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**To cite this article:** Bening Mayanti & Petri Helo (2024) Circular economy in supply chain management: a framework for database tool development to enhance sustainability, International Journal of Environmental Studies, 81:4, 1962-1979, DOI: [10.1080/00207233.2024.2350757](https://doi.org/10.1080/00207233.2024.2350757)

**To link to this article:** <https://doi.org/10.1080/00207233.2024.2350757>



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Published online: 08 May 2024.



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# Circular economy in supply chain management: a framework for database tool development to enhance sustainability

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## ABSTRACT

The study surveys circular economy (CE) theoretical building blocks, conceptualisation, and practical implementation within the supply chain. A narrative review synthesises the knowledge and maps research in the CE field. There are six major building blocks: waste management, industrial ecology, bioeconomy, cradle to cradle, green supply chain management, and product-service system. The paper examines their role and their overlapping activity within the supply chain. This study also generates a database containing 43 circular strategies, based on different stages in the supply chain. Each strategy is marked by its contribution towards CE, such as resource conservation, narrowing the loop, slowing the loop, or closing the loop. The database can assist actors to implement possible circular actions and policy makers to formulate supportive legislation. This study contributes to the contention of CE and its implementation.

## KEYWORDS

Circularity; sustainability; reduce; repair; reuse; recycle

## Introduction

The conventional linear model of industrial development called ‘take-make-dispose’ is becoming irrelevant. We urgently need to implement a new economic model, viz., the circular economy (CE). This linear model entails resource losses throughout its product life cycle. About 21 billion tonnes of materials consumed during manufacturing are not physically included in the products; and only 40% of waste is reused, recycled or recovered [1]. McKinsey [2] predicted a yearly economic gain from CE practice in Europe of about €0.6 trillion for primary resources and €1.2 trillion for non-resource and externality benefits by 2030.

Boulding in 1966 posed the question of CE, concerning economic growth and environmental quality [3]: the ‘spaceman economy’. It was defined as an economy *in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form*

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*even though it cannot escape having inputs of energy.* The model also advocated reducing throughput, resulting in less production and consumption.

There is a rapid growth in studies of CE. Google Trends showed low interest in CE until 2013, and the search has consistently increased until now. On the scientific side, the search for the CE term on Scopus has resulted more than 4800 articles in 2021 which covered a broad spectrum. It was reported that CE played an important role throughout a product life cycle, and was a condition for sustainability [4]. Other implied that CE is about phasing out waste, focusing on the end-of-life (EoL) management [5]. These examples show that CE can mean many things because of pre-existing concepts that provide circular ideas. These pre-existing concepts may confusingly overlap.

Moreover, previous studies rarely discussed the practical implementation of CE. Hence, this paper considers these problems concerning CE conceptualisation and practical implementation. One objective is to contribute towards CE conceptualisation based on it being essential within the product life cycle. Another objective is to assemble various strategies to implement CE in different product life cycle stages. These two aims can be achieved by the following research questions (RQ): i. What are the main building blocks of CE? ii. What are the contributions of the CE building blocks to the product life cycle? iii. How can circularity be approached on a practical level?

## Material and methods

A narrative review was used in this study. It is intended for subjects that have been examined in diverse ways by researchers within different fields [6]. It offers a general view of the literature, the conceptualisation of new studies, or the re-conceptualisation of established research [7]. A narrative review can synthesise current knowledge, map a research field, and generate a timeline for a research topic [6]. Narrative review can act as a summary of studies offering a relatively comprehensive overview of the knowledge in that area [8].

The methods section for narrative review can help to make clear the main message of the review [8]. The study started with a pre-literature search to help formulate the objectives. The researchers formulated the RQs and then searched the Scopus database, since it has a wide coverage of journals, including natural science, social science, and interdisciplinary fields, including CE topics. There is a robust exporting feature [9]. The terms used to search the literature were related to the objectives of this study and Boulding's 'spaceman economy', such as 'circular economy', 'circular economy AND closed loop', 'resource flow', 'circular economy AND resource flow', 'closed loop supply chain', 'material flow', and 'waste management'.

The next step was article screening to select relevant articles. The screening process was conducted by applying inclusion criteria (language, type of article, subject area, number of citations), followed by abstract screening focusing on history, other pre-existing concepts, relevance to the product life cycle, and practical implementations. Using citation numbers as inclusion criteria has drawbacks since relevant articles can be excluded. Hence, a manual search was applied based on the relevant knowledge and references found in the articles. Next, the researchers gathered, assessed and synthesised articles on the concepts and practical implementations. The results will be characterised as CE building blocks (Section 3), CE conceptualisation (Section 4), and CE practice within the supply chain (Section 5).

## CE and related concepts

### *Waste management*

Waste management concerns activities related to waste control in order to protect the environment and human health, and conserve resources [10]. The approach is guided by the waste management hierarchy, an agreed list of desired activities, prioritising waste prevention [11]. This list identifies the most suitable option in managing waste that will result in the most ecological environmental outcome. Waste hierarchy emerged to replace open dumping that have led to land scarcity, hygiene issues, and toxicity [12]. Later, the waste hierarchy changed. Waste, once considered to be unwanted matter, is now regarded as a resource. The new model incorporates the cascade principle, in which economic value is considered when managing waste [13]. Cascading based on environmental and economic considerations aims for the spaceman economy by avoiding waste disposal in the first place and maximising its potential through reuse in the production process.

Even so, the implementation can be hampered by compromised benefits or unsupportive policies. Compromised benefit can be shown by recycling, which should be prioritised before energy recovery and landfilling, but has its own consequences. Transport from the collection point to the processing facility can be costly, and product disassembly may require an energy intensive process or use of toxic chemicals, resulting in higher overall environmental impacts than incineration [14]. From a policy standpoint, a policy that fails to clarify some terms (e.g. what is considered waste or a by-product) can lead to difficulty in applying a certain measure such as a failure to reuse certain materials directly in the industrial process because the legislation requires certain treatment before it goes back into the process [15]. If the benefit of following the waste hierarchy is uncertain, environmental life cycle costing (ELCC) can be applied and the results can assist decision-making [16].

### *Industrial ecology*

Industrial ecology (IE) is an economic model not isolated from other surrounding systems; it interacts with the biosphere and should be compatible with the natural ecosystem [17]. It covers the fields of industrial ecosystem, industrial metabolism (IM), industrial symbiosis (IS) [18]. The term 'industrial ecosystem' itself was conceived by Frosch & Gallopoulos [19]. They argued that industries needed to optimise material and energy, and use waste as raw material for other processes. They recognised that an ideal industrial ecosystem is not attainable but shifting towards this principle can reduce environmental impacts. Their views appeared at about the time that an alternative to the end-of-pipe approach was thought necessary. IE was meant to combine the end-of-pipe approach and waste prevention in a comprehensive approach.

