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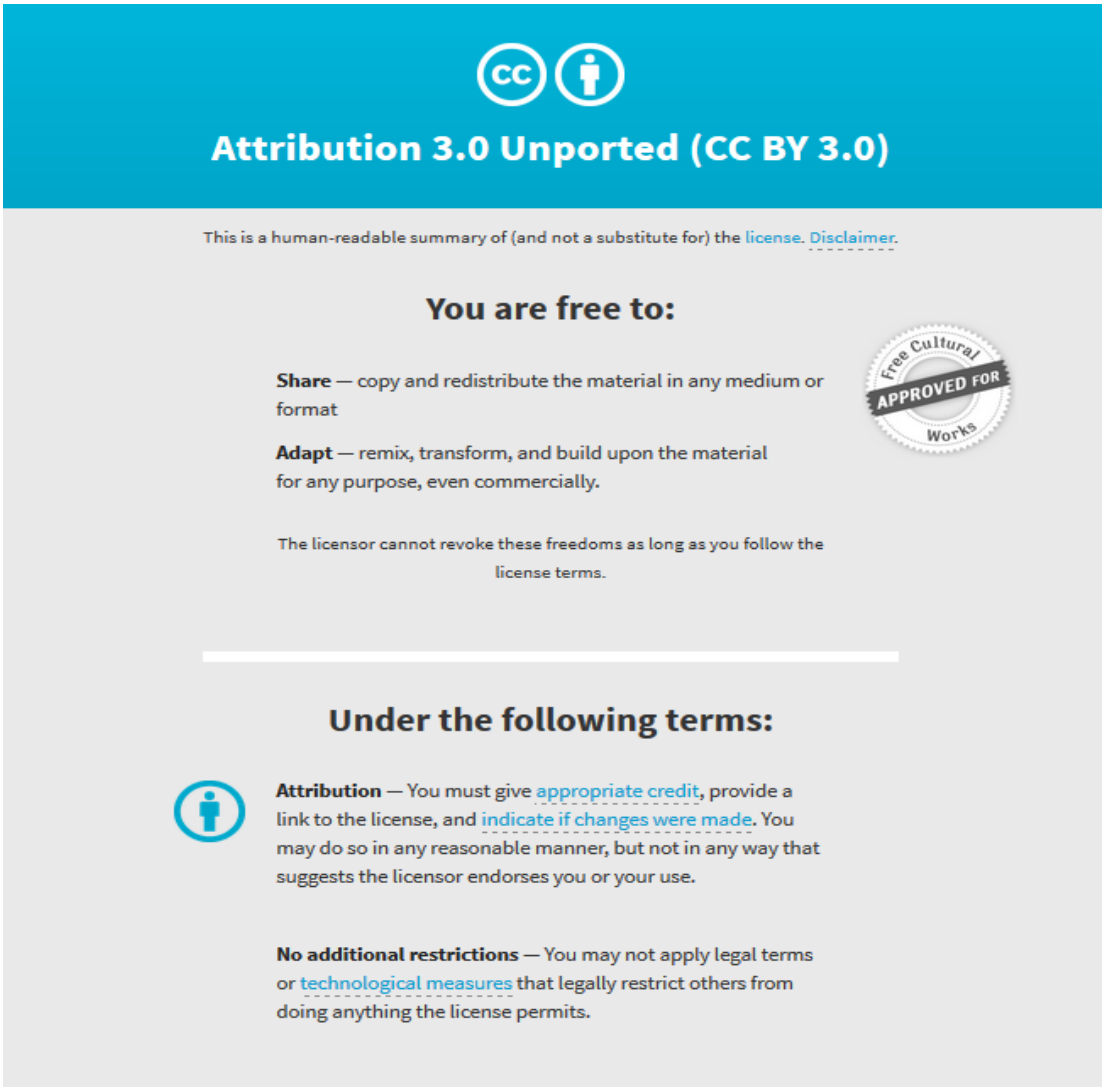

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Article

Business Model Innovation to Create and Capture Resource Value in Future Circular Material Chains

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Abstract: This article briefly discusses the origins and development of the business model concept resulting in a high level definition. Against this backdrop, frameworks from the literature around green business models with examples of green business models and the business model innovation process are presented. The article then discusses the origins and meaning of different "green" concepts relevant for the circular value chain concluding with a high level definition. The article finally outline the process by which a business model for a circular value chain can be developed taking into account the social dilemma that exist in these type of situations. The article concludes with the specific questions that need to be answered in order to create an appropriate business model for a circular value chain.

Keywords: Business Model Innovation, circular economy, closed-loop economy, industrial ecology, industrial metabolism, industrial symbiosis, integrated chain management

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The objective of this paper is to provide a set of questions that will enable business model innovation, within the framework of circular value chains, which maximises access to multiple profit pools.

1. Business Model Innovation

Business model innovation falls under the heading of value appropriating innovations as either a standalone innovation or as a necessary complement to value creating innovations [1–5]. The increasing relevance of business model innovation can be seen in domains like airlines where new business models have increased their share fivefold over the last 30 years, in retailing where new

business models have doubled their share over the last 30 years and in several different studies by e.g., IBM on CEO priorities—which have increasingly focused on business model innovation over the last 10 years frequently driven by the emergence of new technologies, the need to manage maturing businesses and markets, the need to better leverage underutilised resources and capabilities, or the need to respond to regulatory, legal or customer preference changes. This means that firms compete through their business models and hence, a superior business model becomes a source of competitive advantage [6].

The business model concept started to be defined, content-wise, in the early 1990s, with the first article using the defined concept of business models written by Forge [7]. The key articles that followed chronologically and that included a set of defined dimensions for a business model were [8–41].

It was also in 2006 that IBM carried out a global study based on interviews conducted with 765 CEOs from leading corporate and public sector organisations worldwide and found that 65 percent of leaders anticipated a fundamental change in their industries over the following two years. As a result, many CEOs claimed to be undertaking innovations in operations and/or products and services. The most significant result of the study was that the financial outperformers put twice as much emphasis on business model innovation as did the underperformers [42]. In another study by IBM around the same time it was found that business model innovation can have a far more profound effect on profitability than any other type of innovation [43].

It is clear that these findings influenced the further work on understanding business models and this can be seen in the definitions that were presented for the constituent parts of a business model in the work published from 2007 onwards as well as an increasing set of questions raised around the business model concept by the following important publications [4,6,44–78].

