, nutrient-rich flour made out of the spent grain. **Waste Management** is relying on information technology to continuously optimize the routes of its trucks in order to reduce costs for collecting recyclables and compost (Bodamer, 2017). For the **Furniture Trust** giving up their warehouse meant even greater reliance on IT and data to coordinate furniture pickups from large organizations and drop-offs to nonprofits. Executive Director Dana DeVeau states, “My dream is not to have a warehouse. And we at this moment have done that with every single project. We assess everything for a given project and determine where everything goes at the beginning. Good or bad, we stick with it. We manage logistics and everything”.

In all cases the **CE value proposition** goes beyond a simple ROI to **incorporate the environmental and social benefits** of such practices, confirming previous findings by Alee (2000) that launching new business models in a knowledge economy requires leveraging the value of knowledge and intangible benefits. Entrepreneurs confirm that they cannot compete with inexpensive imports from China on the basis of cost alone, even when they are able to offer competitive pricing. **Local sourcing** is becoming increasingly important to large corporations, hospitals, and universities and becoming a key part of the CE value proposition by entrepreneurs Save That Stuff, The Furniture Trust, Circular Blu, RISE Products, and Preserve. This confirms previous findings by Ghisellini et al. (2016). The companies use different **strategies to capture value**. Some entrepreneurs take unwanted equipment or waste for free (Circular Blu, Seeding Labs), while others are charging for such services (RISE Products). Non-profit organizations such as Seeding Labs and The Furniture Trust rely on grants and corporate underwriting to supplement revenues; others such as Circular Blu, RISE

and Preserve capture value based on customers willingness to pay for a product that is both high quality and socially/environmentally responsible.

For corporations, the CE provides **new business opportunities** and ways to **reduce risks from changing customer preferences, regulation or supply chain disruptions**. Both First Solar and Dell are monitoring European Union circular economy policies and actively participating in industry groups and policy discussions to promote a CE open market globally. First Solar is also involved in discussions with EU officials to ensure a level playing field for all companies in the sector, such as the take-back mandates for solar panels under the WEEE directive adopted in 2012. Prior to the inclusion of PV panels in the WEEE directive, First Solar had already established a voluntary collection and recycling program, which was viewed as an industry best practice for end-of-life management by the EU. Tellurium is a scarce material and by taking back its products the company ensures a continuous supply, reducing risk and increasing raw material security. Raytheon has been able to align its strategy with customers' energy efficiency goals by reducing the carbon footprint of its products. The company must also comply with EU regulations on hazardous materials in products. Its partnership with ERI helps it comply with state bans on disposal of electronic products such as computers, cell phones, printers and others, while simultaneously generating revenue from resale and recycling (Raytheon, 2017).

Small companies can offer **better customer service and greater flexibility**, which has become an important part of their value proposition and factors for success. “While we provide many services that a larger company can provide, our customer service is better, which is part of our value proposition,” shares Levy, founder of Save That Stuff. Large companies, on the other hand, have the ability to provide **global solutions** such as product take back and recycling, which is of paramount importance to some multinational corporations (Veleva and Bodkin, 2017).

Table 1 summarizes the main strategies used by participating companies to incorporate CE principles into their business models, based on Laubscher and Marinelli's (2014) framework. The top three strategies reported by study participants include *strategic sourcing, supply loops* and *IT/data management*, which confirms previous research (WBCSD, 2011; Ghisellini et al., 2016). Not surprisingly large corporations are reporting focus on product design and composition to allow for reuse and remanufacturing. Seven of the 12 companies report offering services in addition to selling products which confirms previous research on the importance of shifting business strategies from selling volumes of products to selling services. HR incentives remain an area that is least addressed presently by large corporations, where mostly the environmental, health, safety and sustainability personnel has CE goals and incentives, while majority of employees are rewarded based on achieving production and sales targets. The interviews with participating companies revealed an additional area for integrating CE principles in the business model, namely *articulating the social and environmental benefits of their products and services*. This confirms the growing importance of sustainability commitments by large organizations, municipalities, and consumers, and the need for policies to advance full-cost accounting.

5.2. Main drivers and enablers for CE strategy

The research revealed that besides companies' mission and vision, **zero waste/sustainability goals, reputation and regulations** are the top drivers/enablers for CE strategies reported by study participants (see Table 2). With the growing popularity of zero waste programs amongst municipalities and large organizations, Waste Management realized that it had to change its business

Table 1
Integration of CE principles with the business model.

Company/Area	Sales model	Product design/material composition	IT/data management	Supply loops	Strategic sourcing	HR incentives	Social & env. benefits*
Circular Blu				✓	✓	✓	✓
Furniture Trust	✓		✓	✓	✓	✓	✓
Preserve		✓	✓	✓	✓	✓	✓
Rise	✓		✓	✓	✓	✓	✓
SaveThatStuff	✓		✓	✓	✓	✓	✓
Seeding Labs	✓		✓	✓	✓	✓	✓
Biogen		✓		✓	✓	✓ limited	✓
Dell	✓	✓	✓	✓	✓	✓ limited	✓
First Solar	✓	✓	✓	✓	✓	✓ limited	✓
PerkinElmer		✓	✓	✓	✓	✓ limited	✓
Raytheon		✓	✓	✓	✓	✓ limited	✓
Waste Management	✓	Talking to packaging industry	✓		✓	✓ limited	✓

Table 2
Top drivers and enablers for CE practices.

Company	Company mission/vision	EU laws	US state mandates	Customer zero waste/sustain. goals	ESG investor/NGOs	Employee attraction & retention	Resilience/reducing risk/access to raw materials	Reputation	Cost savings	Local sourcing
Circular Blu	✓			✓				✓	✓	✓
Furniture Trust	✓			✓		✓		✓		✓
Preserve	✓	✓	✓	✓				✓		
Rise	✓		✓	✓				✓		✓
SaveThat Stuff	✓		✓	✓				✓		✓
Seeding Labs	✓			✓			✓	✓		✓
Biogen	✓		✓		✓	✓		✓		
Dell	✓	✓	✓	✓	✓	✓	✓	✓	✓	
First Solar	✓	✓		✓	✓		✓	✓		
PerkinElmer	✓	✓		✓	✓	✓		✓		
Raytheon	✓	✓	✓	✓		✓		✓		
Waste Management	✓		✓	✓				✓	✓	

*Additional drivers reported include green standards such as LEED (by Furniture Trust), and ease and convenience of handling all surplus equipment (Furniture Trust, Biogen, Dell).

model from landfilling to providing diversified services if it wanted to remain competitive in the market. Over the past 15 years it has expanded its business into recycling and composting, and has recognized the growing opportunities in this area as result of customer demand and regulations (e.g., Massachusetts Organics waste ban in 2014). Previous research has also revealed the growing importance of **corporate and municipal sustainability commitments and zero waste goals** (Walker et al., 2008; Nidumolu et al., 2009; Giunipero et al., 2012; Veleva et al., 2017).

