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Improving Circular Economy Business Models: Opportunities for Business and Innovation

A new framework for businesses to create a truly circular economy

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The circular economy (CE) is aimed at closing material loops by reducing and recovering resources in production and consumption processes. Many studies have discussed how CE helps companies create business opportunities while bringing environmental benefits. The business case for CE involves complicated issues such as industrial symbiosis, governmental interventions and the transformation of company culture. It is important to consider the whole context of CE when changing policies or business elements to optimise resource efficiency and avoid unsustainable consumption. By reviewing industry research reports and academic studies, this article summarises important circular business models and strategies and indicates current major barriers to CE. In addition, we explore multiple business cases and point out three important considerations that, if not used correctly, can lead to improper policies and environmental degradation when designing circular business models. These are (a) the use of biodegradable materials, (b) modular design for product life extension and (c) upcycling for new production processes. We then present a framework for companies to clarify vital considerations for resolving these issues based on systems thinking. The implications for business managers and policy makers are also discussed. This article serves to provide a better understanding of CE and explores how companies innovate in line with CE trends.

Introduction

The CE is an economic system used to transform the traditional linear economy and it has been considered as a potential enabler of sustainable development (1). In a linear economic system, raw materials are extracted, manufactured, used and then discarded; such an end-of-life process leads to environmental degradation due to the continued exploitation of limited resources (2). CE can be defined as "an industrial system that is restorative or regenerative by intention and design" (3). It replaces the end-of-life concept with restoration, taking products and material use from 'cradle to grave' to 'cradle to cradle' (3, 4). That is, CE considers discarded products or components as materials and resources for the input of new production processes. For manufacturing industries facing challenges of resource scarcity and environmental impact, it is important to reduce, reuse and recover resources in production and consumption processes and keep products and materials at their highest utility and value (5, 6). In order to do so, manufacturing industries require their business models, products and supportive networks to be redesigned to fulfil circular solutions (7). CE thereby creates an opportunity for business innovation which is aimed at value creation, cost reduction, revenue generation and resilience enhancement (8).

CE is not a brand-new idea for sustainability issues. The original concept emerged from the 1960s with the awareness of limited resources and coexistence of economic and environmental systems (2). It gradually matured with the development of cleaner production, the performance economy, product service systems (PSS) and regenerative design. Cleaner production is a corporate initiative applied to reduce the impact of products and production by eliminating harmful materials and emissions (9). The performance economy serves to create wealth with less resource consumption *via* selling performance (for example, results and utilisation), instead of selling goods (10). PSS combines marketable products and services to satisfy customer needs while extending the product life cycle (11). Regenerative design regards production as a resilient ecosystem, where energy and materials can be replaced and reused continuously (12). The above concepts have been incorporated into managerial practices and principles for CE and form sustainability visions for companies (2, 8). In addition, for the past 10 years, CE has received more attention regarding how companies associate it with business model innovation and create environmental and social value (13).

Although manufacturing industries might focus more on the production aspect of circularity, the core of CE is not merely about how companies produce and recycle eco-friendly products. It actually goes beyond single product and service design and requires changes to the whole production process and consumption behaviour, including consumer awareness, network-centric operational logic, community integration and even governmental interventions (13–15). Since this complicated process involves multiple actors and strategic plans at the micro level (for example, circular products and business models) as well as the macro level (policies and regulations) (16), any improper decision might lead to failure. Many studies have discussed the advantages and challenges of CE, but few of them indicate that some misconceptions about circular manufacturing can guide companies to unsustainable performance. Based on the exploration of business cases, this article clarifies crucial aspects that influence the design of business models and sustainability, provides a holistic context and considerations for resolving these conflicts and discusses the implications and managerial practices for companies that intend to develop circular business models.

Circular Business Models and Strategies

CE contains multiple elements such as resource recovery, energy conservation, product life extension and recycling. These elements should be associated with revenue streams to help companies develop their business models. Companies also need to clarify how they create, deliver and capture value within closed material loops (1, 17, 18). Below we review and summarise important CE business models and their strategies from industry research reports and academic studies.