The definitional insights from this previous work is summarised by Arend [79] when he defines the business model on a high level of abstraction as how an organization creates value by transforming and transferring information, physical resources, private, public or other categories of goods through the deployment of resources, capabilities, relationships, structures and other factors, driven by an identifiable monetary or operational aid sourced from customers, partners, volunteers, governments or other stakeholders. This clarifies why the specific dimensions of a business model will vary by sector, firm and activity-system and hence there is no specific set of dimensions that will be relevant across many firms.

Arend [79] also outlines five areas of concern as relates to the business model concept from a theoretical perspective:

- The first concern is the unresolved overlap of the business model idea with established concepts, levels of analysis, theories, *etc.*;
- The second concern is a lack of independence of the concept from other levels of analysis. The business model concept is a concept that varies depending on the firm, the industry, or the nation in which it is being employed as well as varying over time;
- The third concern relates to whether a business model can define a unique (and informative) level of analysis;
- The fourth concern is the lack of any consistent definition of the term "business model." The current variation in definitions appears too wide (e.g., includes contradictory statements).

Without some level of consensus regarding the idea and its drivers and boundaries, it is difficult to make headway on its theoretical value;

- The fifth concern is a lack of solid empirical support thus far. This does not mean that there is none just that the complexity of isolating and linking it causally is hampered by the second and fourth concern above.

One key insight is that the business model concept is useful in the way it breaks down high level strategies into specific managerial tasks for businesses grounded in new technologies or new approaches, especially if they have challenges as relates to making money [80], and enable effective communications around how technology is translated into value and then into profit [26]. This conclusion is supported by the conceptual ease by which successful new business approaches like those brought to market by e.g., Apple, Ryan Air, Google, Twitter, Facebook, *etc.*, can be explained using the business model concept.

A business model is made up of a set of dimensions and business model innovation means an innovation in at least one of these dimensions. A framework for green business models is outlined in the Figure 1 below.

Figure 1. Framework for green value creation and realisation (adapted from [81]).

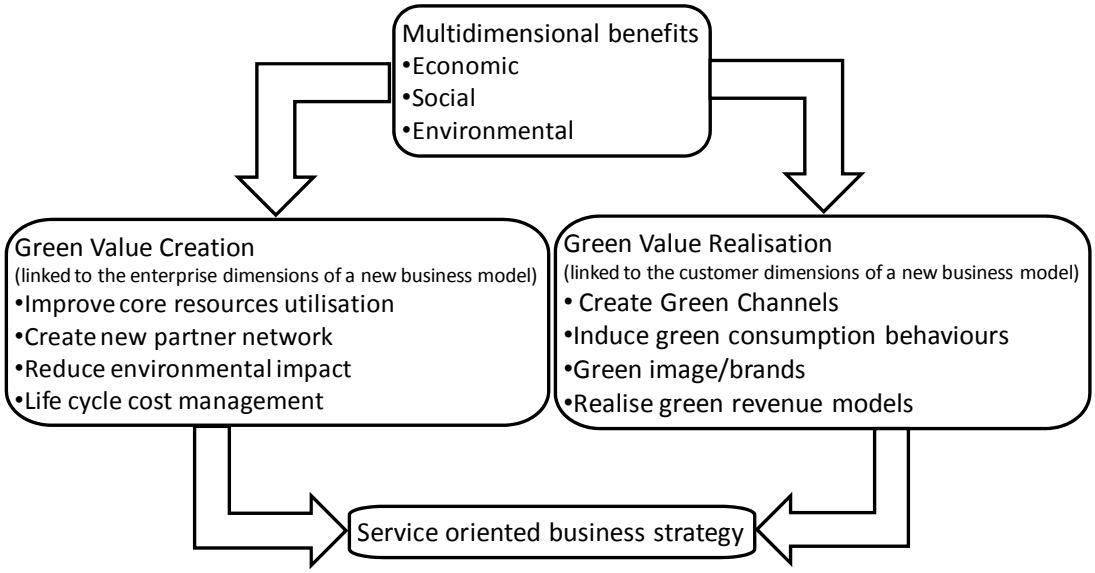
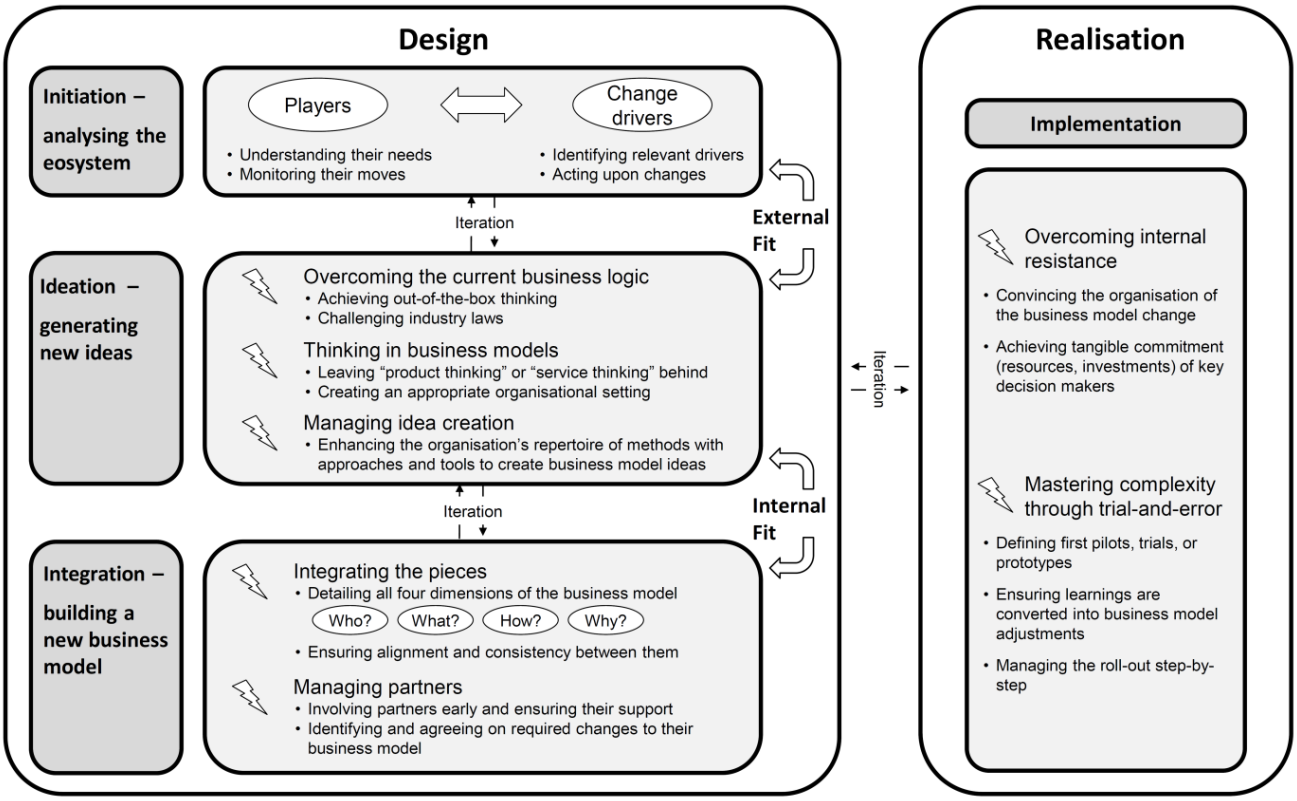