Industrial ecology and industrial symbiosis are two terms that are used interchangeably. Li [18] stated that IE encompasses a broader notion, with IS being one of its parts. IS discovers ways to create a network of knowledge to enable the physical exchange of materials, by-products, and energy within geographic proximity to support higher levels of closed-loop ecosystems [20]. Although it is not possible to end waste completely, this exchange will reduce the sum of waste since

part of it will be input for others. The Eco-Industrial Park (EIP) is an example of IS implementation that exploits geographical proximity [21]. It is formed through a top-down approach from the government or a bottom-up initiative from industrial consortia. Mo Park et al. [20] maintain that the top-down approach begins with government supports in the form of regulation or finance, whereas a bottom-up initiative occurs organically because businesses just interact with one another on the basis of economic advantage.

### **Bioeconomy**

The bioeconomy – or the biobased economy- is economic activities that use renewable resources, including converting the resources and waste into value-added products [22]. Some scholars argue that economic growth is the priority in the bioeconomy, making it a challenge to promote social and environmental issues [23]. The bioeconomy comprises the use of biobased materials for food, feed, fuel, and pharmaceutical sectors, including multi-output production process and use through a cascading approach [24].

Although transitioning into a bioeconomy can provide economic benefits, the process poses some challenges. These include competition in using certain biomass for different purposes, translating research into scalable processes, creating viable business models, and creating socially accepted products [23]. To achieve a sustainable bioeconomy, principles of safeguarding, avoiding, and prioritising should be implemented [25]. Safeguards call for production processes that will not exceed the regenerative rate of a renewable resource and the availability of finite resources. Avoiding refers to the prevention of the production of nonessential products and the loss of biobased material [25]. Innovation is a prerequisite to ensuring that biobased material can be used entirely, e.g. biorefineries to avoid loss through multi-output production. Prioritising optimises the use of biobased resources and guides the production towards resolving the competition issue, where one resource can produce multiple products. Priority should be given to basic human needs, high-value products, and sectors with no sustainable alternatives [25,26].

The bioeconomy could contribute to a near closed-loop system through biorefineries and the cascade principle. It helps with resource limitation by using renewable materials and eliminating environmental risk once the material is returned to nature. Nevertheless, the need for additional energy can increase sharply and toxic substances can accumulate after cascading processes [26]. Considering the use of more sustainable energy sources and monitoring the output of products and by-products to ensure the optimum of overall outputs are essential. Muscat et al. [25] raised concern about food-feed-fuel competition, highlighting the importance of new metrics capturing resource and waste efficiency for the entire bio-based system, including a clear definition for the concept.

### **Cradle to cradle (C2C)**

The cradle-to-cradle (C2C) was developed based on the natural system's intelligence to break the conflict between the environment and economic growth [27]. The natural

system refers to regenerative biological systems where almost all waste goes back into the system as input [28]. Two systems keep material in the loop: biological metabolism and technical metabolism [27]. Biological metabolism returns the materials from products to the environment through diffuse pathways. The products are produced from renewable sources and become nutrients in producing new resources. The technical system recirculates non-renewable materials within the industrial system and become raw materials in manufacturing new products. The materials are repeatedly used in the technical cycle showing a reduced quality, and they finally flow back to the biological system [27].

Unlike eco-efficiency, which aims for 'less bad' with the main objective situated in the economy, C2C aims to balance economic, environmental, and social goals as triple top lines aiming for 'more good' practice [28]. It has three main principles: waste equals food, using clean energy, and celebrating diversity [27].

- 'Waste equates to food' aims at closing the loop through recirculating nutrients in other product life cycles. C2C focuses on designing a system where the waste output becomes an input in the other process.
- 'Using clean energy' is interpreted as consuming energy that can be regenerated such as wind, geothermal, photovoltaic/solar, hydro, and biomass. Currently, total dependence on renewable energy is still not possible since the supply can only provide intermediate-load [29].
- 'Celebrating diversity' mimics a natural ecosystem with various organisms. It could improve the system's resilience by avoiding one-size-fits-all solutions and designing products and systems based on local environments, cultures, and economics [30].

The cradle-to-cradle shares the closest characteristics with CE; some researchers use the terms interchangeably [31]. C2C also aligns with the Boulding principle of having a continuous cycle within the system. The drawbacks of C2C are the narrow focus on upcycling and waste elimination, which might not be relevant to all industries [32]. It also focuses on using infinite renewable energy sources and it seems to neglect the question of energy efficiency [30]. The renewable energy capacity is still insufficient; therefore, not considering efficiency can lead to higher energy consumption than the existing practice [30]. Moreover, Bjørn & Hauschild [33] reported that some composites could not be separated thermodynamically or require huge energy, increasing the impacts of unnecessary recycling processes. Additionally, assuming that biological nutrients are fundamentally good is misleading [34].

### **Green supply chain management**

Green Supply Chain Management (GSCM) originates from supply chain management and environmental management [35]. Supply chain is a network of actors involved in the movement of services, products, finances, and information to customers on both the upstream and downstream [36]. Mentzer et al. [37] distinguish between supply chain and supply chain management. They argue that the supply chain is an existing phenomenon in business, but supply chain management (SCM) is managed deliberately by actors in the network. SCM is a holistic strategy in synchronising traditional business functions

with inter-functional coordination within a company and inter-corporate coordination within a supply chain to improve the performance of every company [36].

GSCM emphasises balancing the economy and the environment [38]. In the GSCM, environment is an integral part of each stage in the supply chain, covering design, material sourcing, manufacturing, transportation, consumption, and EoL [35]. Government regulation, company initiative, consumer awareness and supplier requirements are the main drivers of GSCM, and reverse logistics (RL) can bridge collaboration between company and supplier [39]. The RL implies a backward logistics flow from the point of discarded products. The combination of forward and reverse logistics practices will promote the system to close the loop [40].

The major feature of GSCM and SCM is the network built among all actors. Supply chain network is rather complex, giving an actor a few different roles, e.g. a company can be a supplier and customer at the same time [36]. Inter-functional and inter-corporate coordination in the GSCM is the key in closing the loop through RL [40]. The basic flows in RL consist of four different processes [41].