Most study participants reported **reputation** as a key driver, which is line with previous research (Veleva, 2010; Schaltegger and Wagner, 2011; Lozano, 2015). Corporate reputation is associated with market positioning, the **ability to attract and retain talent**, improved relationships with regulators, NGOs, and investors, and lower cost of capital. Biogen, PerkinElmer and Raytheon reported corporate reputation and the ability to attract and retain talent as important considerations when responding to Millennials' desire to work for socially and environmentally responsible companies (Heldrich et al., 2012; Deloitte, 2017).

Despite the lack of U.S. federal mandates, **European Union regulations** (e.g., WEEE, RoHS, REACH and CE policies) and **U.S. state laws** (e.g., take-back mandates and disposal bans) influence global corporate behavior and create market opportunities for both large companies and entrepreneurs. "We are heavily influenced by European regulations. They are the strictest, and they end up becoming our global standard to a large extent. We need to make our products comply everywhere rather than make different products for the different markets", shared Chip Wallace, Director of EHS at PerkinElmer. For Raytheon state mandates are driving

corporate practices on a global scale. "The regulations here in Massachusetts really help to move the needle. The CRT ban, recyclables ban, and organic waste ban are the things that drive performance. This acts as a big driver for us to impose sustainable goals across the company", shared Frank Marino, Senior Manager EHS&S at Raytheon. Research has found that the 2014 Massachusetts Organic Waste Ban has led to significant growth in entrepreneurial companies partnering with large organizations around food donations and composting. Analysis of the impacts revealed significant direct and indirect economic benefits, such as a 150% increase in employment and a \$175 million increase in statewide economic activity over a two-year period (ICF, 2016).

For corporations like First Solar and Dell, **building a resilient supply chain and ensuring access to key raw materials** is of paramount importance. Both companies rely on scarce metals. Tellurium, a critically important material in First Solar PV panels, is a relatively rare metal that is primarily sourced as a byproduct of copper production. End-of-life PV recycling is expected to provide a sustainable future supply of semiconductor material, leading to productivity of 100 GW per year by 2050 (Redinger et al., 2013; Houari et al., 2014; Fthenakis, 2012). Furthermore, the glass from panels is easily recycled into glass products.

For publicly held companies, **socially responsible investors** (also known as ESG investors), are another important driver as reported by Biogen and PerkinElmer. Such investors have grown significantly over the years representing 1 in 5 dollars invested under professional management in the U.S. in 2016 (SIF, 2016). They have played an important role in advancing corporate sustainability, climate change actions, and reducing toxic chemicals and waste

(Veleva and Sethi, 2004).

The top driver for entrepreneurs is their **passion to address environmental problems while also creating social benefits**. This confirms previous research on the link between entrepreneurialism and environmentalism (Dixon and Clifford, 2007) and the role of sustainability-driven entrepreneurs compared to opportunity-driven ones (Parrish, 2010). While entrepreneurs report some of the same CE enablers as corporations (sustainability commitments, zero waste goals and state and EU regulations), they further benefit from the **increasing focus on local sourcing**. As the founder of Save That Stuff shared, “We also appeal to organizations that want to work with a local company with roots in the area. For them it’s not about the price”. This confirms previous research by York and Vencataraman (2010) who demonstrate how climate change concerns have increased demand for localized production that “favors multiple entrepreneurs operating at a small scale to provide a local market, rather than incumbent firms”. They further argue that “time to market can be a critical factor in pushing environmental innovations to localized markets.” RISE Products, for instance, is able to pick up spent grain from local breweries within 6 h of use, which is the threshold time for ensuring product quality. This responsive pickup infrastructure enabled by technology and data management, benefits local breweries, bakeries and customers.

Obtaining some **financial benefits** such as raising revenue through resale or no-cost removal of equipment is another important driver for owners of surplus products or waste. Sending equipment for recycling or landfill/incineration can cost anywhere from \$80 to \$100 per ton in New England compared to recycling or composting which costs around \$50 per ton (Lucarelle, 2017). For small New York City breweries the monthly cost for disposal of spent grain is about \$4500. Partnering with RISE reduces this cost to \$2000 per month and creates social and economic benefits from turning the waste into a healthy product. Having **information** about potential options is key, which confirms previous research that this driver supports all other managerial drivers (Tyagi et al., 2012; Veleva and Bodkin, 2017). Similarly, Dell has found that consumers are more willing to send back their old electronics if they have information about available options and are provided with a **free and convenient** way to do so.

Green standards are important for educating customers and supporting reverse logistics and demand for remanufactured products. For Furniture Trust, the Leadership in Energy and Environmental Design (LEED) standard has been an important driver for corporations to seek alternatives to landfill disposal of office furniture as they look to achieve the required number of points for certification. **Space constraints** and **ease/convenience of handling surplus products or waste** were also reported as important drivers

for large organizations seeking more sustainable options, which confirms previous research (Tyagi et al., 2012; Veleva and Bodkin, 2017). With the lack of space to store old equipment and staff to manage it, biotech companies for example, are seeking partners to take their surplus R&D equipment and furniture as quickly and efficiently as possible.

5.3. Key challenges for expanding CE strategies

The top challenges reported by both entrepreneurs and corporations include the **lack of regulation and incentives**, the **lack of data and indicators** to measure and communicate impacts, and the **cost of product/waste take back** (see Table 3). Additional challenges include the **lack of awareness and market demand**, **access to financing** and the **complex product or packaging design** that prevents proper reuse/recycling. Chip Wallace, EHS Director at PerkinElmer clearly articulated these challenges, stating, “If there is a compliance requirement, that’s the best way of getting companies to do it. There is a lack of customer demand or awareness. Identifying substitutes to go into our products in order to make them compliant is a significant task.”