Figure 1 illustrates that green value creation is about more than money, that there are two simultaneous and linked problems that have to be solved: That of creating multidimensional value for stakeholders and that of appropriating as large a share as possible of the monetary equivalent of this value from the paying customer or paying stakeholders; and that this normally requires a service oriented approach which means e.g., that manufacturing firms entering this domain must servitize.

An integrative framework for business model innovation is outlined in the Figure 2 and can be complemented with practical guidelines from Bisgaard *et al*. [82].

Figure 2. Phases of the business model innovation process and their key challenges [83].



The figure above illustrates the iterative process with the key steps (analysing, ideation, integration and implementation) as well as the key challenges to be overcome in the business model innovation process.

Since the specific business model dimensions are context specific and vary over time we will only illustrate an example of business model dimensions as outlined by Roos [4] based on an empirical study of business models in manufacturing firms. Business model innovation requires the change in at least one of the constituent dimensions of a given business model (business model dimensions for a manufacturing firm is given in Table 1).

Table 1. Example of business model dimensions for manufacturing firms ([5], p. 104).

1.	Positioning of THIS business within the company's strategy
2.	Description of the Product-Service-System/Solutions offering
3.	Identification of target customer segments, target consumer segments and other definitive stakeholders
4.	Value proposition for each of the target customer segments, target consumer segments and other definitive stakeholders
5.	Description of how the target customer segments, target consumer segments and other definitive stakeholders that capture value from the offering
6.	What competitive advantage does the offering enable or contribute to within the target customer segments, target consumer segments and other definitive stakeholders
7.	Value attribute, attribute preference and attribute performance for each of the target customer segments, target consumer segments and other definitive stakeholders
8.	What requirements must be fulfilled by the target customer segments, target consumer segments and other definitive stakeholders in order to be able to benefit from the offering

Table 1. *Cont.*

9. Description of how the Product-Service-System/Solutions offering should be implemented at the target customer segments, target consumer segments and other definitive stakeholders to ensure the targeted benefits (value)
10. Place, role and strategy of THIS business in the business ecosystem of which it is part
11. Technology base of the Product-Service-System/Solutions offering
12. Design base of the Product-Service-System/Solutions offering
13. Art base of the Product-Service-System/Solutions offering
14. Counselling (Hermeneutic) base of the Product-Service-System/Solutions offering
15. Outgoing Logistics and Distribution Channel choice for each of the target customer segments, target consumer segments and other definitive stakeholders
16. Incoming Logistics and Supply Chain Choice
17. Relationship width, depth and frequency for each of the target customer segments and other definitive stakeholders
18. Value Configuration (Value Chain, Value Shop, Value Network) and associated transaction and coordination cost issues
19. Resources, Competitive Advantage and Resource Deployment Structure (IC Navigator)
20. Cost structure due to strategic choices and identification and management objectives for associated economic value added drivers as well as bankruptcy predicting indicators
21. Revenue Models with focus on accessing multiple profit pools and maximising the number of revenue streams/pricing logic combinations aimed at achieving an economic value added for the business exceeding the revenue stream from its primary offering

This can be compared to the green business models identified by [84] as outlined in Table 2:

Table 2. Identified types of green business models ([84], pp. 30–31).

• **Greener products/processes based business models** provide the buyer with economic and environmental benefits through their use. This group contains a very diverse set of innovative products and processes applied in companies that achieve better environmental performance by, for example, saving resources and minimising emissions and waste.
• **Waste regeneration systems**, which are based on the re-use or recycling of waste as new products. This business model is focused on valuing waste, or using it as an input for a new product to be sold on the market.
• **Alternative energy-based systems** include a wide range of applications, products and systems based on renewable energy deployment. Business models using these systems can be focused on sales or offer a technical service.
• **Efficiency optimisation by ICT**—ICT technologies provide a wide range of solutions for energy and resource use control, establishment of smart grids, cloud computing, as well as teleconferencing and online shopping. ICT solutions-based models generally can be of two types: ICT service-based models, which include companies ensuring the monitoring of the consumption or redistribution of resources; and ICT products-based models, which are centred on the ICT systems or software and hardware packages that are offered and sold to customers. Once the system is installed, customers learn to use it to monitor their resource use.

Table 2. *Cont.*

- **Functional sales and management services models** focus on providing the functions and benefits of the product instead of the physical product itself. The simplest models are based on delivering services using materials and techniques that are superior to alternatives from an environmental perspective. In the more developed models, instead of paying for the product itself the customer pays for the functional performance of the product. The service provider takes over the control of the use of the product. Therefore, the producer has an incentive to improve the output yield and to extend the life-span of the product by making it more durable, reducing the need for spare parts, making it more energy efficient and improving maintenance. These models can also encourage the remanufacturing and re-use of the product.
- **Innovative financing schemes** represent long- and medium-term investment arrangements often focused on the improvement of environmental performance, which is also linked to economic performance. The best known example is ESCO (Energy Saving Companies) providing energy efficiency and other services and taking on the risk of the performance of the project or product. Compensation and profits for the service providers are tied to energy efficiency improvements and savings in energy costs. The DBFO (Design Build Finance Operate) model is a similar contractual relationship between a customer and a private contractor. It is often used in construction projects that require long-term investments.
- **New sustainable mobility systems** are alternative transportation schemes with a reduced environmental impact. Examples include more efficient and cleaner public transport systems, car or bike-sharing/renting models and schemes for increasing the application of electric or bio-gas based vehicles.
- **Industrial symbiosis** involves sharing the use of resources and by-products amongst industrial actors on a commercial basis through inter-firm recycling linkages. In industrial symbiosis, traditionally separate industries engage in an exchange of materials and energy through shared facilities. The waste of one company becomes another's raw material.
- **Green neighbourhoods and cities** consist of complex and geographically wide systems combining many eco-innovative solutions and involving a large range of actors. Green neighbourhoods and cities are designed with the aim of minimising both inputs of energy, water and food, and waste outputs of heat, air, water and other pollution. Power comes mainly from renewable sources of energy. The main objective is to create the smallest possible ecological footprint and to produce the lowest amount of pollution possible, to efficiently use land, compost used materials, recycle them or convert waste into energy.