- Product acquisition/gatekeeping. The products from end-users are acquired to be processed further in the next RL stage or repaired and returned to the customers.
- Collection. Acquired products that are not returned to customers are transferred to the collection facility.
- Sorting and inspection. Collected products are sorted based on the inspection result of their appearance and condition.
- Disposition. A decision is made whether the sorted products will be reused or disposed of. Reuse options include repair, reuse, remanufacturing, and recycling.

Some elements in the GSCM overlap other CE building blocks. Waste hierarchy is part of RL where the use of discarded products is optimised. Additionally, the broad coverage of GSCM that begins from the design phase correlates with C2C, where design plays a major role in ensuring that the products can be recirculated in biological or technical cycles.

### **Product service system**

Product service system (PSS) is *'a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer need'*. [42]. The ideal PSS is that the business provides functions for the customers, so that they do not need to own the product [43]. Service-oriented firms are paid to provide a service through the products so that they have the incentive to prolong the product lifespan, thus ensuring that the products are used intensively. The value proposition emphasises service delivery instead of ownership [37]. This approach allows companies to shift towards circularity by minimising throughput.

PSS can be grouped into four categories: product-oriented service, use-oriented service, result-oriented service [43].

- Product-oriented service relies on product sales, complemented with added service. The environmental benefit comes from prolonging the product's life through

maintenance to reduce materials and energy consumption. Examples of product-oriented services include maintenance contracts or take-back agreements.

- Use-oriented service. The provider owns the product which is intensively used through sharing or renting. The benefit is from the efficient use of materials and energy since fewer products are needed (e.g. car-sharing system or laundrettes).
- Result-oriented service sells the 'results' to the consumers. This model requires the company to develop a new way of function fulfilment (e.g. delivering a 'pleasant atmosphere' instead of air conditioning equipment).

Shifting to a complete service-system presents challenges for the consumer and business. It requires a cultural shift since society attaches status to the ownership of goods [42]. Business also faces challenges such as cultural inertia, where the current business already provides profit, difficulty assessing the trade-off between environmental and economic saving, and lack of regulatory support [44].

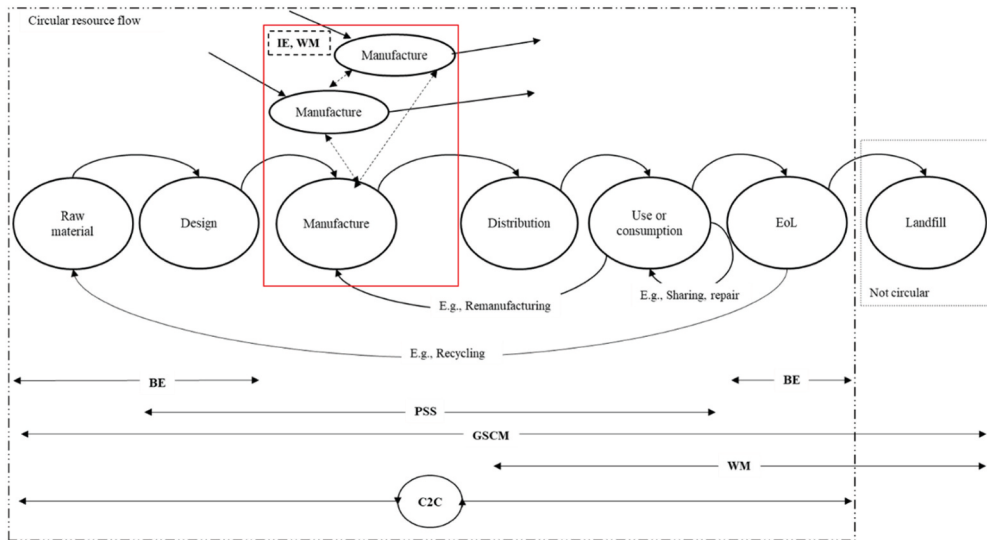
### Toward CE conceptualisation and definition

The concepts mentioned in the previous section embed the idea of a closed economic model. They have their own but intermeshed features, and they build a new broadly independent concept now known as CE. The breadth and novelty of CE allows it to build links between independent concepts. It is an umbrella concept: a notion or idea applied lightly to incorporate and account for various phenomena [45]. An umbrella concept can draw a relation between pre-existing concepts that were initially unrelated by converging on specific, shared characteristics. Not only does the definition of the umbrella concept suit CE, but its trajectory also started with the period of excitement [45]. This period marked the early days after the concept was coined. Scholars, policy makers, business, and other stakeholders were excited by the prospect of CE to fill the knowledge gap in maintaining economic growth without risking the environment. The CE concept, at present, seems to be under pressure from a new consumerist ideology [45].

Many researchers have started questioning the theory and practice of the CE concept. The absence of a consistent definition can lead to difficulties. It creates confusion in academic and political discussions that may affect national governments, hesitating to incorporate CE into their national policy [4,46]. It can also delay the transition to an ecological future: the premise brought about by CE is promising, but the lack of clarity of the concept, guidelines and examples, deter businesses from making a shift towards circularity [31].

### Circular economy throughout the product life cycle

CE building blocks have their own distinctive features and serve accordingly along the product life cycle. This study synthesised these features and showed how practices can contribute towards CE. These characteristics include resource conservation, narrowing the loop, slowing the loop, and closing the loop [37,47] – to use the language of Bocken *et al* [37]. Resource conservation ensures sufficient resources for the future and minimises the environmental impacts [48]. Narrowing the loop refers to resource efficiency,



**Figure 1.** CE building blocks related to resource flow in a circular product life cycle (IE: industrial ecology, WM: waste management, BE: bioeconomy, PSS: product service system, GSCM: green supply chain management, C2C: cradle to cradle).

slowing the loop deals with resource prolongation during the consumption stage, and closing the loop recirculates the resources back into the supply chain [37].

Figure 1 shows the interaction and role among CE building blocks regarding the resource flow throughout the product life cycle. As the CE building blocks overlap, the implementation of one concept will result in the indirect implementation other concepts. Example shown in the industrial ecology application in an eco-industrial park (red box in Figure 1). Organic waste from one company flows to another company as a resource and is transformed into valuable materials. The concept of exchanging material and energy between industries is based on the industrial ecology principle, but waste valorisation is a part of the bioeconomy, waste hierarchy, and C2C [26].