Note: Additional barriers include: lack of scale to meet needs of large customers (SaveThatStuff), fluctuating commodity prices (WM, Preserve, Save That Stuff, regulation as a barrier (RISE)); lack of CE vision that aligns with CSR and zero waste goals (Biogen), need to get entire industry onboard (Biogen, Dell, First Solar).

As discussed earlier, **measuring and communicating the environmental and social benefits of CE practices** is critical for establishing a viable CE business model and attractive value proposition. CE practices generally require higher short-term expenses that lead to long-term cost-savings and risk mitigation, therefore it is vital that non-financial benefits are measured to communicate value. Most companies, however, report challenges in identifying and tracking such indicators. Both Furniture Trust and Seeding Labs measure fair market value (FMV) of repurposed equipment but as David Qualter of Seeding Labs shares, “this metric doesn’t resonate with anyone. From a PR or marketing point of view it is meaningless.” Measurement is a challenge even for established companies. Preserve founder and CEO Hudson shares that a major challenge for them is “the lack of dollars and time to do the measurement that we’d like to do. One of the things we’ve found is that people get intrigued by sustainability and the big companies have done a great job measuring and reporting. We aren’t capable of doing that and surviving.”

While the corporations in the study have more sophisticated measurement and reporting methods than entrepreneurial companies (e.g., Dell and First Solar are using life cycle analysis, and all

Table 3
Key challenges for expanding CE strategies.

Company/Area	Cost of product/ service or take back	Lack of regulation & incentive	Lack of financing/ resources	Lack of awareness & market demand	Complex product design/technical challenges	Lack of brand awareness	Lack of data, indicators to measures impacts (e.g. social)	Lack of mature/ knowledgeable suppliers; supplier leverage
Circular Blu	✓	✓	✓	✓		✓	✓	✓
Furniture Trust	✓	✓	✓	✓		✓	✓	
Preserve	✓	✓	✓	✓			✓	
Rise	✓	✓	✓	✓		✓	✓	
SaveThat Stuff	✓	✓	✓		✓		✓	
Seeding Labs	✓	✓	✓			✓	✓	
Biogen	✓	✓			✓		✓	✓
Dell	✓	✓			✓		✓	✓
First Solar	✓	✓		✓				✓
PerkinElmer	✓	✓	✓					✓
Raytheon		✓		✓	✓		✓	
Waste Management		✓			✓			

companies use the Global Reporting Initiative guidelines), they tend to focus on environmental metrics with little to no measures of the social or economic impacts. Commonly used indicators typically include “output” measures that track reuse, recycling, composting, energy recovery, incineration, and landfill diversion versus impact measures such as greenhouse gas emissions avoided, hazardous materials avoided, jobs and other social impacts, improved resilience and employee engagement. This confirms previous findings about the lack of standardized and effective CE indicators for business that raise awareness among internal and external stakeholders to support a transition to a CE (Krauz, 2012; Song et al., 2015; Veleva et al., 2017).

Related to measurement is the **lack of market demand** which is a result of both low awareness of available options and benefits (Rizos et al., 2015), and a lack of government policies to address environmental externalities and shift to taxing resources instead of labor (Daly, 1996; Stahel, 2016). For Preserve a key barrier for scaling up CE practices is the lack of interest from large companies. In addition, “50% of consumers don’t care. If you think about 250 million adults in the U.S. roughly 125 million care, depending upon where you put the light green and dark greens. Most don’t care that much. It’s not going to create ‘purchase intent’. In terms of barriers to implementing CE strategy, there is a lack of incentives. In the past 8 years there was interest, but with the new administration that has changed,” shares Hudson of Preserve.

Logistics and technical issues were reported by several companies including RISE Products, Dell, Waste Management and First Solar. For instance, Chris Lucarelle, Regional Manager Recycling at Waste Management shared that with the increasingly complex packaging, recycling is becoming more challenging. Dell has worked for two years with one supplier to streamline the process of regrinding old plastics and incorporating it into new products. The company has also changed the design of its products to allow for easier disassembly and recycling. “We are at the beginning of the learning curve in terms of developing new technology processes, which really brings down the costs in terms of recycling and recovering materials,” states Andreas Wade, Global Sustainability Director at First Solar. These findings confirm previous research that cleaner production and design for environment (DFE) are critical elements of an effective CE strategy (Linton et al., 2007; Ghisellini et al., 2016).

Dell and Biogen reported the **varying degree of maturity across the supply base** and the **need for industry collaboration** to catalyze their efforts and reduce costs. “We are partnering with Millipore on reusable packaging, which is a huge issue especially with reverse logistics. In pharma, it’s all about fiber-free packaging. But to make economies of scale work, we would need to get more companies involved,” shared Johanna Jobin, Director of EHS&S at Biogen. Lisa Brady, Senior Director Sustainability & Risk Management at Dell shared a similar challenge, “We want competition to take off so that the cost goes down to produce. That’s when economics comes into play. It requires more companies to participate so that suppliers change their practices.” Currently there aren’t many suppliers who have the knowledge and expertise to remanufacture or recycle complex products, according to Lina Azuero, Principal Program Manager for Supply Chain Sustainability at Dell. The key is leveraging the purchasing power of companies within an industry to pressure suppliers to change their practices.

For some companies, **articulating a clear vision for what the CE means for their industry** and aligning it with current sustainability goals is a challenge. “We are looking at our 2030 sustainability strategy and our next generation of goals and targets. We are currently working towards zero waste to landfill and it’s just for non-hazardous waste from operational facilities, excluding construction and demolition (C&D) waste and hazardous waste.

What’s the next evolution of corporate targets related to waste? If Biogen is going to set its next target, what would that look like or be? We need to define what the CE means for a biotech company like us”, shared Jobin from Biogen.