And the five green business models identified by [85] are outlined in Table 3.

Table 3. Identified types of green business models ([85], p. 27).

- Companies working with **green supply chain management (GSCM)** source bio-based, energy-efficient or surplus and waste materials from external suppliers. This has proved to secure more stable sourcing, creat resource-efficient production or support the branding of the company by substituting core components that are crucial for their production and that will have the highest business impact. Although green supply chain management has not significantly changed their revenue streams.

Table 3. *Cont.*

- Companies working with **cradle to cradle** (**C2C**) design and produce biodegradable, decomposable and reusable products. They start by focusing on one product line to see if the product is profitable. A few larger companies have taken the approach further by using the cradle to cradle mindset as a driver to systematically take products and components back into own production.
- Companies working with **take-back mechanisms** (**TBM**) distribute waste and surplus materials to their own or other companies' production. They have all seen new revenue streams, cost-cutting opportunities and risk management in taking their own (or others') products or packaging back into own production. This creates an incentive to design products to be recyclable and decomposable and to retain product ownership.
- Companies working with **functional sales** (**FS**) have seen competitive advantages and new revenue streams in selling the functionality of their product or adding services to it. They have changed the cost structure and risk schemes for their customers, due to lower investment cost, lower operational risks and higher customisation options. This has often created new and closer customer relations.
- Case companies working with **industrial symbiosis** (**IS**) is a collaboration where companies buy and sell residual products, materials and resources. It has created interlocking systems where companies cycle their surplus and waste materials to reduce cost and the need for new materials.

The insights from Tables 1–3 above are that:

- The dimensions of a business model are firm and domain specific on the level below the generic components.
- The identified types of green business models is a subset of the possible green business models since they are only modifications of some of the business model dimensions and are only combinations of very few modified dimensions.
- There are many as of yet unidentified and hence untried business models available for circular economy value chains.

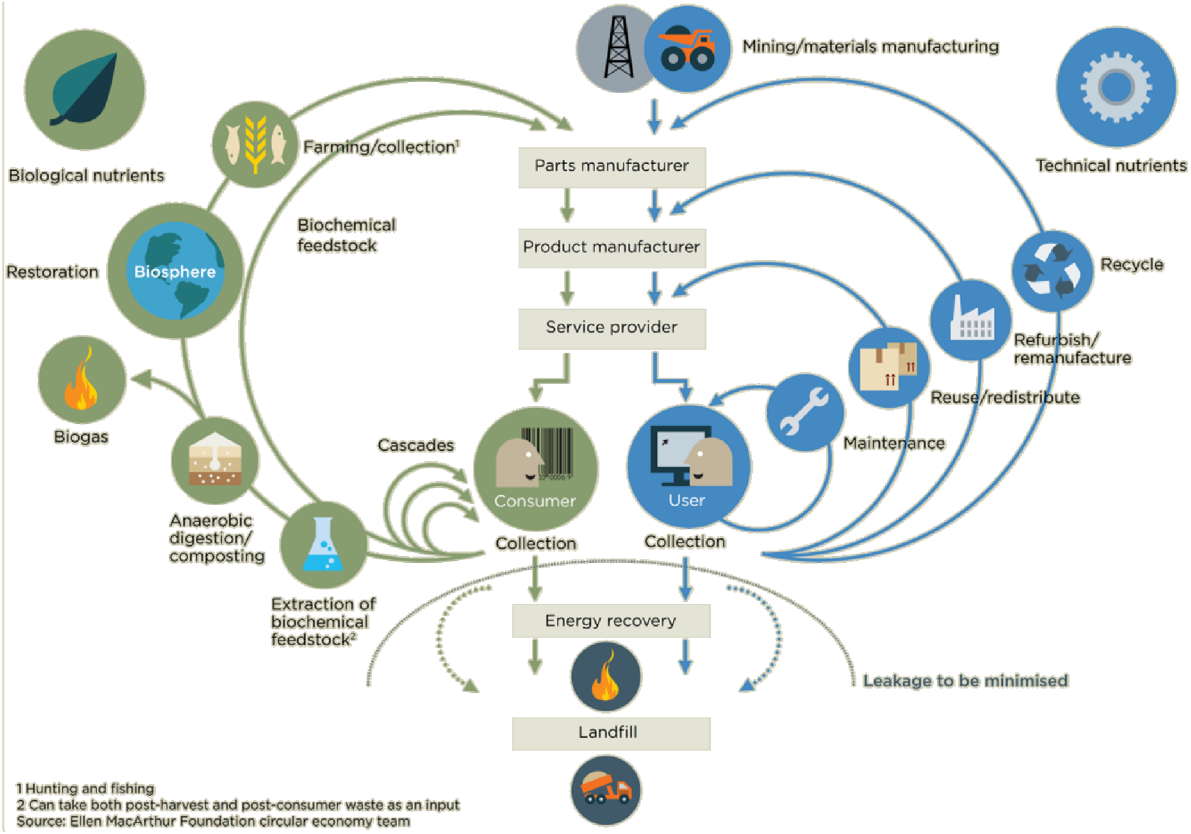
Hence, the business model approach is relevant for designing, understanding and effectively communicating the ways in which novel approaches to circular value chains can be translated into value and consequently into profit.

2. The Circular Value Chain

The circular value chain is built on the principle of ensuring that all intermediary outputs (physical, energy, informational, relational *etc*.) that have no further use in the value creating activities of the firm are provided as input to other value chains external to the firm. There are several different but linked terminologies used to describe this conceptual approach e.g.:

- **Circular Economy** (concept introduced by [86]): is a generic term for an industrial economy that is, by design or intention, restorative and in which material flows are of two types, biological nutrients, designed to re-enter the biosphere safely, and technical nutrients, which are designed to circulate at high quality without entering the biosphere [87]. The principle is illustrated in Figure 3.