Accenture, Ireland, (19) has analysed 120 case studies and proposed five circular business models in its report. These models are (a) circular supplies, (b) resource recovery, (c) product life extension, (d) sharing platforms and (e) product as a service. The circular supplies model means that companies earn revenues *via* supplying renewable, recyclable or biodegradable resources in place of disposable and virgin materials. The resource recovery model reprocesses disposed products and turns them into new or available products or energy. Such a model often transforms waste into value through recycling or upcycling services. In the product life extension model, companies reduce production costs of new products *via* repairing, upgrading or remanufacturing. The sharing platform model makes possible shared access to products. It decreases the product ownership rate and encourages users to share products such as vehicles and accommodation. As for the product as a service model, companies provide leasing or renting services, where customers pay only for the product use instead of buying the whole product (19).

tRansition from linear 2 circular (R2π) is a three-year research project beginning in 2016. It explores markets and policies of CE and shows how circular business models can be implemented. By analysing cases in electronics, food, plastic, textile and water sectors across European countries, this project has identified seven patterns of circular business models, including (a) circular sourcing, (b) resource recovery, (c) reconditioning, (d) remaking, (e) access, (f) performance and (g) coproduct recovery (20). The first six patterns are similar to the five models in Accenture's report while the coproduct recovery pattern implicates another way to run a circular business. This pattern creates a new industrial value chain, where residual outputs or byproducts of a company can become feedstock or inputs for another company. For example, fly-ash from coal combustion can be used as clinker for producing cement. Such a pattern usually works *via* co-located facilities since proximity can save transport costs and reduce energy use (20). In other words, industrial symbiosis can be applied to enhance circular production. The Kalundborg Symbiosis is a well-known example that integrates nearly 20 different byproduct exchanges to create ecological benefits (21).

Table I Circular Business Models and Their Strategies

Reference	Resource supplies	Resource recovery	Product-service systems			Open innovation	
Accenture (19)	Circular supplies	Resource recovery	Product life extension	Sharing platforms	Product as a service	–	–
R2π (20)	Circular sourcing	Resource recovery	Re-condition, re-make	Access	Performance	Co-product recovery	–
Pieroni et al. (13)	–	–	–	Access	Performance	Industrial symbiosis	Alternative ownership

By reviewing 94 academic papers, Pieroni *et al*. (13) identify three archetypes of CE-oriented business model innovation, including (a) access, (b) performance and (c) industrial symbiosis. These archetypes require elements such as reverse logistics, take-back systems, incentives and service-oriented revenue schemes to fulfil the circular supply chain. In addition to the emphasis on business sectors and environmental value, Pieroni *et al*. (13) also present an archetype dedicated to social sustainability, namely alternative ownership: cooperatives and collectives. This archetype focuses on integration with local communities, partnerships with non-governmental organisations (NGOs) and employee ownership. Although this model is not purely profit-oriented, it does facilitate CE. For example, Globechain, a British product reuse platform, enables corporations and users to donate their unwanted equipment and materials to charities or social enterprises *via* its data technology, thus extending the product longevity. Jégou and Manzini (22) also show how an interactive community encourages residents to share resources and create mutual assistance.

Based on the above discussions, **Table I** summarises four categories of circular business models, including resource supplies, resource recovery, PSS and open innovation. Resource supplies and resource recovery focus on how companies replace virgin raw materials with renewable resources and turn them into the input of circular production. These models require the technology to help companies collect and extract available resources from recycled materials. PSS is a concept of multiple models, including product-oriented PSS, use-oriented PSS and result-oriented PSS. Products play a central role in product-oriented PSS and use-oriented PSS; these models extend product longevity by providing maintenance, sharing or leasing services (11). Result-oriented PSS is based on the idea of a performance economy, where 'ownership-based' business models are replaced with 'pay-per-use' models to reduce production and fulfil CE requirements (8, 23). As for open innovation, it encourages companies to work with different sectors or communities to expand their vision and resources. Knowledge and information sharing is the key to successful collaboration (14).

The above categories of business models show how companies or manufacturers can engage in circular production. To further clarify how they create and capture value, it is important to look at managerial practices. Through extensive studies of value creation in CE, Ünal *et al*. (18) have summarised six guiding principles for addressing managerial practices in circular business models, including (a) energy efficiency driven practices, (b) environmentally-friendly material usage-driven practices, (c) 'design for X' (DfX) practices (for instance, design for recycling, design for remanufacturing and reuse and design for disassembly), (d) support of all partners to develop awareness and new skills, (e) establishment of effective communication with stakeholders and (f) managerial commitment. **Figure 1** connects the proposed business model categories with the managerial practices and business strategies. The resource supplies and recovery models indicate 'what' resources (i.e., renewable, eco-friendly and biological materials and energy) should be utilised and restored in production processes. The PSS model implicates 'how' companies and designers elevate the design of circular products and interact with customers *via* service offerings. The open innovation model implies 'who' companies or manufacturers should work with to develop a new alliance and novel ideas and skills. Managerial commitment is the most important prerequisite that influences the attitudes and decisions of all stakeholders and actors in the business model (8).