Entrepreneurs face additional challenges such as **access to financing** to scale up operations, **lack of brand awareness**, lack of **scale to meet the needs of large companies**, and **difficulties competing on cost alone**, which confirms previous research findings (Linder and Williander, 2015; Rizos et al., 2015; Veleva et al., 2017). Erik Levy, founder of Save That Stuff clearly articulated some of these challenges, “For some of our clients, the economy of scale of services required is too large, and we can’t compete”. Yet, localizing operations is a key part of the CE as it reduces the energy required to transport goods and waste, while contributing to local economies and programs. With the support of Food X, a food accelerator in New York City, RISE Products is working to patent its process so it can secure investor funding to grow the business. The mentoring and financial support have been critically important for the young company in refining their business plan, identifying partners such as Whole Foods and Nestle, and patenting their process. Yet **access to financing** remains a major challenge for the company and the other entrepreneurs in the study, confirming Rizos et al. (2015) finding that “the lack of government support and encouragement including the provision of funding opportunities, training, effective taxation policy, and import duties, is widely recognized as a significant barrier in the uptake of environmental investments.”

Most companies in the study shared that they **cannot compete on costs alone** even when they offer competitive pricing for their CE products or services. They are targeting a particular market niche and leveraging customers’ desire to achieve positive environmental and social impacts. While initially starting with tote bags that cost \$13 each, Circular Blu has brought the price down to an average of \$4.50/bag yet it still cannot compete with cheap bags made in China which cost 10–15 cents/bag. The company, however is optimistic that by increasing the volume of bags produced they can further reduce costs. Preserve, which has been in business for much longer and has the scale of manufacturing to reduce costs, reports that in some categories their products are still more expensive “We don’t offer premium pricing, but our price is higher. We seek to be priority priced with everything we do. Our reusable plates are a little higher price than something that you’d find from China, and certainly more expensive than the disposable alternative,” shared Hudson, Founder and CEO.

5.4. Future opportunities for scaling up CE practices by business

The research revealed that companies see **increasing regulation (globally and locally), customer demand and strategic partnerships** as the greatest opportunities in the future (see Table 4). Government policies can help institutionalize best practices and incentivize demand for product reuse or waste repurposing. “Mandates would help Seeding Labs provide a unique solution for corporations and reshape the impact we are having”, believes Qualter. In addition, **government financing** could help entrepreneurs both design new products and processes as well as scale up their practices and increase brand awareness. This confirms previous research by Rizos et al. (2015) about the importance of available financing for small to medium sized companies focusing on designing environmentally-friendly products or processes. Further, there is a need to **eliminate regulations and policies that act as a barrier** to adoption of CE practices. As shared by Bertha Jimenez, co-founder of RISE, “Regulations could be your friend or your enemy. In New York State, there’s no problem for us to take spent grain from breweries and convert it into useful

Table 4
Future opportunities to scale CE practices.

Company/Area	Increasing regulation	Increasing cost of disposal	DfE and modularity	↓ cost of bio plastics, upcycling	Strategic partnership, industry collaborations	↑ awareness & customer demand	Green labels & certifications	Employees as driver	Increasing brand awareness
Circular Blu	✓				✓	✓	✓	✓	✓
Furniture Trust	✓		✓		✓	✓	✓	✓	✓
Preserve	✓				✓	✓			✓
Rise	✓	✓			✓	✓	✓		✓
SaveThatStuff	✓	✓			✓	✓		✓	
Seeding Labs	✓				✓	✓			✓
Biogen	✓		✓	✓	✓				
Dell	✓		✓	✓	✓	✓	✓	✓	✓
First Solar	✓	✓	✓		✓	✓	✓		✓
PerkinElmer	✓							✓	
Raytheon	✓					✓			
Waste Management	✓		✓			✓			

Note: Additional drivers include: advances in recycling technology (WM, Preserve, SaveThatStuff, First Solar), local sourcing (Rise, SaveThatStuff); increasing role of IT/software (PerkinElmer, Rise, Dell).

product. In San Francisco, however you can't even pick it up because they have an exclusive waste contract with their haulers."

Increasing customer awareness and demand through eco-labels and certifications like LEED, Zero Waste, NSF International and the forthcoming EU Product Environmental Footprint Initiative, are also seen as critically important for creating CE opportunities for business. Jimenez would like to see her company offer a zero waste certification to breweries in the future and educate consumers about the benefits of flour from spent grain. "We have to educate the bakers on the product so they can educate their customers. It's indirect B2C. It's a barrier because there is a lack of awareness around the brewing process and the byproduct that is created. When you start talking about 'spent barley', people have no idea what you're talking about."

Strategic partnerships along the supply chain are critically important for creating viable CE business models. For Circular Blu this involves partnerships with hospitals to ensure a constant supply of sterilization wrap; with waste and recycling companies like Save That Stuff that collects and separates the sterilization wrap for them; with suppliers who make their products; with NGOs to identify people with disabilities to make their products, and with corporations to buy their products. As summarized by Co-Founder Chris Bodkin, "We have found that when we create strategic partnerships, you can find ways for others to help fund programs that help them. Even our manufacturing partner is strategically aligned. He is a taking a big risk with us, because he usually gets million dollar orders, and he's making 3500 bags for us. He does this because he thinks we could be big. These types of co-benefitting relationships help to cultivate ways to do business consistently."

Adoption of **green chemistry/design for environment to eliminate hazardous materials, introduction of packaging standards, and modular product design** were identified as important future opportunities to scale up CE practices. According to Dana DeVeau of the Furniture Trust, furniture must be designed to be modular and free of flame retardants in order to allow for disassembly and reuse. The heightened awareness and interest by **young employees** and increasing **zero waste commitments by cities and companies** are also expected to support business strategies in waste repurposing and product reuse. For example, the New York City mayor's goal of achieving zero waste by 2030 is a key enabler for RISE Products and other companies focused on waste reduction.

Introducing **effective CE indicators to measure and**

communicate the environmental, social and economic impacts of CE practices is seen as another future opportunity to support both entrepreneurs and large corporations. Such indicators are critical for educating consumers and developing a stronger CE value proposition. As Bodkin explained, "Most people working in hospitals want to increase recycling. They understand the connection between human health and environmental health. We say, by recycling this material, each bag diverts 2 pounds of CO₂ from the atmosphere as compared to creating a new bag from scratch."

One solution to the challenge of having a more localized production and consumption and scaling up such practices is **creating de-centralized but coordinated networks of entrepreneurs, corporations and other stakeholders**. Circular Blu has already begun to work in this direction as shared by Bodkin. "We are decentralized and work with multiple partners and stakeholders. We identify different partners to get our raw material and to support the recycling of the material. People contact us if they want to start a program, and we facilitate it even if it doesn't directly benefit our company." Jimenez of RISE Products is considering a similar strategy, "If we want to grow, we will have to replicate our business locally in other places so we aren't shipping lots of waste around."