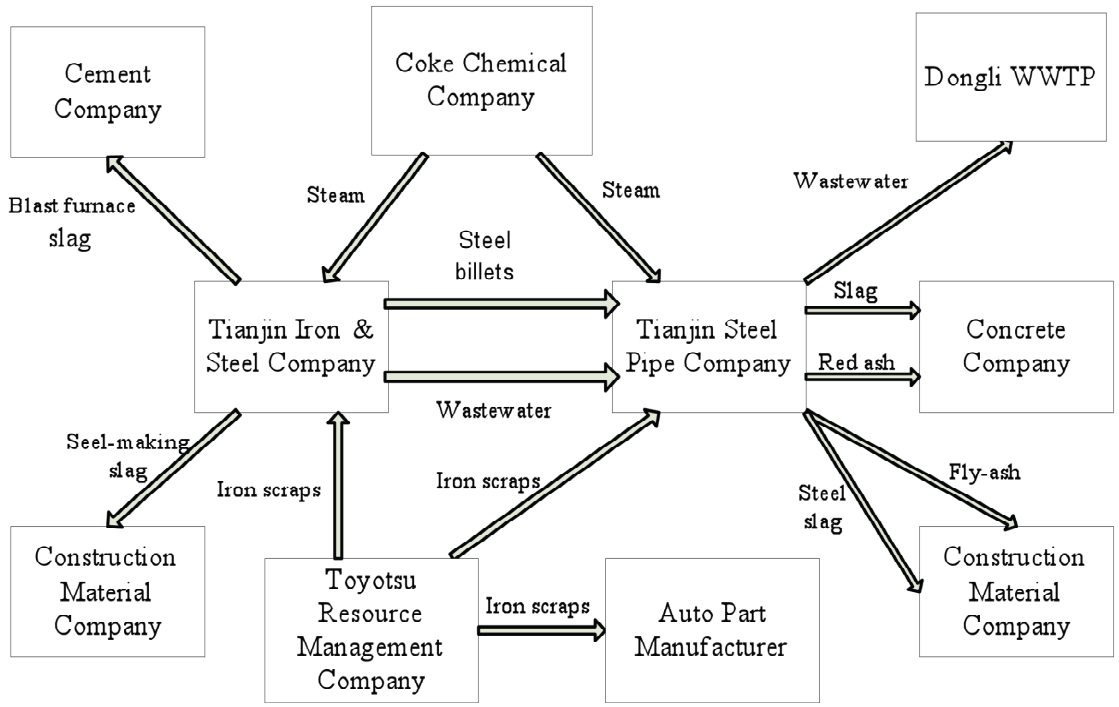
Figure 3. The circular economy—an industrial system that is restorative by design ([88], p. 24).



- **Closed-loop Economy** (concept introduced by [89,90]): is aiming at a high recycling ratio and maximum economic efficiency [91].
- **Industrial Ecology** (concept introduced by [92]): is the study of material and energy flows through industrial systems. The global industrial economy can be modelled as a network of industrial processes that extract resources from the Earth and transform those resources into commodities which can be bought and sold to meet the needs of humanity. Industrial ecology seeks to quantify the material flows and document the industrial processes that make modern society function. Industrial ecologists are often concerned with the impacts that industrial activities have on the environment, with use of the planet's supply of natural resources, and with problems of waste disposal. Industrial ecology is a young but growing multidisciplinary field of research which combines aspects of engineering, economics, sociology, toxicology and the natural sciences. Industrial ecology has been defined as a "systems-based, multidisciplinary discourse that seeks to understand emergent behaviour of complex integrated human/natural systems" [93]. The field approaches issues of sustainability by examining problems from multiple perspectives, usually involving aspects of sociology, the environment, economy and technology. The name comes from the idea that we should use the analogy of natural systems as an aid in understanding how to design sustainable industrial systems [92]. The associated concept of Industrial ecosystem is based on a natural paradigm, claiming that an industrial ecosystem may behave in a similar way to the natural ecosystem wherein everything gets recycled [94].

- **Industrial Metabolism** (concept introduced by [95]): covers the whole integrated collection of physical processes that convert raw materials and energy, plus labour, into finished products and wastes [96]. The goal is to study the flow of materials through society in order to better understand the sources and causes of emissions, along with the effects of the linkages in socio-technological systems [97,98].
- **Industrial Symbiosis** (concept introduced by [99] in the economic sense and [100] in the waste sense): is the sharing of services, utility, and by-product resources among industries in order to add value, reduce costs and improve the environment [101]. Industrial symbiosis is a subset of industrial ecology, with a particular focus on material and energy exchange [102]. An example is outlined in the Figure 4 below.

Figure 4. Industrial ecosystem in Tianjin ([103], p. 2).



- **Integrated Chain Management** also known as Integral Chain Management [104], is an approach for the reduction of environmental impact of product chains. Such a product chain exists out of an extraction phase, a production phase, a use phase and a waste phase. The ultimate goal of Integrated/Integral Chain Management is a reduction of environmental load over the whole chain [105].

These types of initiatives are taking place on three scales: The lowest scale is on the level of the individual firm or groups of discrete firms aiming to increase the efficiency of the production and as a consequence reduce the necessary energy and material inflow as well as the associated waste. The second level is on the level of groups of firms e.g., clusters, supply chains, *etc*. Where sharing of resources contribute to several participants increased efficiency either by reducing e.g., energy use/cost or by providing the opportunity of one firm to proved "waste" from its process as input into another firm's value creating process [industrial symbiosis and industrial metabolism]. When co-located in planned industrial areas, this is known as eco-industrial parks [106]. The third level is at the level of

nations where these types of initiatives are legislated or strongly incentivised. These developments are taking place at different speed in different countries, and China, Japan, Germany and the Nordic countries are among the most experienced and developed in institutionalising industrial recycling initiatives [107].

Based on the above, the circular value chain is defined as a value chain where:

- all inputs are minimised for one unit of output *i.e.*, it is maximally efficient;
- minimal losses take place in the processing of the inputs in terms of energy, water, material, information, *etc.*;
- all side streams from the processing and unutilised inputs (both colloquially known as waste) into the processing are captured and value is added to maximise their inherent profit potential using the waste hierarchy approach;
- the profit potential in these value added "waste" products is then realised.

In this article, a circular value chain business model (or green business model) is one in which all intermediary outputs that have no further use in the value creating activities of the firms are monetised in the form of either cost reductions or revenue streams.