The diversity of the building blocks enables flexibility in implementation along the supply chain (Figure 1). The supply chain itself can be straightforward or complex where there are various parties, and each party has more than one role [36]. The network may be inside one company among different functions (inter-functional) and outside one company (inter-corporate), stretching from micro up to macro network [36]. This level of implementation is also discussed widely in CE, where it covers three different levels, viz., micro (individual firm or consumer), meso (eco-industrial system), and macro (city, province, region, nation) [5].

### CE enablers and definition

This study formulated four enablers: policy, research and technological development (RTD), business model, and consumers. Each enabler is key in one or multiple product life cycle stages. Their interaction is also essential to expedite CE.

The lack of proper policies impedes companies that may wish to adopt environment-friendly practices [49]. Currently, policies that support CE focus on the EoL stage to phase out waste [50]. Nonetheless, the policies concerning waste management have ambiguity, such as in the definition of waste and by-products or the variety of targets throughout the waste hierarchy [20]. Combination of different policy instruments will be needed to accelerate CE including environmental target, tax, incentive and subsidies, ecolabelling, etc.

RTD includes the use of more advanced technology (e.g. blockchain, internet of things (IoT), additive manufacturing, etc.) and data-driven decision-making to improve design, manufacturing, distribution, logistics, measurement and traceability [38]. Blockchain provides transparency and the history of product flow. IoT and big data enable companies to optimise their processes by using sensors to collect data and control their production lines. Nevertheless, barriers to adopt advanced technologies may include their non-availability and the adoption lag that may result from path dependency. Some technologies are not economically or technically viable on a commercial scale [51]. Other barriers are high investment costs, supply chain integration, lack of skills, resistance to change, and inability to understand the benefits [52].

Switching to CE will require new businesses model to create, deliver, and capture values. Six circular business models are based on product design through slowing and closing the loop [52]. The circular business model underlines the importance of delivering performance with ownership of the products remaining with the providers instead of selling the products [53].

- An access and performance model where the consumers do not own physical products (e.g. car-sharing).
- Extending product value by recovering from products by returning to the manufacturer (e.g. retailer accepting clothing return).
- Long-life model where the companies deliver long-life products and maintenance (e.g. durable products).
- Encourage sufficiency by delivering solutions to reduce consumption (e.g. energy service companies).
- Extending resource value by recovering value through recycling (e.g. recycling used tyre).
- Industrial symbiosis where residual outputs from one process becomes inputs for another (e.g. EIP Kalundborg).

Companies should rethink the way they obtain revenue while supporting efforts to retain products as long as possible in the consumption stage [43]. Providing reliable and accessible service centres is also important; otherwise, buying new products will be preferred over getting them repaired [37].

Consumers are also enablers in CE. The success of circular business model implementation relies on consumers' response to the new model. Ownership is still highly valued. Information about how the new business model works should be readily accessible [43], while consumers can still opt to reject the product in the form of service and choose the conventional model, i.e. ownership.

This study defined CE as a regenerative economic model focusing on resource flow and management through the use of renewable resources, resource efficiency, prolonging resources at the consumption stage, and recirculating resources from discarded products into the value chain, enabled by research and technology development, the business model, consumers, and policy.

## **Circular economy practices throughout the product life cycle**

### ***Circular practices and their related circularity characteristics***

Numerous circular practices have been implemented even before the term CE was coined. [Table 1](#) summarises these circular approaches that showed CE characteristics defined in Section 4.1, viz., resource conservation, resource efficiency (narrowing the loop), prolonging the resource life span (slowing the loop), and recirculating secondary resources into the production process (closing the loop). The ‘approaches’ refer to circular practices that can be adopted by actors, whereas ‘characteristics’ are types of circular contribution within supply chain.

This research described six product life cycle stages: raw material sourcing, product design, manufacturing, distribution, use, and EoL management. These stages are suitable for classifying the approaches ([Table 1](#)) since they cover the whole phases of resource or material flow, and are distinct stages. Moreover, they are considered common in the product life cycle [31]. The approaches, found in the literature, were various practices that can contribute towards CE through resource conservation, narrowing the loop, slowing the loop, and closing the loop.

[Table 1](#) is a database to guide actors in understanding CE and its practical actions where suppliers, manufacturers, transporters, consumers, and waste companies create ecosystem. Approaches to CE may vary with the organisation. Bigger organisations with more resources may implement multiple approaches. Smaller ones can start with one approach. This database could also assist policymakers to identify CE implementations that have not been supported sufficiently by the policies. Among 43 approaches in [Table 1](#), the circular characteristics of resource conservation comprised 20%, whereas narrowing, slowing, and closing the loop constituted 26%, 26%, and 28% of the practices.

The higher proportion of closing the loop indicated the close connection between waste management and CE. It could result from the long history of waste management implementation, including its waste hierarchy system. Waste management continues to evolve through different principles such as ‘polluter pays’ and extended producer responsibility where various policy instruments are employed [67].

### ***Circular economy implementation]***

It is unlikely for a system to be completely circular or non-circular. The variety of approaches available for implementing CE demonstrates its flexibility, while highlighting the challenge of achieving a fully circular system. Implementing a circular economy initiative can be top-down or bottom-up. A top-down initiative is characterised by the influence of command and control from the government. A bottom-up initiative is from