The study also revealed the opportunities for **small entrepreneurial players to influence large market players**. As summarized by Hudson at Preserve "There's something about what Preserve has been doing that makes the larger companies interested in us. One example is with Berry, a company with \$4 billion in sales and \$9 billion in market cap. They work with the Gimme 5 program every year and they make the Preserve 2 Go™ container. In Europe we work with VDL, the company that makes the Mini Cooper. They are an eco-friendly/socially responsible business and they are huge." This finding confirms research by [Hockerts and Wustenhagen \(2010\)](#) that entrepreneurial partnerships with large players can stimulate disruptive innovation leading to transformation of entire industries towards sustainable development.

6. Implications for companies and policy makers

The current study and proposed framework (see [Fig. 3](#)) confirmed many findings from prior research and identified new challenges and opportunities for the **emerging entrepreneurial players and corporations**. First, it is critically important to establish *financially attractive models for owners of unwanted products or waste*. At minimum, owners of surplus products or waste seek lower cost or no cost processes. The ability to receive recognition

from a donation, reduce the costs of disposal or raise revenue can provide additional incentives for owners. Entrepreneurs can offer lower cost disposal options to corporations by enhancing the value of their waste as opposed to disposing it. This, combined with the marketability of the new products or services creates tighter relationships between supplier and vendor. Companies launching CE business models must offer *easy and convenient ways to handle waste and surplus products* to overcome inertia from business-as-usual practices and internal resistance to change. In a CE *developing a strong marketing strategy and close relationship with suppliers and customers* is of critical importance as entrepreneurs have to ensure both a constant supply of waste/old products and constant demand for CE products/services. While the Internet and social media have made it easier than ever to buy and sell online, establishing close relationships requires trust, quality products and services, and competitive pricing. Research has found that in many cases, companies' marketing strategy is still often based on word-of-mouth and face-to-face interactions (Veleva and Bodkin, 2017). Establishing strategic partnerships with CE recyclers and other entrepreneurs (e.g., companies focused on donations) can expand potential distribution channels and help minimize costs. Growing *awareness about the environmental and social impacts of waste generation and disposal* through implementing effective indicators and increasing the *pressures on large companies to report and minimize waste* could further increase demand for CE products and services. Furthermore, with the recent Chinese National Sword restricting the imports of recycling materials, finding local waste repurposing solutions could become an imperative, which could lead to new opportunities for entrepreneurs.

The present study and proposed framework offer valuable lessons and insights for **managers in charge of handling waste, packaging or surplus equipment**. First, it reveals that there are *increasing opportunities for cost-effective, easy and responsible methods for handling waste*. Managers should examine their peers and competitors' practices to identify emerging opportunities and best practices both within and between industries. Managers should also stay informed about potential regulations around product disposal, waste bans or reporting mandates. Identifying and implementing strategies for eliminating waste could further reduce risks and costs, and protect their company's reputation. Finally, managers could advance the idea of using upcycled products or remanufactured equipment as a strategy to improve reputation, and in some cases, the bottom line. Understanding and communicating the benefits of such practices is key for overcoming potential resistance from within the organization.

The study demonstrates that **policymakers** have a key role to play in advancing CE practices by a) enacting effective regulations or eliminating regulatory hurdles to CE practices; b) providing incentives to companies engaged in such practices, c) providing financial support, and d) raising awareness about the issue. *Local zero waste goals* or *waste bans*, for example, can act as powerful drivers for waste generators to find alternative solutions as demonstrated by the 2014 Organics Waste Ban in Massachusetts. Enacting regulations promoting the *elimination of toxic chemicals from products and packaging*, and the advancement of *design for disassembly* are critical for enabling reuse of products and materials. Examples of such regulations include the California Green Chemistry Initiative for consumer products and the Leadership in Environmental and Energy Design (LEED) for buildings. Policymakers should also examine their current regulations to identify potential barriers to CE practices. Introducing *reporting requirements for waste* similar to the City of Boston Building Energy and Disclosure Ordinance (City of Boston, 2017) can increase transparency about the amount of waste generated and create incentives for large organizations seeking alternatives to landfill or incineration.

Policymakers can also provide *tax incentives* for companies offering CE products and services similar to the Swedish tax break for repaired products (Orange, 2016). Providing *financial support* to entrepreneurs and other organizations in the form of grants, low interest loans, or business incubators, is critical for supporting smaller companies as confirmed in the literature (Lowitt, 2008; Rizos et al., 2015). In addition, government agencies could partner with non-profit organizations to *help raise awareness about the issues by launching CE labels, awards, benchmarking studies or networks*. As this study demonstrates there is a need for developing effective indicators for measuring and communicating the environmental, social and economic benefits of CE products and services to raise awareness and increase demand. Policymakers could support academic or other nonprofit organizations aiming to develop indicators, tools, training and the creation of local networks of entrepreneurs, corporations and other stakeholders interested in advancing the CE. As a major buyer of goods and services in the U.S. government *can leverage its purchasing power to increase demand for CE products and services* (federal and state governments in the U.S. purchase close to \$1 trillion of goods and services each year).

7. Conclusion

Companies are key players in fostering the transition to a CE as they have the responsibility and capabilities to implement innovative strategies for designing-out waste, reusing products and materials, and influencing consumer awareness and demand for green products. This study demonstrates that several common factors are driving the emergence of CE business models and collaborations despite the lack of federal mandates in the U.S. These include: a) municipal and corporate sustainability commitments and zero waste goals, b) U.S. state mandates and European Union directives, c) corporate reputations, d) employee attraction and retention, e) ESG investors, f) local sourcing, and g) increased focus on resilience and risk reduction. The main challenges reported by both entrepreneurs and corporations include a) a lack of regulation and incentives, b) a lack of data and indicators to measure and communicate the impacts, c) the cost of product/waste take-back, d) a lack of awareness and market demand, and e) the complex product or packaging design that prevents proper reuse/recycling. Entrepreneurs are leveraging technology and strategic partnerships with large corporations to create value for their partners and communities by reducing risks, costs, and improving company reputations and social impacts. Their future growth and success, however, requires financial, administrative, and educational support.