3. Approaching the Business Model Design on the Firm Level

The starting point is a mapping of all inputs and outputs relating to the existing operations. These exist in physical space (e.g., material, energy, *etc*.), digital space (e.g., information) and relational space (e.g., inter-organisational and interpersonal relationships).

For each of the existing outputs, or inputs the waste hierarchy approach is applied. The approach has five principle steps: prevention (including minimisation); preparing for re-use; recycling; other recovery (e.g., energy recovery); and disposal [108] and further developed in [109]. The reduction element is about using less of anything and everything, hence this step contributes to the efficiency of the organisation and is directly measurable in monetary terms. The preparing for re-use step is about the actions taken that will enable re-use of something that otherwise could not be re-used. In other words it is about adding value to potential waste product to make it into a valuable input for someone else and hence enables its conversion into money by the firm—a simple example would be sorting and collection of waste paper into an easily transportable container. The recycling element is about endothermic or exothermic processes that change the waste material into something that is ready as an input into someone else's value adding activities. These changes can be of two types: The converting of low-value materials into high-value products—known as up-cycling) (e.g., composting of waste (exothermic) into fertilizer) or the converting of valuable products into low-value raw materials—known as down-cycling (chopping of wood residue (endothermic) into suitable input for heat-generation through burning). The other recovery step is around the recovery of something that normally would not have been recovered and then converting it into something valuable. A common example is the recovery of waste-energy from a process that is then used as input to the same energy intensive process in order to reduce the energy costs. It could also be e.g., the recovery of methane from organic waste treatment that gets used for energy generation which in turn can get used for electricity generation and sold into the grid. The final step is disposal, this step is the residual when all other steps have been

taken into account and represent a "failure" in the circular material chain. This step may include very energy intensive steps like e.g., incineration in order to minimise the environmental impact of the waste product.

Since Business Models are an answer to the *How* questions as relates to strategy, it is essential that the principle strategies as relates to future circular material chains are identified. The author has found that the most common ones are:

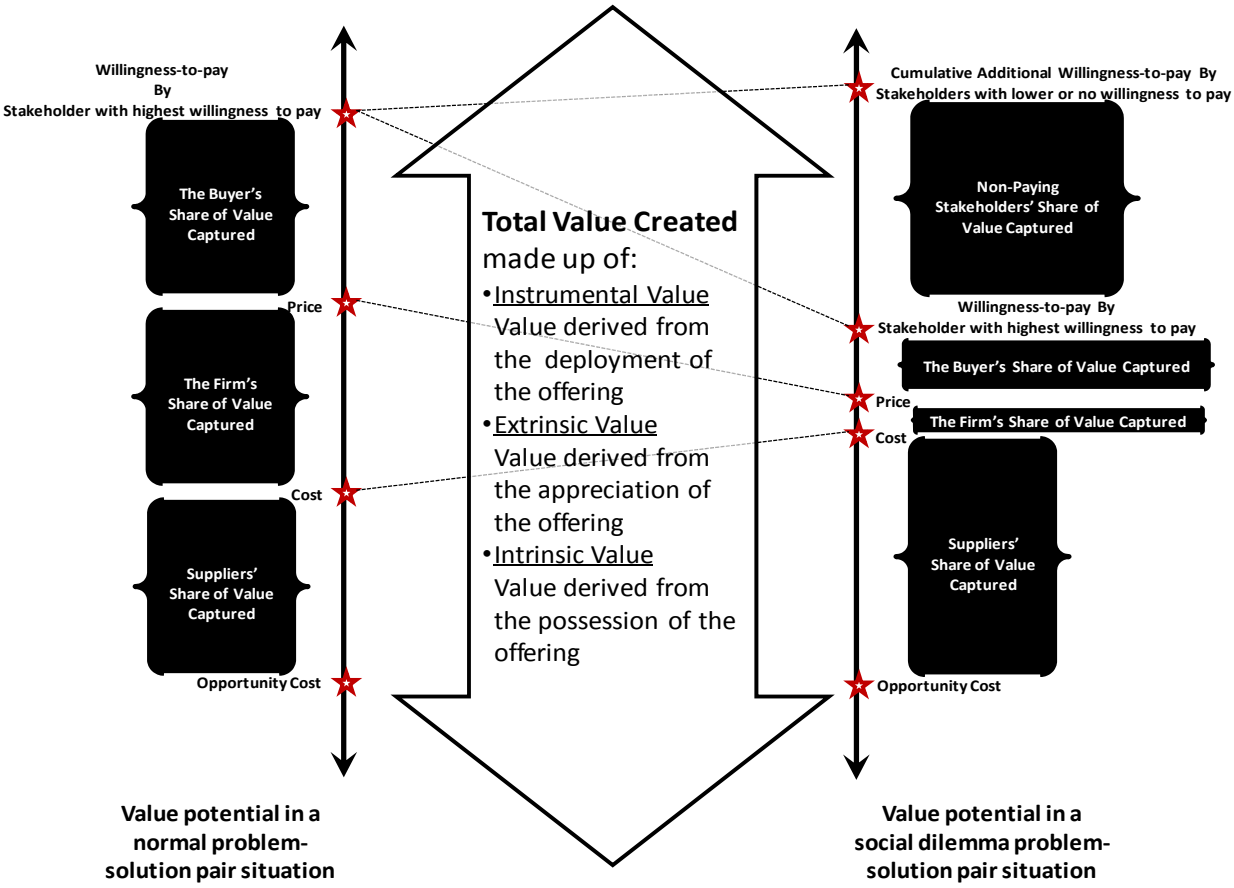
- Accumulate tomorrow's valuable resources (sometimes at yesterday's prices). This requires asset ownership/property right retention.
- Be a rapid adopter of new technologies that enables a circular value chain with lower input and lower waste whilst increasing operational efficiency, e.g., microbial consortia engineering including synthetic biology that enables the creation of efficient biological systems for bio-mining with a dramatic reduction in the need for energy in the extraction of minerals; Urban mining of gold from electronic waste has a yield of 18 g/tonne whereas commercial goldmines operate at around 1 g/tonne for new mines but this opportunity is only accessible using new processing techniques.
- Contract for the design, financing, build and operation of physical offerings to create incentives that are conducive to the circular material chain e.g., Rolls-Royce power-by-the-hour offering for aircraft engines, Michelin tyres-by-the-km, City-wide bike rental, Private Finance Initiatives (PFI), Build-Own-Operate (BOO), Build-Operate-Transfer (BOT), *etc*. This provides a strong economic incentive for the prevention of waste.
- Design for Reuse e.g., 95% of a Volvo truck is designed to be reused or recycled and hence it is mostly bolted together rather than welded together. This includes standardised platforms, standardised components as well as modularisation. Of eBay's turnover around 15% is second-hand watches and jewellery and the total volume is increasing.
- Move from ownership to functionality (e.g., from photocopier ownership to photocopier rental with added pay-per-use). This is one of the drivers of servitization in manufacturing firms.
- Substitute input factors that are not renewable or cannot be recycled e.g., some rare earth elements, with input factors that can be recycled and are renewable e.g., cellulose based biochemicals substituting petroleum based petrochemicals.
- Work with the most demanding customers and work in the regulatory most demanding jurisdictions in the circular material chain space to ensure innovation driven progress towards profitability in previously unprofitable domains.