**Table 1.** CE approaches throughout product life cycle.

Product life cycle stage	CE approach		Circularity characteristics	Reference
	Approach	Description		
Raw material	Environmental stewardship	Sourcing responsibly managed raw material.	1	[47]
	Renewable alternative	Switching to renewable alternatives.	1	[24]
	Green procurement	Purchasing goods or services with lower impacts.	1	[54]
	Taxation	Taxing limited resources to encourage the use of less harmful alternatives.	1	[55]
	Eliminate distorting subsidies	Reducing subsidies that can harm the environment.	1	[55]
Design	Design for durability	Delivering durable products supported by maintenance.	3	[37]
	Design for modularity	Delivering independent parts which can be assembled, repaired and upgraded.	2, 3	[56]
	Design for disassembly	Delivering products that can be separated to support repair and recycling.	3, 4	[37]
	Prototyping and design for feedback	Creating prototypes and testing them to get immediate feedback before going full scale.	2	[50]
	Dematerialisation	Reducing materials in products without compromising the quality.	2	[57]
	Production on demand	Producing goods when demand is present.	2	[58]
	Life cycle assessment	Designing products by considering environmental impacts.	1	[59]
Manufacturing	Energy and material efficiency	Optimisation to decrease energy and material inputs.	2	[1]
	Energy recovery	Using energy waste or by-product.	4	[59]
	Material recovery	Using the residual value of products or material from the manufacturing process.	4	[37]
	Renewable energy	Using renewable energy.	1	[1]
	Industrial symbiosis	Exchanging knowledge, material, energy with manufacturers in the vicinity.	4	[18]
	Leasing service	Providing service to satisfy users' needs.	3	[43]
	Advanced technology	Switching to advanced technology (e.g. automation).	2	[60]
	Cascading	Converting biomass in a sequential manner to optimise resource use.	2	[24]
Distribution	Eco-labelling	Voluntary practice to signify environmental performance.	1	[59]
	Route and schedule optimisation	Determining the most efficient route and schedule.	2	[61]
	Reusable packaging or pallets	Using pallets multiple times.	3	[62]
Use or consumption	Leasing pallets	Renting pallets and leaving maintenance to the leasing companies.	3	[62]
	Sharing	Sharing the products among users.	3	[43]
	Leasing	Accessing products without having ownership.	3	[43]
	Repair and maintenance	Extending lifetime by restoring to an optimal function.	3	[37]
	Reuse	Extending lifetime through second hand use.	3	[37]
EoL	Repurpose	Using products for a purpose other than their original function.	3	[63]
	Digitalisation	Accessing products in digital form.	2	[53]
	Refurbish	Restoring and bringing old products up to date.	3	[64]
	Source separation	Separating waste to optimise value recovery.	4	[65]
	Dynamic waste collection	Planning a collection based on real-time bin occupancy.	2, 4	[66]

*(Continued)*

**Table 1.** (Continued).

Product life cycle stage	CE approach		Circularity characteristics	Reference
	Approach	Description		
	Route optimisation	Determining the most efficient route.	2, 4	[62]
	Take back program	Collecting, sorting, and processing waste to be manufactured.	4	[40]
	Environmental target	Setting policy target to improve EoL management.	4	[51]
	Recycling incentive	Providing incentives for recycling.	4	[56]
	Location optimisation	Optimising the location of disposal points.	4	[67]
	Remanufacture	Using parts of discarded products for new products with the same function.	3, 4	[64]
	Recycling	Recovering materials to obtain the same or lower quality.	4	[64]
	Energy recovery	Processing waste to recover energy.	1	[64]
	Energy recovery optimisation	Adjusting WtE parameter to improve efficiency.	1,2	[16]
	Cascading waste	Processing biowaste in a sequential manner to optimise value recovery.	2, 4	[13]

**Note:** 1: resource conservation, 2: narrowing the loop, 3: slowing the loop, 4: closing the loop.

individuals, organisations or civil society who demand greener actions, products, or legislation [47].

A top-down initiative starts with a global goal, which is specified at the lower level of the hierarchy. Examples can be found in countries such as China, the Netherlands, and Denmark which have formulated a national plan. China is a pioneer of top-down initiatives with the CE promotion law and regulation of electronic waste that was preceded by the cleaner production promotion law and the law on pollution prevention and control of solid waste [68]. The Netherlands has launched a government programme for CE to reduce the use of primary raw materials and set priorities for several sectors, including biomass, food, plastics, manufacturing industries, construction, and consumer goods [69]. The Danish government has developed a strategy to achieve circularity through digitalisation, design, consumption, and recycling [70].

At local levels, the top-down initiative includes an EIP. The government supports the EIP through subsidies and policies. This practice is common in South Korea, which has a long history of industrial ecology. Ulsan city became an industrial cluster to boost the economy in 1962. Later, the Ministry of the Environment imposed more stringent regulations in response to environmental problems caused by industrial activities [20]. The response by industries was to apply end-of-pipe measures that were insufficient. The government then required cleaner production and environmental management systems for single companies and the entire cluster as one unit while providing funding [20]. This symbiosis makes possible the reuse and treatment of solid waste, wastewater, sludge, energy, boiler water, and other materials.

The bottom-up initiative focuses on more specific goals of smaller entities. The bottom-up initiative will then be integrated into a higher-level goal or initiative. One example is the repair café movement in the Netherlands: groups of people with expert volunteers who helped repair everyday items [71]. This is now common worldwide. Another example is applying the business model of access

and performance which is applied through sharing or leasing [43]. Companies transitioning to provide services instead of selling their products may face consumer resistance. On a larger scale, the bottom-up initiative can also be found in EIP. This park formation may arise when different industries are close to one another e.g. the industrial park in Kalundborg, Denmark in the 1960s. A symbiosis occurred because of the need of companies that another nearby companies could fulfil. Later, other companies entered into agreements to exchange energy and materials when they realised the economic gain to be had from this arrangement [21].

Top-down circularity can create significant change through effective policy. It provides straightforward guidelines and unified goals because the initiative is centralised. Nonetheless, the framework from a top-down initiative can be difficult to translate to lower-level organisations with limited resources leading to unrealistic expectations. Since a bottom-up initiative is decentralised, any initiative that starts with the concerned parties tend to be more realistic, because it will be adjusted to their vision, resources, and capabilities. If, however, such an initiative is not aligned with the central authority's goals, the government will not support it. Nonetheless, these two types of initiatives are not mutually exclusive and can assist the transition towards CE.

## Conclusion

This paper aims to contribute to CE implementation by identifying its building blocks, characteristics, enablers, and role in the resource flow throughout the product life cycle. The synthesis of CE from pre-existing concepts that intermesh makes it an umbrella concept that helps to connect diverse ideas. Here, we define CE as *a regenerative economic model focusing on resource flow and management through the use of renewable resources, resource efficiency, prolonging resources at the consumption stage, recirculating resources from discarded products back into the value chain, enabled by research and technology development, business model, consumers, and policy.*

A database tool has been developed to assist CE implementation. The database contains 43 circular approaches covering different stages of the supply chain. The specific circular contributions, such as resource conservation, resource efficiency (narrowing the loop), resource prolongation (slowing the loop), and resource recirculation (closing the loop), were determined for each approach. The research findings have shown that closing the loop was the most common circular contribution throughout the supply chain.

This study has some limitations in both method and topic. A narrative review lacks systematic literature selection that could result in a biased outcome. Improvement can be applied by conducting systematic reviews covering a similar topic or using this study to navigate topic selection within the CE area. Future studies can expand similar research to understand the role of CE building blocks by incorporating specific products or systems, such as plastic or nutrient cycles. The applicability of the database can be tested by using real cases from different sectors.