In summary, the above strategies and practices help define the role, resources and value network of companies and stakeholders; they also provide basic guidance and direction for designing circular business models in the early design phase.

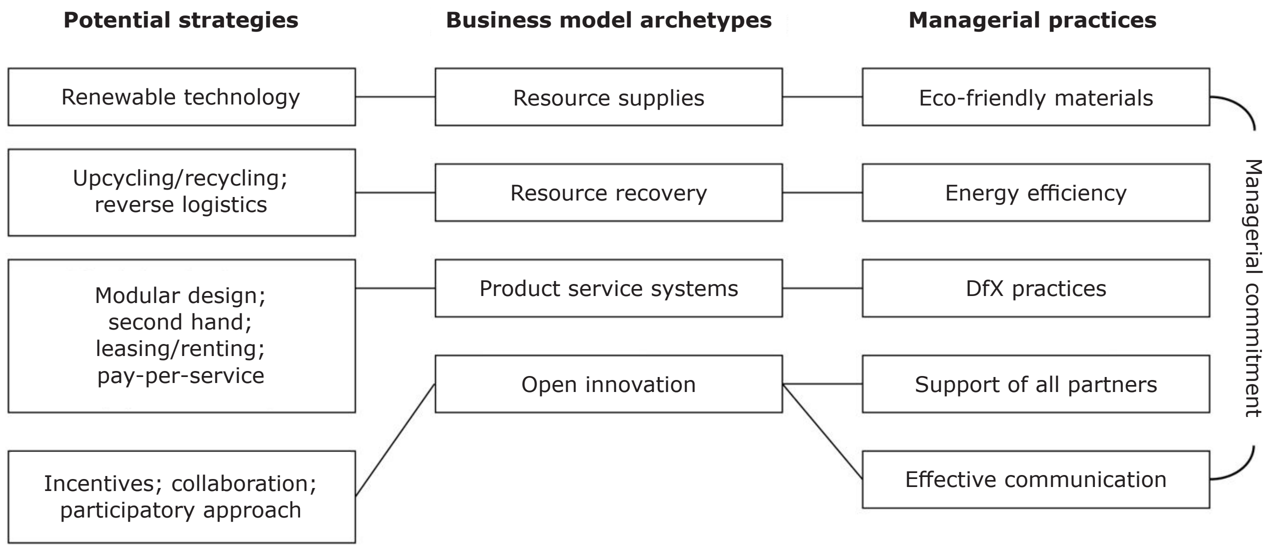

Fig. 1. Managerial practices and strategies in circular business models. Data are adapted from (8, 13, 18, 19, 20)

Barriers to Circular Business Models

New technology and processes for resource renewal can help improve circular production. However, how managerial commitment changes stakeholders' and customers' thinking and behaviour is actually the key to CE. As CE involves many complex elements and value networks, multiple challenges and barriers will emerge when designing circular business models.

Figure 2 presents both the inside and outside barriers to circular business models. By interviewing 153 business leaders and 55 government officials in Europe, Kirchherr *et al*. (15) classified CE barriers into four categories, including cultural, regulatory, market and technological barriers. Major cultural barriers are lacking consumer interest and awareness and a hesitant company culture. The circular system will not be closed if customers lack environmental concerns and are irresponsible about returning materials and components back to the cycle when products are no longer in use (8, 24). As shown in **Figure 2**, low consumer awareness and a lack of proper take-back systems will generate difficulties in material identification and separation, ensuring purity, distribution and transportation, which are great challenges for resource recovery (25). Furthermore, circular business models sometimes require radical innovation that accompanies investment risks (26). For example, since bio-based plastics are more expensive than fossil fuel based plastics, suppliers might fear for investments in providing circular resources (15). Even though the resources are available to support biological and technical cycles, companies still need more DfX practices and facilities to ensure the optimisation of material flows and keep the flexibility and upgradability of circular products (16).