In order for a business model to be constructed around any of the above strategies, it must be grounded in a valuable problem. A problem is considered valuable if it can be used to construct a valuable problem-solution pair, *i.e.*, a problem-solution combination where the cost of the solution is lower than the cost of the problem whilst still being non-trivial in its development [110]. If a valuable problem-solution pair is addressed, value is created, hence the prerequisite for a profitable business model is the existence of a valuable problem–solution pair [111]. From this, follows that the first requirement for constructing a successful business model is the identification of at least one valuable problem-solution pair. Such problem–solution pairs exist since there exist several waste related situations that are costly and that could be solved at a lower cost than keeping the present state, but not

trivially so by the beneficiaries of the solution [112,113]. Hence, it is possible for firms to create value by addressing some of these problems.

The second prerequisite for an economically sustainable business model is that there exists a way for the firm to appropriate a large enough share of the created value [2,111]. A complication in the waste domain is that many of the problem-solution pairs are of the social dilemma type. A social dilemma occurs when individuals in interdependent situations face choices in which the maximization of short-term self-interest yields outcomes leaving all participants worse off than any feasible alternatives [114]. Since the problem-owner of a social dilemma problem is a broad collective of stakeholders, there is frequently no individual actor with an incentive to solve the problem as long as the solution shares the pay-off structure across the stakeholders with an insufficient pay-off to the solution provider [115]. In these types of social dilemma situations, valuable problems, even if properly formulated, may not be perceived as opportunities by individual firms [111] since a firm may indeed be able to create more value by addressing a social dilemma problem but may still capture less value then before because the created value is dispersed among all problem-owners, many of which the firm cannot capture any value from [111]. Using the complete sub-set of value definitions *i.e.*, instrumental, intrinsic and extrinsic [116] and the division of this value between suppliers, buyers and the firm [117] and comparing a normal valuable problem–solution pair situation with a valuable social dilemma problem-solution pair situation [111] will make the firm conclude that the problem–solution pair is not worth pursuing, which is identified in the following Figure 5.

Figure 5. Illustration of why valuable problem-solution pairs in social dilemma situations may not be pursued by the firm.



As can be seen from the Figure 5 the firm's ability to capture value in a social dilemma problem-solution pair situation is substantially lower than in a normal problem-solution pair situation. This means that the fundamental issue is not about increasing the value creation (although that is always a desirable objective) but about how to increase the firm's value appropriation [111]. This means that the fundamental issue is in fact a business model design challenge. This conclusion is also supported in the literature [81,85,118–129].

Some of the problems can be illustrated by comparing the linear value creation process of inputs—value creation—waste with the circular value creation model as outlined in Table 4.

Table 4. Comparing the circular economic approaches with potential barriers in the existing linear economic system.

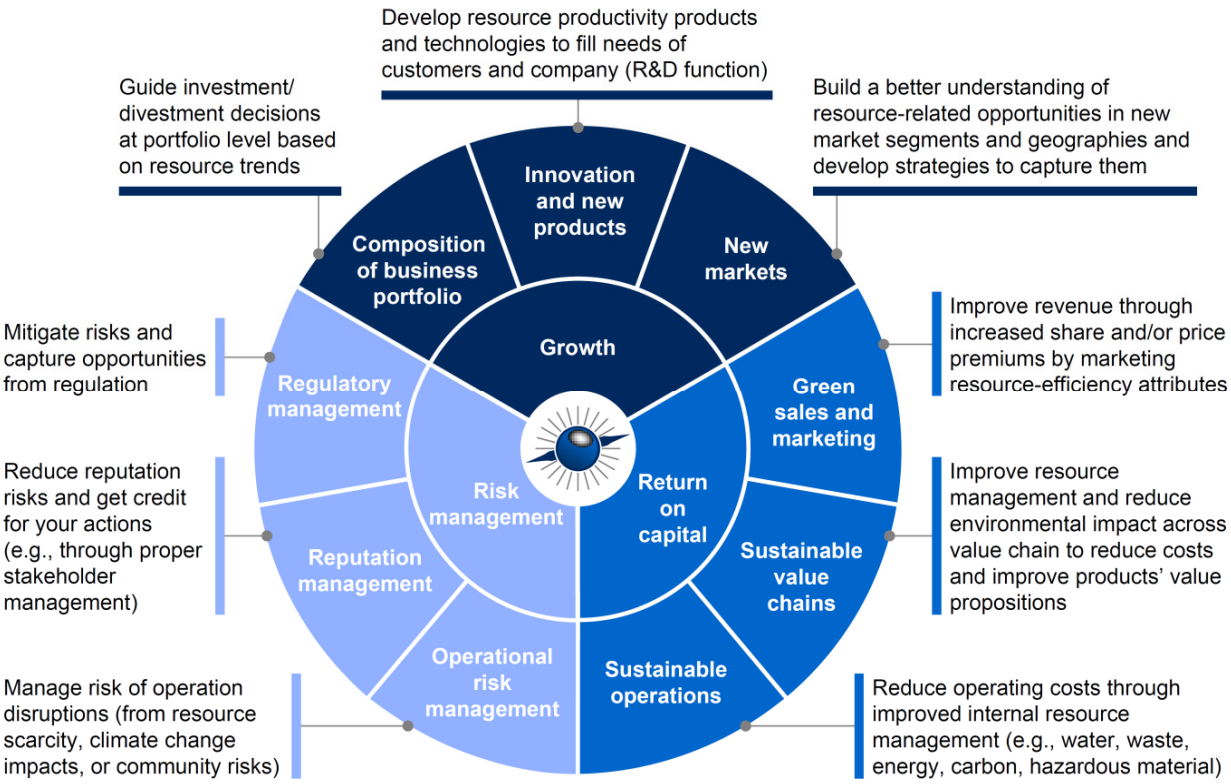
Proposed circular economy value creation model	**Potential challenge from linear value creation process firms**
Structured and rapid return of used-products to use through minimising necessary changes to return it to use, minimising necessary refurbishment before return to use, minimising necessary remanufacture before return to use and hence minimising the time before the product is returned to use. Achieving this increases the savings potential as relates to material, labour, energy, capital and information embedded in the product as well as minimising negative externalities like emissions, water and energy use, toxicity impact *etc*.	There is a potential substation effect between returned used products and sale of new products that may prevent the move towards returning used products to the market. The profit differential between new products and returned used products my act as a barrier to moving towards returning used products to the market. The cost of making market ready used products in terms of cost of capital for necessary investments (equipment, training *etc.*) plus the operational cost may make the proposition unprofitable. The firm may not have enough capital to embark on the journey and financial institutions may not on balance provide capital given uncertainty and risk around the proposition
Maximising the physical presence, through intervention, in use of material, e.g., new product that gets transformed into reused product gets transformed into remanufactured product, and then gets transformed into recycled product.	The same objectives as above are valid plus potentially insufficient efficient and/or effective technologies for executing the necessary remanufacture or recycling in an economically viable way.
Identifying maximum length journeys of the components of the original product on each step of the way.	The same objectives as above are valid plus the fact that the firm may lack the requisite competence to identify potential journeys or the requisite understanding of what it takes to get approval for use or to win business in each step.