## Author contributions

Both authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Bening Mayanti and Petri Helo. Bening Mayanti wrote the first draft of the manuscript, and Petri Helo commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

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## References

- [1] Ellen MacArthur Foundation, 2013, *Towards the circular economy vol. 1: An economic and business rationale for an accelerated transition* (London: EMAF).
- [2] McKinsey, 2015, *Growth within: A circular economy vision for a competitive europe* (London: McKinsey).
- [3] Boulding, K.E., 1966, The economics of the coming spaceship earth. In: H. Jarrett (Ed.) *Environmental quality in a growing economy: Resources for the future. Essays from the sixth RFF forum* (Baltimore: Johns Hopkins University Press), pp. 3–14.
- [4] Geissdoerfer, M., Savaget, P., Bocken, N.M.P. and Hultink, E.J., 2017, The circular economy - a new sustainability paradigm? *Journal of Cleaner Production* **143**, 757–768. doi: [10.1016/j.jclepro.2016.12.048](https://doi.org/10.1016/j.jclepro.2016.12.048)
- [5] Kirchherr, J., Reike, D. and Hekkert, M., 2017, Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling* **127**, 221–232. doi: [10.1016/j.resconrec.2017.09.005](https://doi.org/10.1016/j.resconrec.2017.09.005)
- [6] Snyder, H., 2019, Literature review as a research methodology: An overview and guidelines. *Journal of Business Research* **104**, 333–339. doi: [10.1016/j.jbusres.2019.07.039](https://doi.org/10.1016/j.jbusres.2019.07.039)
- [7] Juntunen, M. and Lehenkari, M., 2021, A narrative literature review process for an academic business research thesis. *Studies in Higher Education* **46**(2), 330–342. doi: [10.1080/03075079.2019.1630813](https://doi.org/10.1080/03075079.2019.1630813)
- [8] Ferrari, R., 2015, Writing narrative style literature reviews. *Medical Writing* **24**(4), 230–235. doi: [10.1179/2047480615Z.000000000329](https://doi.org/10.1179/2047480615Z.000000000329)
- [9] Iowa State University, 2022, Database comparisons. Available online at: <https://instr.iastate.libguides.com/c.php?g=901522&p=6492159> (accessed 28 August 2018).
- [10] Babbitt, C.W., 2017, Foundations of sustainable food waste solutions: Innovation, evaluation, and standardization. *Clean Technologies and Environmental Policy* **19**(5), 1255–1256. doi: [10.1007/s10098-017-1364-7](https://doi.org/10.1007/s10098-017-1364-7)
- [11] Deus, R.M., Battistelle, R.A.G. and Silva, G.H.R., 2017, Scenario evaluation for the management of household solid waste in small Brazilian municipalities. *Clean Technologies and Environmental Policy* **19**(1), 205–214. doi: [10.1007/s10098-016-1205-0](https://doi.org/10.1007/s10098-016-1205-0)

- [12] Zhang, C., Hu, M., Di Maio, F., Sprecher, B., Yang, X. and Tukker, A., 2022, An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. *Science of the Total Environment* **803**, 1–13. doi: [10.1016/j.scitotenv.2021.149892](https://doi.org/10.1016/j.scitotenv.2021.149892)
- [13] Do, Q., Ramudhin, A., Colicchia, C., Creazza, A. and Li, D., 2021, A systematic review of research on food loss and waste prevention and management for the circular economy. *International Journal of Production Economics* **239**, 1–22. doi: [10.1016/j.ijpe.2021.108209](https://doi.org/10.1016/j.ijpe.2021.108209)
- [14] Bjørn, A. and Strandesen, M., 2011, The cradle to cradle concept - is it always sustainable? Presented at the Life Cycle Management conference, Berlin, 28–31 August.
- [15] van Buren, N., Demmers, M., van der Heijden, R. and Witlox, F., 2016, Towards a circular economy: The role of Dutch logistics industries and governments. *Sustainability (Switzerland)* **8**(7), 1–17. doi: [10.3390/su8070647](https://doi.org/10.3390/su8070647)
- [16] Mayanti, B., Songok, J. and Helo, P., 2021, Multi-objective optimization to improve energy, economic and, environmental life cycle assessment in waste-to-energy plant. *Waste Management* **127**, 147–157. doi: [10.1016/j.wasman.2021.04.042](https://doi.org/10.1016/j.wasman.2021.04.042)
- [17] Erkman, S., 1997, Industrial ecology: An historical view. *Journal of Cleaner Production* **5**(1–2), 1–10. doi: [10.1016/S0959-6526\(97\)00003-6](https://doi.org/10.1016/S0959-6526(97)00003-6)
- [18] Li, X., 2018, Industrial ecology and industrial symbiosis - definitions and development histories. In: J. Taylor (Ed.) *Industrial ecology and industry symbiosis for environmental sustainability* (Cham: Springer International Publishing), pp. 9–38.
- [19] Frosch, R.A. and Gallopoulos, N.E., 1989, Strategies for manufacturing. *Scientific American* **261**(3), 144–152. doi: [10.1038/scientificamerican0989-144](https://doi.org/10.1038/scientificamerican0989-144)
- [20] Mo Park, J., Park, J.Y. and Park, H.-S., 2016, A review of the national eco-industrial park development program in Korea: Progress and achievements in the first phase, 2005–2010. *Journal of Cleaner Production* **114**, 33–44. doi: [10.1016/j.jclepro.2015.08.115](https://doi.org/10.1016/j.jclepro.2015.08.115)
- [21] Ehrenfeld, J. and Gertler, N., 1997, Industrial ecology in practice: The evolution of interdependence at Kalundborg. *Journal of Industrial Ecology* **1**(1), 67–79. doi: [10.1162/jiec.1997.1.1.67](https://doi.org/10.1162/jiec.1997.1.1.67)
- [22] European Commission, 2012, *Innovating for sustainable growth: A bioeconomy for Europe* (Luxembourg: European Commission).
- [23] McCormick, K. and Kautto, N., 2013, The bioeconomy in Europe: An overview. *Sustainability (Switzerland)* **5**(6), 2589–2608. doi: [10.3390/su5062589](https://doi.org/10.3390/su5062589)
- [24] Stegmann, P., Londo, M. and Junginger, M., 2020, The circular bioeconomy: Its elements and role in European bioeconomy clusters. *Resources, Conservation & Recycling: X* **6**, 1–17. doi: [10.1016/j.rcrx.2019.100029](https://doi.org/10.1016/j.rcrx.2019.100029)
- [25] Muscat, A., de Olde, E.M., Ripoll-Bosch, R., Van Zanten, H.H.E., Metze, T.A.P., Termeer, C. J.A.M., van Ittersum, M.K. de Boer, I.J.M., et al., 2021, Principles, drivers and opportunities of a circular bioeconomy. *Nature Food* **2**(8), 561–566. doi: [10.1038/s43016-021-00340-7](https://doi.org/10.1038/s43016-021-00340-7)
- [26] Carus, M. and Dammer, L., 2018, *The “circular bioeconomy” - concepts, opportunities and imitations* (Hürth: Nova Institut).
- [27] McDonough Braungart Design Chemistry, 2013, *Cradle to cradle certified product standard version 3.0* (Amsterdam: Cradle to Cradle Products Innovation Institute).
- [28] Braungart, M., McDonough, W. and Bollinger, A., 2007, Cradle-to-cradle design: Creating healthy emissions – a strategy for eco-effective product and system design. *Journal of Cleaner Production* **15**(13–14), 1337–1348. doi: [10.1016/j.jclepro.2006.08.003](https://doi.org/10.1016/j.jclepro.2006.08.003)
- [29] Ankrah, N.A., Manu, E. and Booth, C., 2015, Cradle to cradle implementation in business sites and the perspectives of tenant stakeholders. *Energy Procedia* **83**, 31–40. doi: [10.1016/j.egypro.2015.12.193](https://doi.org/10.1016/j.egypro.2015.12.193)
- [30] Geng, V. and Herstatt, C., 2014, *The cradle to cradle (C2C) paradigm in the context of innovation management and driving forces for implementation* (Hamburg: Hamburg University of Technology).
- [31] Geisendorf, S. and Pietrulla, F., 2017, The circular economy and circular economic concepts — a literature analysis and redefinition. *Thunderbird International Business Review* **60**(5), 771–782. doi: [10.1002/tie.21924](https://doi.org/10.1002/tie.21924)