CE has been considered as an enabler of sustainability. In turn, sustainability should not only address resource recovery and eco- economic decoupling but also deal with social issues such as safety, labour rights and community empowerment. Kirchherr *et al*. (5) reviewed 114 definitions of CE and found that only 13% of definitions referred to the holistic concerns of sustainability (i.e. considerations of economic, environmental and social dimensions). CE seems relatively silent on the social dimension (27). For example, the recycling of hazardous electronic waste (e-waste) should be carefully managed, but untrained workers in India carried out dangerous procedures without protective equipment and thus resulted in occupational health hazards (28). As many companies today have claimed to promote corporate social responsibility (CSR), social concerns should be incorporated into their business strategies. Therefore, the conflict between economic growth, labour rights and health is a serious issue that companies must address. For manufacturing companies, it is important to find new partnerships for building innovative and collaborative business models (6). Open innovation such as industrial symbiosis or alternative ownership lets multiple companies or partners share resources and information, but the protection of intellectual property rights and sensitive information might become a problem (29).

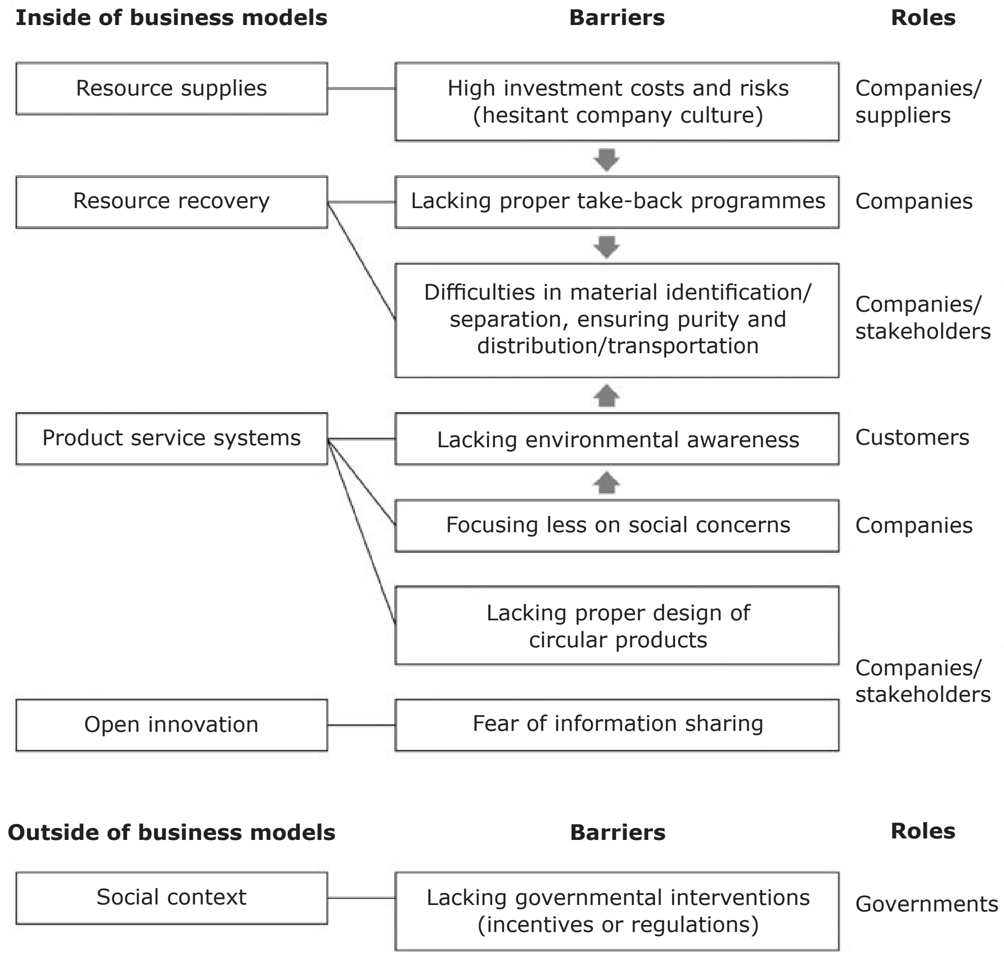

Fig. 2. Major barriers to circular business models. Data are adapted from (5, 15, 24, 25)

In addition to the above challenges inside the business model, regulatory barriers such as obstruction of laws and regulations and limited circular procurement could also obstruct circular manufacturing in some cases (15). Therefore, synergistic governmental interventions including incentives, regulations and penalties could be potential drivers that improve companies' and stakeholders' attitudes and behaviour.