The study has several limitations. First, it only included 12 companies. A future study should consider including a larger number of leading companies to examine emerging drivers, challenges and opportunities for transitioning to a CE. Such a study could focus on recruiting pairs of entrepreneurs and corporations to examine the underlying factors for establishing successful partnerships and how value is created and captured. Another shortcoming of the study is that it focused primarily on B2B companies. Research has suggested that consumer behavior will play a critically important role in the shift towards a CE, thus examining B2C businesses is necessary. Future research should examine how business model innovations are able to address both the rational and irrational motives of consumers and change their behavior to embrace CE practices (e.g., buying green or remanufactured products, returning products for reuse or recycling, leasing instead of buying products).

The main contribution of this study is that it proposes a new framework for corporate-entrepreneur collaboration in a CE. It

examines the role of environmental entrepreneurs in making the links in reverse supply chains and their strategic partnerships with corporations and other organizations to advance the CE. The research confirms previous findings regarding the ability of entrepreneurs to introduce innovative business models, products and services that address environmental problems, while creating social and economic benefits. It demonstrates that in a CE, value is created along the value chain, which is seen as a system (e.g., customers become suppliers of old products and waste). For both entrepreneurs and large corporations, establishing long-term partnerships with key players in this system is crucial for creating and capturing value. In addition, communicating the social and environmental benefits in addition to the financial/economic benefits is critical for establishing viable CE business models. Advancing CE practices requires redesigning products and packaging to eliminate toxic chemicals and promote ease in disassembly and recycling. Scaling up the market-driven changes, however, will require the collaboration of numerous stakeholders such as governments, NGOs, academic institutions, large companies,

entrepreneurs, and consumers in order to raise awareness and drive demand for green products while also driving participation in take-back efforts. Finally, there is a need for government leadership in shifting tax policies and helping to decouple profits from resource consumption.

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Appendix A. Participating companies' business model, top drivers/enablers, challenges and future opportunities

Company	Sector/Type	Revenues/Yr founded	Circular business model & partnerships	Drivers & Enablers	Key challenges	Future opportunities
Circular Blu	Healthcare (Private)	2015	Takes hospital sterilization wrap (#5 plastic) for free and upcycles into tote bags sold back to the healthcare industry. Manufacturing partner processes and manufactures the material. Partners with disability charity to offer donations for each bag purchase. Partnerships with hospitals & waste haulers to get sterilization wrap. Partnership with Halyard Health and others to sell the bags. Reduces costs and waste for hospitals; helps customers meet social & environmental goals.	Co-founders Chris and Gavin Bodkin worked for Practice Greenhealth and saw the large amounts of sterilization wrap going to landfill. They launched the company to address this environmental problem and create social benefits by hiring/supporting people with disabilities. <u>Enablers:</u> Need to fill the gap between hospitals and landfills and help reduce waste; CSR commitments of large customers; healthcare pressured by NGOs to reduce waste.	Lack of regulation; lack of environmental awareness and available options; need to separate material, hospital logistics and space issue; product cost is higher compared to Chinese imports; lack of social impact metrics; access to financing; lack of supplier leverage; lack of brand awareness.	Forming strategic partnerships (e.g., with organizations hiring people with disabilities); working with GPO for the healthcare industry; increasing brand awareness; growing decentralized business model by creating a network with similar companies in other regions to increase impact (e.g., currently working with a partner in Colorado).
Furniture Trust	Furniture (non-profit)	2008	Charges a fee to take unwanted furniture from large organizations & donates to educational institutions & nonprofits. Holds annual Eco-Carpentry Competition for high school students. Helps companies reduce waste & meet their community support/social goals. Long-term partnerships with companies (e.g. Vertex, Biogen, Liberty Mutual) to support CSR goals. IT and data management helps improve logistics and eliminates warehousing.	Founder Christine Mosholder managed commercial renovation projects for years and saw high-quality furniture going to disposal. She launched the company to address this waste problem while also creating social benefits. <u>Enablers:</u> companies' sustainability commitments; ease and convenience of handling surplus furniture & supplies; LEED raised awareness, served as driver for waste reduction.	Lack of regulations; shifting focus from LEED to WELL building standard; higher costs compared to disposal; challenges measuring and communicating the social impacts; lack of resources (e.g., financing) and brand awareness.	Partnerships with manufacturers and dealerships; modularity and standardization; increasing regulation; increasing awareness of LEED and the full range of impacts of waste elimination; CSR & zero waste commitments.
Preserve	Recycling (private)	1996	Makes household products from recycled plastic including toothbrushes and cutlery. Partners with retailers and companies like Stonyfield Farm to collect polypropylene packaging. Partners with 2–3 processors to make their products. Partners	Founder Eric Hudson started the company in the mid-1990s when recycling took off but people questioned what happened with collected material. He launched the company to solve this issue & offer a better toothbrush design. <u>Enablers:</u>	Higher cost to manufacture in some categories; lack of demand from large companies and consumers; lack of funding & time to adequately measure product impacts and footprint (e.g., LCA, social impacts); government regulations as	Investment in better recycling technology (e.g., optical sorting) to improve quality of collected plastic; regulation (exploring strategies to expand to EU); growing interest by large suppliers (e.g., Berry Global, VDL) and other companies.