- [32] Kopnina, H. and Padfield, R., 2021, (Im)possibilities of “circular” production: Learning from corporate case studies of (un)sustainability. *Environmental and Sustainability Indicators* **12**, 100161. doi: [10.1016/j.indic.2021.100161](https://doi.org/10.1016/j.indic.2021.100161)
- [33] Bjørn, A. and Hauschild, M.Z., 2013, Absolute versus relative environmental sustainability: What can the cradle-to-cradle and eco-efficiency concepts learn from each other? *Journal of Industrial Ecology* **17**(2), 321–332. doi: [10.1111/j.1530-9290.2012.00520.x](https://doi.org/10.1111/j.1530-9290.2012.00520.x)
- [34] Reijnders, L., 2008, Are emissions or wastes consisting of biological nutrients good or healthy? *Journal of Cleaner Production* **16**(10), 1138–1141. doi: [10.1016/j.jclepro.2008.02.003](https://doi.org/10.1016/j.jclepro.2008.02.003)
- [35] Srivastava, S.K., 2007, Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews* **9**(1), 53–80. doi: [10.1111/j.1468-2370.2007.00202.x](https://doi.org/10.1111/j.1468-2370.2007.00202.x)
- [36] Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G., et al., 2001, Defining supply chain management. *Journal of Business Logistics* **22**(2), 1–25. doi: [10.1002/j.2158-1592.2001.tb00001.x](https://doi.org/10.1002/j.2158-1592.2001.tb00001.x)
- [37] Bocken, N.M.P., de Pauw, I., Bakker, C. and van der Grinten, B., 2016, Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering* **33**(5), 308–320. doi: [10.1080/21681015.2016.1172124](https://doi.org/10.1080/21681015.2016.1172124)
- [38] Yu, Z., Khan, S.A.R. and Umar, M., 2022, Circular economy practices and industry 4.0 technologies: A strategic move of automobile industry. *Business Strategy and the Environment* **31**(3), 796–809. doi: [10.1002/bse.2918](https://doi.org/10.1002/bse.2918)
- [39] Diabat, A. and Govindan, K., 2011, An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling* **55**(6), 659–667. doi: [10.1016/j.resconrec.2010.12.002](https://doi.org/10.1016/j.resconrec.2010.12.002)
- [40] Van Engeland, J., Beliën, J., De Boeck, L. and De Jaeger, S., 2020, Literature review: Strategic network optimization models in waste reverse supply chains. *Omega (United Kingdom)* **91**, 1–22. doi: [10.1016/j.omega.2018.12.001](https://doi.org/10.1016/j.omega.2018.12.001)
- [41] Agrawal, S., Singh, R.K. and Murtaza, Q., 2015, A literature review and perspectives in reverse logistics. *Resources, Conservation and Recycling* **97**, 76–92. doi: [10.1016/j.resconrec.2015.02.009](https://doi.org/10.1016/j.resconrec.2015.02.009)
- [42] Tukker, A. and Tischner, U., 2006, Note from the field product-services as a research field: Past, present and future. Reflections from a decade of research. *Journal of Cleaner Production* **14**(17), 1552–1556. doi: [10.1016/j.jclepro.2006.01.022](https://doi.org/10.1016/j.jclepro.2006.01.022)
- [43] Tukker, A., 2015, Product services for a resource-efficient and circular economy e a review. *Journal of Cleaner Production* **97**, 76–91. doi: [10.1016/j.jclepro.2013.11.049](https://doi.org/10.1016/j.jclepro.2013.11.049)
- [44] Annarelli, A., Battistella, C. and Nonino, F., 2016, Product service system: A conceptual framework from a systematic review. *Journal of Cleaner Production* **139**, 1011–1032. doi: [10.1016/j.jclepro.2016.08.061](https://doi.org/10.1016/j.jclepro.2016.08.061)
- [45] Blomsma, F. and Brennan, G., 2017, The emergence of circular economy: A new framing around prolonging resource productivity. *Journal of Industrial Ecology* **21**(3), 603–614. doi: [10.1111/jiec.12603](https://doi.org/10.1111/jiec.12603)
- [46] Ghisellini, P., Cialani, C. and Ulgiati, S., 2016, A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production* **114**, 11–32. doi: [10.1016/j.jclepro.2015.09.007](https://doi.org/10.1016/j.jclepro.2015.09.007)
- [47] Bennett, N.J., Whitty, T.S., Finkbeiner, E., Pittman, J., Bassett, H., Gelcich, S. and Allison, E. H., et al., 2018, Environmental stewardship: A conceptual review and analytical framework. *Environmental Management* **61**(4), 597–614. doi: [10.1007/s00267-017-0993-2](https://doi.org/10.1007/s00267-017-0993-2)
- [48] Umweltbundesamt, 2019, Resource use and its consequences. Available online at: <https://www.umweltbundesamt.de/en/topics/waste-resources/resource-use-its-consequences> (accessed 1 December 2021).
- [49] Hartley, K., van Santen, R. and Kirchherr, J., 2020, Policies for transitioning towards a circular economy: Expectations from the European union (EU). *Resources, Conservation and Recycling* **155**, 1–10. doi: [10.1016/j.resconrec.2019.104634](https://doi.org/10.1016/j.resconrec.2019.104634)