As shown in **Figure 2**, most barriers have mutual influence on each other and they refer not only to firms but also to their suppliers, stakeholders, customers and even the government. To deal with these barriers, design and systems thinking with collaborative networks should be built to generate appropriate circular business models.

Improving Circular Business Models

Although CE is aimed at reducing waste and keeping materials at their highest utility, it is not always guaranteed to produce sustainable solutions. Pieroni *et al*. (13) have indicated that not all CE-oriented business models can accommodate sustainable principles. Below we point out three ways in which the misconception of circular manufacturing could lead to environmental degradation. These include improper or incomplete considerations of (a) the use of biodegradable materials, (b) modular design for product life extension and (c) upcycling for new production processes. These issues are respectively associated with the three business models discussed previously, namely resource supplies, PSS and resource recovery. The three models here represent different phases of circularity, including input, use and return of resources.

Circular supplies use materials extracted from discarded products or renewable or bio-based resources that can be returned to the natural environment (20). Generally, biodegradable materials are considered to be more environmentally friendly. However, the question remains uncertain when it comes to the life cycle assessment (LCA). For example, more and more companies have promoted the marketing of biodegradable shoes. Unfortunately, biodegradable materials actually make soles fragile and have a limited time for storage since they can be decomposed by oxygen and water; the broken shoes also cannot be repaired (30). Consequently, the average life cycle of biodegradable shoes is far shorter than traditional shoes, especially for island countries which are usually hotter and wetter. Customers thus purchase more products and create more production waste. Another example is biodegradable drinking straws used to replace disposable plastic straws. Biodegradable straws are often composed of paper or bio-based polylactic acid (PLA). However, paper straws consume more wood and water resources while PLA straws require a specific temperature and humidity to be decomposed. For countries that do not have available facilities to recycle PLA, PLA products will be treated as general waste and result in linear production (31). The above cases demonstrate that the effect of circular sourcing depends on policies and conditions of countries and regions. **Figure 3** shows that using bio-based or recyclable materials without considering the duration of products in social, geographical and institutional contexts might shorten the overall product life cycle and increase production or consumption waste, energy use and investment costs.

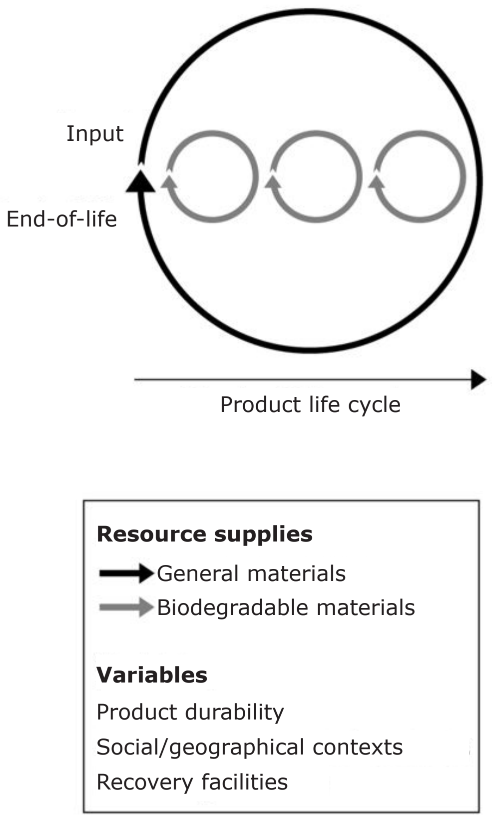

Fig. 3. The misuse of biodegradable materials could shorten the product life cycle

The second misconception occurs in DfX practices for circular products. When it comes to design for disassembly, modular design is regarded as the gateway to product life extension because easy disassembly makes products maintainable, repairable and upgradable on a modular basis (32). Proper modular design can be beneficial for recycling. However, according to Schischke *et al.* (33), modular product design does not necessarily meet the sustainable requirements since it needs more material consumption for producing multiple modules (see **Figure 4**). In addition, to take modular smartphones as an example, users might replace broken modules with new ones to extend the lifetime of devices, but they might also upgrade replaceable modules more frequently to keep pace with new technology features (33). In other words, modular design principles seem to resolve repairing and recycling issues, but the results still depend on consumption behaviour. Furthermore, product life extension requires service offerings for maintenance or recycling. Technical problems such as lacking repair shops or inconvenient services will decrease users' willingness to deal with their products. On the other hand, for electronic products phased out rapidly, some modules might be no longer available when customers need replacement. Accordingly, the design of circular products should consider not only the product flexibility but also collaborative consumption and supportive services that encourage customers to bring used products back to the cycle (34). Furthermore, product and process optimisation for resource efficiency is required to ensure the reduction of energy and material use, and it can be fulfilled by applying resource efficiency measures (REM) and redesigning manufacturing processes (16). In summary, the considerations of modular design should go beyond pure product innovation; they involve service strategies, customer behaviour and the attributes and conditions of the industry.