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Company	Sector/Type	Revenues/Yr founded	Circular business model & partnerships	Drivers & Enablers	Key challenges	Future opportunities
			with retailers like Whole Foods and Target to sell their products. Digital Marketing firm ecosphere helps with marketing. Selling products in 18 countries and exploring manufacturing in the EU. Partners with individual customers to take-back used products.	Increasing awareness about environmental benefits of recycled products; <i>Gimme 5</i> program allowed customers to return used PP products via Whole Foods collection bins; sustainability commitments; state mandates (e.g., Organics waste ban in MA promotes compostable cutlery); declining costs of bio based plastics.	a barrier (e.g. FDA and food packaging).	
Rise	Food (private)	2016	Takes "spent" grain from microbreweries at \$2000 per month vs. \$4500/month for MSW disposal. Upcycles the spent grain into nutrient-rich flour that is sold to bakers, grocery chains, and potentially large-scale food producers like Nestle. Product creates value for breweries (cost reduction and environmental/social benefits) and for bakeries & consumers (healthy product with high level of protein, fiber and iron, with less carbohydrates).	Concept emerged in 2013 science class focused on mapping waste from industries in NYC to use as raw material for others. Founder Jimenez first launched Rise as non-profit but in 2016 became for-profit and brought on several other grad students from NYU. Received an award from Food X, a NYC startup accelerator; seeking partnerships with retailers & space to ↑ manufacturing. <u>Enablers:</u> CSR commitments of partners; NYC 2030 zero waste goal; focus on local sourcing; cost savings; health conscious consumers.	Higher cost compared to conventional flour; access to financing to scale up production to reduce costs; technical expertise; regulation as a barrier in some markets (e.g., San Francisco; FDA); lack of consumer awareness; need for better measurement and education of bakeries & consumers, access to lab and production space.	Business incubators (e.g., member of Food X); increasing commitments to zero waste; partnership with retailers like Whole Foods and Target, and manufacturers like Nestle; ↑ demand for local products; ↑ demand for healthier food; regulation; strategic sourcing & launching zero waste certification for breweries; optimizing logistics via new App.
Save That Stuff	Waste management (private)	1990	Boston-based recycling & waste services company that charges a fee to take all types of waste and promote reuse, recycling and composting, which enhances their value (i.e. Styrofoam, office stationary equipment). Sorts and sells/gives away reusable material via network of partners (e.g., Freecycle, Craigslist, recyclers). Partnership with Waste Management on composting; with Circular Blu on sterilization wrap. Offers better customer service, helps meet CSR goals, local vendors; cost savings compared to disposal. Consulting customers on waste reduction.	Founder Eric Levy began by picking up curbside cardboard in Boston in 1990. Cardboard was bulky, so Levy offered cost-reducing pickup services and was able to sell cardboard for a premium. Then he began picking up recyclables & delivering them to a recycling partner. Success driven by state regulations (e.g., Organics Waste ban), customers' goals of zero waste and commitment to use local vendors; ability to take all waste & surplus product and offer local reuse, recycling or composting with better customer service than large competitors.	Access to financing; fluctuating commodity prices; struggles with data and metrics (to communicate impacts to customers); complex products not possible to recycle; lacking scale to meet demands of some large customers.	Customers moving toward transparent waste companies; growing importance of local operations and zero waste goals; increasing regulation; long-term partnerships with strategically-selected customers (e.g., Whole Foods); shift to advising customers how to get to zero waste; growing organics market.
Seeding Labs	Biotechnology (non-profit)	2007	Takes surplus R&D equipment from biotech and pharma companies and U.S. universities for free; sends to scientists in developing countries (charges small flat fee). Value for large companies: ↓ disposal costs, helps meet social and environmental goals; tax deductions; for manufacturers removes	Nina Dudnik came up with the idea in 2003 while working as a graduate student in West Africa. She won the MIT \$100 K Entrepreneurship Competition in 2006 and the Echoing Green Fellowship in 2007 that helped launch the company. She identified a gap between used, high-value and functional	Challenging to forecast supplies (need diverse donors); competition from online auctions; lack of regulation; access to financing (equipment program covers 40% of costs, grants for the rest); lack of meaningful metrics to show impacts (FMV is not meaningful).	Looking to expand in Europe, which is more regulated; building long-term relationships with companies to source equipment; increasing brand awareness.

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Company	Sector/Type	Revenues/Yr founded	Circular business model & partnerships	Drivers & Enablers	Key challenges	Future opportunities
Biogen	Biotech (Public)	\$11.4 billion	<p>equipment from secondhand markets & introduces scientists in developing countries to their products. Social benefit to universities and researchers in the developing world. Strategic partnerships with biotech & pharma companies; with 3rd party logistics company Barrett Distribution Center to enable flexibility with space and staffing (reduced cost for warehousing, labor); IT to track 80 categories of products.</p> <p>Several CE programs to eliminate waste (i.e. zero waste to landfill goal, single-stream recycling, electronics take-back). Partners with Cambridge Scientific for R&D equipment remanufacturing and resale, with Seeding Labs for donations, with Furniture Trust for surplus furniture donations, with EL Harvey for recycling and composting, with Triumvirate to down-cycle plastics; with Terracycle for drug take back, with Millipore to develop reusable packaging; Using green chemistry to eliminate hazardous chemicals; compostable cutlery.</p>	<p>equipment that was being discarded by large biotech/pharma companies & scientists in need in Africa. Partners with 40 universities mostly in Africa. 99 corporate donors including Amgen, Biogen, Vertex, eppendorf. \$4.9 million equipment donated; 17,000 scientists & students benefitted in 2016. <u>Enablers</u>: CSR commitments & employee engag.; ↓ competition with new instruments for manuf.; exposing scientists in developing countries to their products.</p> <p><u>Drivers</u>: Strategy driven by sustainability goals such as “zero waste to landfill” and “net zero carbon”. Seeks to maintain sustainability reputation, attract and retain talent; top management support for initiatives; state mandates main driver (e.g., California drug take-back; organics ban in Massachusetts); industry collaborations around packaging (e.g., via association PPSWG); employee leadership in identifying CE partners.</p>	<p>Lack of CE vision and need to align current zero waste goals with CE vision; time & costs as barrier to finding local partners for reuse/remanu-facturing; lack of guidelines; lack of federal mandates; challenges measuring impacts; need to get the entire industry onboard; generating internal buy-in to leverage budget increase.</p>	<p>Green chemistry to reduce chemical use; regulations; upcycling opportunities (e.g., good quality plastic waste); develop reusable packaging; bio plastics; industry collaborations to scale up practices; new compost processing capabilities of waste partner.</p>
Dell	Technology solutions provider (Private)	\$56.9 billion	<p>Closed-loop plastics supply chain (making 91 products incl. first PC OptiPlex 3030 certified by UL Environment for circular design); design for disassembly; partnerships with: Goodwill for electronics take-back, National Christina Foundation for donations, supplier for regrinding plastics, aerospace industry to take reclaimed carbon fiber (industrial waste) for use in notebooks; corrugated paper back to vendor; use of ocean plastics for packaging material; leasing of products in commercial space; resale of nearly 1 million units per year via outlet.</p>	<p><u>Drivers</u>: EU mandates including WEEE, RoHS, REACH, waste and packaging directives; building resilient supply chain and reducing risks; customer demand for recycled plastics and leasing business models; ESG investors and NGOs pressures for product take-back & recycling; sust. commitments and goals; ability to attract & retain talent. Top-down and bottom-up support (as risk reduction); 2020 Dell Legacy of Good Plan commits to closed-loop recycling & use of PCR plastics (100 million lbs back in products by 2020); goal to develop 100% waste free packaging; Ellen MacArthur Foundation CE100 member; LCA driving product design.</p> <p><u>Drivers</u>: Upper management support,</p>	<p>Fast changes in software –how do you design for that? Material substitution causes challenges with competition, resiliency, and longevity; data gaps; scalability – how to get competition to adopt and help leverage upstream supplier practices; lack of suppliers who can meet CE needs; lack of federal mandates.</p>	<p>Closed-loop recycling driver/industry momentum; increase in green labeling and certifications; DfE and modularity; greater adoption of life-cycle assessment (LCA); design for disassembly; doesn't patent closed-loop recycling to promote greater industry adoption; encourages open-source approach to ocean plastics sourcing.</p>
First Solar	Solar energy (Public)	\$2.95 billion	<p>Established first global PV module recycling program</p>	<p><u>Drivers</u>: Upper management support,</p>	<p>Cost of logistics of taking back old PV; lack of market</p>	<p>Mandates for reuse & recycling (EU); global</p>