- [50] Papahristou, E. and Bilalis, N., 2017, Should the fashion industry confront the sustainability challenge with 3D prototyping technology. *International Journal of Sustainable Engineering* **10**(4–5), 207–214. doi: [10.1080/19397038.2017.1348563](https://doi.org/10.1080/19397038.2017.1348563)
- [51] Basu, P., 2013, Design of biomass gasifiers. In: R. Zanol (Ed.) *Biomass gasification, pyrolysis and torrefaction second edition* (London: Elsevier Inc), pp. 249–313.
- [52] Raj, A., Dwivedi, G., Sharma, A., Lopes de Sousa Jabbour, A.B. and Rajak, S., 2020, Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics* **224**, 1–17. doi: [10.1016/j.ijpe.2019.107546](https://doi.org/10.1016/j.ijpe.2019.107546)
- [53] Edwards, J., Othman, M., Burn, S. and Crossin, E., 2016, Energy and time modelling of kerbside waste collection: Changes incurred when adding source separated food waste. *Waste Management* **56**, 454–465. doi: [10.1016/j.wasman.2016.06.033](https://doi.org/10.1016/j.wasman.2016.06.033)
- [54] Aldenius, M. and Khan, J., 2017, Strategic use of green public procurement in the bus sector: Challenges and opportunities. *Journal of Cleaner Production* **164**, 250–257. doi: [10.1016/j.jclepro.2017.06.196](https://doi.org/10.1016/j.jclepro.2017.06.196)
- [55] Söderholm, P., 2011, Taxing virgin natural resources: Lessons from aggregates taxation in Europe. *Resources, Conservation and Recycling* **55**(11), 911–922. doi: [10.1016/j.resconrec.2011.05.011](https://doi.org/10.1016/j.resconrec.2011.05.011)
- [56] Allwood, J.M., Ashby, M.F., Gutowski, T.G. and Worrell, E., 2011, Material efficiency: A white paper. *Resources, Conservation and Recycling* **55**(3), 362–381. doi: [10.1016/j.resconrec.2010.11.002](https://doi.org/10.1016/j.resconrec.2010.11.002)
- [57] Van Ewijk, S. and Stegemann, J.A., 2016, Limitations of the waste hierarchy for achieving absolute reductions in material throughput. *Journal of Cleaner Production* **132**, 122–128. doi: [10.1016/j.jclepro.2014.11.051](https://doi.org/10.1016/j.jclepro.2014.11.051)
- [58] van Renswoude, K., ten Wolde, A. and Joustra, D.J., 2015, *Circular business models - part 1: An introduction to IMSA's circular business model scan* (Amsterdam: IMSA).
- [59] Damen, M.A., 2012, *A resources passport for a circular economy: An assessment of the possible content and format of a resources passport in order to successfully contribute to the achievement of the circular economy* (Utrecht: Utrecht University).
- [60] Esposito, M., Tse, T. and Soufani, K., 2018, Introducing a circular economy: New thinking with new managerial and policy implications. *California Management Review* **60**(3), 5–19. doi: [10.1177/0008125618764691](https://doi.org/10.1177/0008125618764691)
- [61] Dadhich, P., Genovese, A., Kumar, N. and Acquaye, A., 2015, Developing sustainable supply chains in the UK construction industry: A case study. *International Journal of Production Economics* **164**, 271–284. doi: [10.1016/j.ijpe.2014.12.012](https://doi.org/10.1016/j.ijpe.2014.12.012)
- [62] Bilbao, A.M., Carrano, A.L., Hewitt, M., Thorn, B.K. and Guiffrida, A.L., 2011, On the environmental impacts of pallet management operations. *Management Research Review* **34** (11), 1222–1236. doi: [10.1108/01409171111178765](https://doi.org/10.1108/01409171111178765)
- [63] Potting, J., Hekkert, M., Worrell, E. and Hanemaaijer, A., 2017, *Circular economy: Measuring innovation in the product chain* (The Hague: PBL).
- [64] Ryyänen, T. and Hyyryläinen, T., 2018, Digitalisation of consumption and digital humanities - development trajectories and challenges for the future. In: *CEUR Workshop Proceedings 2084*, (Helsinki), pp. 363–371.
- [65] McLeod, F., Erdogan, G., Cherrett, T., Bektas, T., Davies, N., Speed, C., Dickinson, J. and Norgate, S., et al., 2013, Dynamic collection scheduling using remote asset monitoring. *Transportation Research Record* **2378**(1), 65–72. doi: [10.3141/2378-07](https://doi.org/10.3141/2378-07)
- [66] Erfani, S.M.H., Danesh, S., Karrabi, S.M. and Shad, R., 2017, A novel approach to find and optimize bin locations and collection routes using a geographic information system. *Waste Management and Research* **35**(7), 776–785. doi: [10.1177/0734242X17706753](https://doi.org/10.1177/0734242X17706753)
- [67] Lindhqvist, T., 2000, *Extended producer responsibility in cleaner production: Policy principle to promote environmental improvements of product systems* (Lund: Lund University).
- [68] Yuan, Z., Bi, J. and Moriguchi, Y., 2006, The circular economy: A new development strategy in China. *Journal of Industrial Ecology* **10**(1–2), 4–8. doi: [10.1162/108819806775545321](https://doi.org/10.1162/108819806775545321)

- [69] The Ministry of Infrastructure and the Environment and The Ministry of Economic Affairs, 2016, *A circular economy in the Netherlands by 2050* (The Hague: Government of the Netherlands).
- [70] Ministry of Environment and Food, Ministry of Industry and Business and Financial Affairs, 2018, *Strategy for circular economy - more value and better environment through design, consumption, and recycling* (Copenhagen: The Danish Government).
- [71] Repair Cafe, 2015, Toss it? No way! Available online at: <https://repaircafe.org/en/> (accessed 9 December 2021).