The third misconception involves upcycling. Upcycling makes use of discarded products or materials and transforms them into new products of higher value (35). Although this concept sounds promising, the definition of 'higher value' could be doubtful. Turning recycled plastic bottles into fashion clothes is a common example of upcycling. However, the high value of clothes comes from their design and brands, instead of the processed polyester. These bottles are still single-use plastics. The processed polyester does not return to the

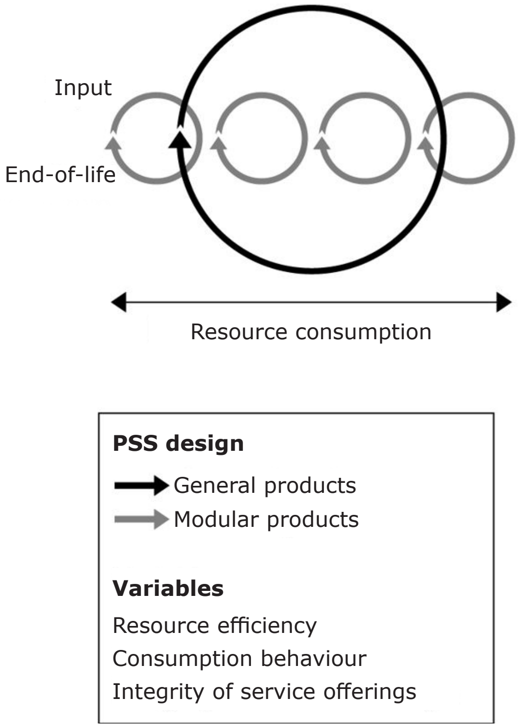

Fig. 4. The misuse of modular design could increase energy or material use

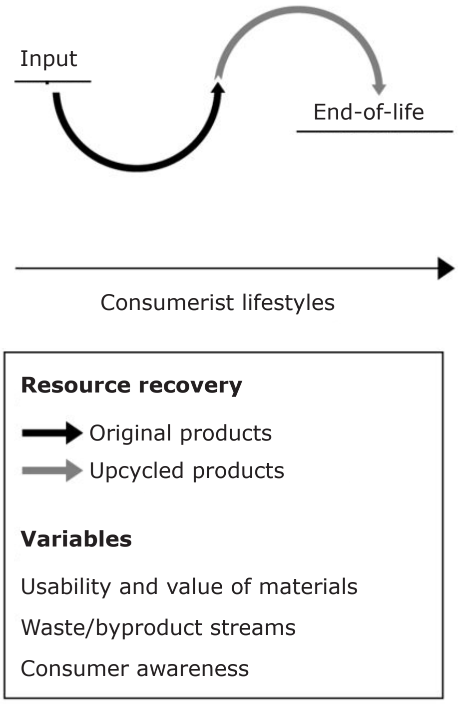

Fig. 5. The misuse of upcycling could foster consumerist lifestyles, resulting in loss of circularity

cycle of bottle manufacturing to decrease the use of fossil-based materials. It seems that the food and beverage industry passes a recycling problem on to the textile and fashion industry; it encourages guilt-free consumption since customers regard these clothes as a sustainable solution (36). Starting marketing campaigns based on circularity and sustainability thinking is important for promoting products and raising customers' environmental and ethical awareness (1). However, such a misconception runs the risk of actually opening the production cycle and leading to more consumerist lifestyles (**Figure 5**). At the moment, rethinking whether discarded products can better return to their original production processes and close the material loop is a top priority of resource recovery. For upcycling, the best situation is to derive resources from waste or byproduct streams of original products and turn them into new and practical products.