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Company	Sector/Type	Revenues/Yr founded	Circular business model & partnerships	Drivers & Enablers	Key challenges	Future opportunities
			in solar industry; Partnering with Industry association SEIA; Promoting standards (CENELEC) to encourage high value recycling for all PV technologies; member of NSF International Joint Committee on PV Sustainability Leadership standard. Recycling and reuse of materials (glass, tellurium, Cd). Recovering > 90% of semiconductor material and 90% of glass. Examining feasibility of reuse vs. recycling.	Commitment to responsible product life cycle approach, EU mandates, ensuring a sustainable supply of raw materials e.g. tellurium. ESG investors; reduce overall environmental footprint; sustainability commitments; reputation; customer relations.; NSF International PV Sustainability Leadership Standard	for recycled materials (e.g., glass, polymers); lack of adoption by entire industry; design for durability creates challenges for recycling (i.e. PV encapsulants).	waste management pressure from NGOs; IRENA/IEA forecasts significant increase in end-of-life PV by 2030–2050.; increasing landfill costs; decreasing recycling costs through advances in recycling technology; potential inclusion of CE requirements for capacity additions.
PerkinElmer	Biotechnology (Public)	\$2.1 billion	Partnership with European Advanced Recycling Network (EARN) to take back & recycle waste. B2B compliance in EU, UK. Mandated by EU RoHS directive to track & reduce toxic chemicals in products such as Pb and Cd. In U.S., customers can trade old equipment for new equipment and company harvests valuable components from old equipment. Zero waste goals in the U.S. and adherence to global standard.	Driven by EU WEEE, RoHS and REACH directives, U.S. state mandates; customer demand (pharma companies with CSR goals), new product features to ↓ energy use, chemicals); reputation; ESG investors; new employees with sust. awareness; less waste driven by focus on lean manufacturing. <u>Enablers:</u> software and IT, space restrictions from customers who need smaller units.	Complex logistics; lack of customer awareness and demand; competing priorities & limited resources; lack of leverage over suppliers; compliance-oriented; regional variation in regulations and take-back infrastructures	High interest from new employees and recruits; software and IT development (e.g., in tracking materials, products, software upgrades to extend use); remote diagnostics for efficient service delivery; increasing regulations.
Raytheon	Defense (Public)	\$24 billion	Zero waste goal and 6 sites certified as zero waste by US ZWBC; 2020 goal to certify 20 sites; focus on energy, sustainable products & services, design for sustainability. Partnership with ERI for used electronics resale & recycling; partnership with suppliers to ↓ packaging (e.g., reusable packaging); compostable kitchenware; with EL Harvey for recycling & composting in Mass; modular products that can be updated in the field; designing energy efficient products; eliminating hazardous chemicals like SF6 and tetra fluoro-methane; Virtual Technology Collaboration (VTC) to reduce business travel.	<u>Drivers:</u> Upper-level management; sustainability goals and commitments (e.g., zero waste certified sites); EU regulations such as REACH and RoHS; state mandates (e.g., electronics bans; organic waste ban in Mass); government sust. procurement; waste reduction goal; cross-functional structure for measuring and integrating sustainability into operations and IT; in 2008, started their sustainability program with seven focus areas; in 2015 developed 2020 sustainability goals; employee engagement program Sustainability Star – an 8 course sustainability training.	Product complexity makes LCA and design changes challenging; lack of customer demand (DoD has goals but poor implementation); lack of federal mandates; challenging to measure impacts.	Increasing global regulation; increasing customer awareness and demand; need to address chemicals and supplies (e.g., Finish waste-to-energy facility); DoD budget expected to increase.
Waste Management	Waste management (public)	\$13.6 billion	Shifting from waste disposal to recycling, composting & consulting. Shift to selling services. Opened anaerobic digester in Boston, MA, in Dec. 2016. Partnership with Save That Stuff on composting & recycling, partners with City of Andover to give them	<u>Drivers:</u> Customers are key drivers of initiatives (increasing focus on zero waste, composting & recycling); U.S. state regulations dictate operational and market shifts (e.g., Mass Organic Waste Ban); disposal costs, IT to improve logistics and reduce costs (e.g., optimize	Technical issues (complex/mixed packaging; Styrofoam difficult to recycle); disposal costs differ in different regions (e.g., \$12-\$15/ton in Ohio vs. \$80-\$100 in Massachusetts).	Development of standardized packaging (packaging industry asking for input to improve design); need to be economically viable; sees role for Walmart to introduce 100% recyclable packaging; increasing regulation.

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Company	Sector/Type	Revenues/Yr founded	Circular business model & partnerships	Drivers & Enablers	Key challenges	Future opportunities
			compost; audits inbound waste streams for contamination. Often charges by volume. Fees for composting and recycling are lower than for disposal, thus helps ↓ costs and meet customer CSR goals.	truck routes, monitor compactors).		

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