A New Framework for Circularity

Figure 6 presents a framework to summarise important considerations for resolving the above mentioned concerns. Although resource supplies, product life extension and resource recovery are related to different business models as well as different phases of product life cycle, these considerations are interconnected. For example, resource supplies have gone beyond the application of bio-based materials. They should consider whether the materials can actually help improve product life extension. Likewise, modular design approaches should emphasise more than just product life extension. Companies should develop comprehensive service systems to manage recycled modular products, byproducts and waste materials for resource recovery or further upcycling processes. These considerations are in accordance with the four main principles of circular products proposed by Urbinati *et al*. (16): (a) energy efficiency and usage of renewable sources of energy, (b) product and process optimisation for resource efficiency, (c) product design for circularity and (d) exploitation of waste as a resource. Moreover, all these considerations should be addressed simultaneously to ensure holistic systems thinking of circular business models.

On the other hand, the centre of **Figure 6** implies that circularity thinking should take social responsibility into account. Reducing material and energy use brings immediate economic benefits for companies, but how business models can contribute to social issues or how companies receive feedback or benefits by dealing with social concerns remains uncertain (2). Actually,

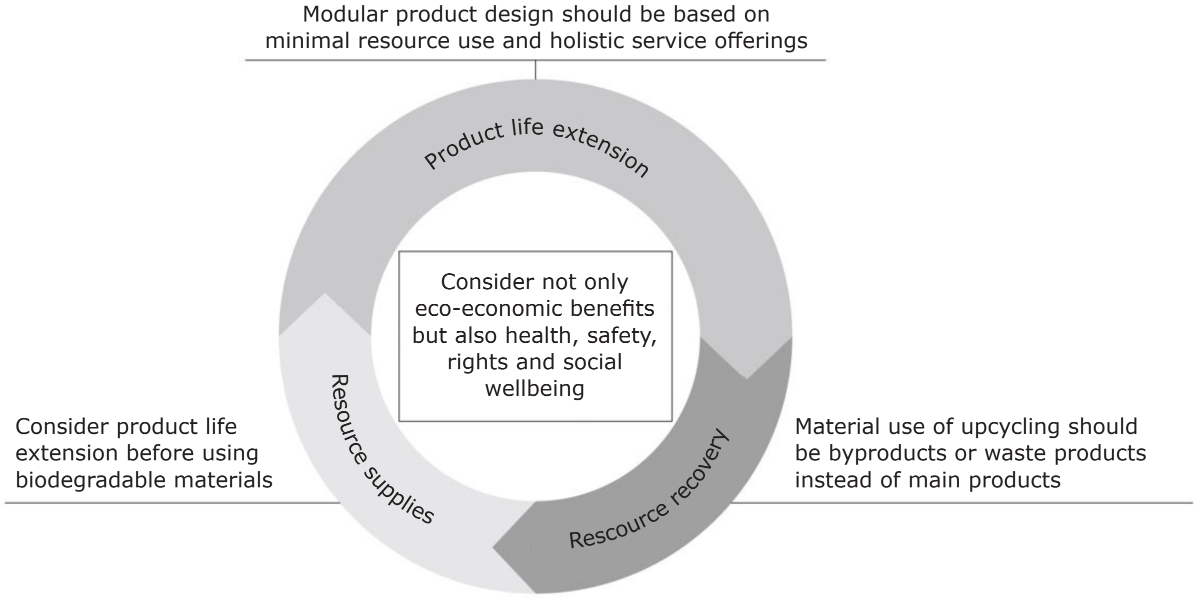

Fig. 6. A new framework for designing circular business models

incorporating CSR strategies into product-service offerings brings advantages beyond product sales. For example, participatory activities such as creative workshops or living laboratories encourage customers and the community to share their resources, lifestyles and experience of using products; these activities not only foster community empowerment but also provide companies first-hand information for improving their products and services (37). Furthermore, taking care of workers' and consumers' health and safety in any phases of product life cycle will create positive brand image for companies.

Opportunities for Circular Business Models Innovation

According to the framework presented in **Figure 6**, product life extension is the key to reducing rapid and excessive consumption for PSS and DfX practices; it is also a main purpose of resource supplies since circular manufacturing requires not just using natural and recyclable materials but also creating durable products to slow material and energy flows. For companies and stakeholders, it is important to create and capture value *via* extending product lifetime in their business models. Product life extension can be twofold: technological and operational. The technological aspect means exploring renewable and durable materials and using them to increase product longevity. The operational aspect implicates how companies influence product use, disposal and recycling through operational strategies. Developing supportive service offerings will aid companies in creating business opportunities. Strategies such as leasing, renting and pay-per-service have been presented in **Figure 1**. These strategies help manufacturers and product owners handle the whole life cycle of products and decide when they should be repaired, recycled or remanufactured. Companies such as Philips, The Netherlands, and Xerox, USA, have turned product-centric policies into solution-based schemes by providing their users rental and maintenance services in the business-to-business (B2B) model. The second-hand scheme has also received increasing attention in recent years. Companies such as LENA, The Netherlands, and Patagonia, USA, apply the ideas of fashion library and clothing recycling to rent, supply or exchange second-hand clothing to extend product longevity and decrease the use of raw materials.

It is clear that selling products is no longer a major way to earn revenues in circular business models. Manufacturing industries must rethink their strategies to reduce the environmental impact while opening new revenue streams (38). New business models with radical innovation and transition can be found in the performance economy, where companies sell information, knowledge and experiences in place of tangible products. DuPont de Nemours, USA, is an example transforming its business from chemistry manufacturer to safety management provider by offering biology and knowledge-intensive solutions (10). Here, information and communication technology (ICT) has become an important tool to support the interaction, management and monitoring systems of products and services (6).

On the other hand, open innovation based on the support and effective communication of all partners will boost business opportunities too. For instance, the Dell Reconnect program (Dell, USA) works with Goodwill Industries, USA, providing over 2000 sites in North America for recycling e-waste. The recycled e-waste is then transported to Wistron GreenTech, Texas, USA, to extract metals and sort plastic components for further processing (39). In addition to the industry alliance, working with customers intensively also helps create environmental and economic value. The concept of customer-to-manufactory (C2M) aids companies in designing products with their customers and building customisable intelligent manufacturing systems (40). Because companies provide customers with personalised products, they avoid producing useless functionality and components and thus save unnecessary resource waste. In addition, with the assistance of industrial internet of things (IIoT) and big data technology, companies can carry out online monitoring for products' health diagnosis and maintenance services (40). That is, understanding customers' personalised needs can help improve resource efficiency.

As discussed previously, managerial commitment is the backbone of circular business models which influences circular-oriented policies, objectives and awareness (18). To raise managerial commitment, cooperative initiatives such as CSR and global reporting initiatives are applied to change corporate culture and stakeholder attitudes (41). In addition, incorporating artistic thinking into corporate culture at the managerial level can promote behaviour change and environmental and social awareness and even extend the product life cycle (42). Support from governments such as incentives or proper tax policy is equally important to transform company and customer behaviour (15, 16). For instance, the Norwegian government levies environmental taxes on plastic producers and importers, but the taxes will be cut if companies recycle enough plastic bottles. Customers also pay a 'mortgage' for buying bottled products; only when they throw the used bottles into the 'mortgage machines' in supermarkets can they retrieve their money (43).

In summary, collaborative networks for open innovation should be built to increase the interaction between stakeholders for circulating resource use. Effective communication and management systems based on well-designed ICT are necessary for developing PSS solutions that reduce production costs and improve resource efficiency.

Conclusions

Circular business models encompass multiple concepts and approaches such as cleaner production, eco-efficiency, the performance economy and PSS; they involve various actors including suppliers, manufactures, customers and even the government. For such a complex system, any misconceptions or improper decisions shortening the product life cycle or expanding consumer demands will cause environmental degradation and unsustainable consumption.

To fulfil the goals and principles of CE, it is important to clarify the holistic context of sustainability, including the impact and value of economic, environmental and social dimensions. Systems thinking should be established to deal with the design of circular business models and the considerations should be addressed at both the micro level and the macro level. At the micro level, companies should conduct LCA and choose renewable and recyclable resources wisely based on product life extension. Renewing waste and byproducts and turning them into new and practical products are also important for resource recovery. In addition, comprehensive service offerings should be developed to reduce consumerism, support recycling mechanisms and extend product longevity. At the macro level, working with governments and different sectors, making good use of incentives and engaging in cooperative initiatives are needed to change production and consumption patterns as well as behaviour and attitudes towards circular lifestyles.

Because CE involves changes in the supply chain, stakeholder networks and product-service offerings, it could be a long-range undertaking. Improving CE business models based on systems thinking will guide policy makers to handling their goals and tasks properly. Only by reconciling short-term goals inside the business models with long-term goals outside the models can companies innovate in line with CE trends.

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