It is interesting to compare the above theoretical barriers with empirically identified barriers. [130] have empirically identified the key barriers and enablers multinational companies face in the implementation process of Circular Economy (defined as a development strategy that maximises resource efficiency and minimises waste production, within the context of sustainable economic and social development) as outlined in the Table 5. [131] have identified resource related value creation levers for businesses as outlined in Figure 6.

Table 5. Key barriers and enablers faced by multinational companies in implementing circular economy [130].

Barriers	Enablers
• Technological: Barriers connected to specific technologies (e.g., recycling technologies) and processes (e.g., product design) that hinder companies to fully adopt the concept. • Legal: Complexity of regulations, discrepancies between international regulations, and their often outdated or rigid characteristics, can unintentionally create additional barriers during the transformation. • Economic: Businesses experience difficulties in defining the business case for adopting the CE concept, which is even more intensified by the current economic situation. • Change in mindset: A reluctance to acknowledge that the current way cannot proceed and a change to a more long-term perspective is necessary, can hinder the implementation of circular economy.	• Leadership: Leadership that appreciates the new strategic direction, understands its benefits but also its risks, and is able to establish a common understanding in the business, can be a powerful enabler during the transformation process. • Collaboration: A company can never achieve full circularity on its own: It is dependent on a network of collaborating organizations to enable the adoption of the concept. Fostering internal as well as external collaboration can therefore be a powerful factor. • Motivation through the concept itself: The concept of Circular Economy unleashes creativity and improves morale by getting the idea that being sustainable, and at the same time benefiting economically, is possible for companies. • Customer behaviour: Customers are increasingly demanding environmentally friendly products and by this are putting more pressure on businesses to adopt more environmentally cautious practices; this can be as significant enabler.

Figure 6. Resource-related value-creation levers for businesses ([131], p. 20).



The conclusion is that the business model, in order to be viable, needs to be grounded in a valuable problem-solution pair, and have the potential for multiple revenue streams enabled by physical, relational, informational and other organisational resources and originate out of profit pools that the firm has not previously accessed (preferably profit pools created by the firm) with a marginal cost of access lower than the marginal economic value added contribution from accessing the profit pool. Some examples of approaches by companies are identified in the Table 6 and, for those interested in more case examples, there are 20 case studies collected by [85] and 55 case studies collected by [84].

Table 6. Examples of companies with green approaches.

Philips has a target for 2012 that 30% of its revenue should come from green products. The next phase of its innovation programme aims to "close the materials loop", with a target of doubling global collection, recycling amounts and recycled materials in products by 2015 compared with 2009 [132].
Desso is aiming to fully implement cradle-to-cradle processes by 2020. The company already processes old tiles, separating the yarn, which goes to one of its suppliers. This supplier has itself invested in a de-polymerization facility and then makes new yarn from the waste. For tiles that still include bitumen, that material is separated and goes into road repairs and cycle paths, or serves as raw material for the cement industry [132,133].
The industrial equipment provider Caterpillar has for 30 years offered remanufacturing for a range of industrial products from earth-moving machines to water pumps. The company claims that remanufacturing saved 59,000 tonnes of steel, 91 metric tonnes of cardboard and over 1,500 tonnes of wood products in 2010. End-of-life parts have a return rate of over 90% [132,134].
Renault vehicles with the eco² mark are designed so that 95% of their mass can be recovered at end-of-life to be reused or recycled. In 2004, Ford introduced a concept car called the Model U that showed the opportunities for modular, layered design, simplified engineering processes and other techniques that help enable remanufacturing and repairs [132].
Patagonia has established its "common threads initiative". The company promises to make durable products and repair faults quickly but also enables customers to fix minor damage. Franz Koch, CEO of clothing manufacturer Puma, says that his company will be the first to bring to market training shoes, T-shirts and bags that are either compostable or recyclable [132].
Waste management companies Veolia Environment, SITA UK and the van Gansewinkel Groep have introduced strategies that aim to enhance source-separation of materials. TerraCycle, a company that organizes the collection of waste from households and "upcycles" them into more valuable products, grew by over 100% per year since its inception in 2001 to $16 million revenue in 2010, the year in which it also started to turn a profit [132,135].
The Japanese electronics firm Kyocera was an early pioneer of refillable toner cartridges. The company says that conventional cartridges can have over 60 parts made from numerous materials—and are typically thrown away at the end of their life. Instead, it produces much simpler cartridges that can be easily refilled. Over the lifetime of the product this saves money because the materials cost is reduced by 50% (while waste is down by 90%). However, despite its efforts over the past two decades, Kyocera admits it has struggled to displace the conventional business model. The reason is that buying decisions are often determined by the retail price of a printer and not the lifetime cost, which includes the cost of toner and maintenance [132,136].

As can be seen from the examples above the green approaches that have a clear value proposition to either the firm (frequently in the form of cost reduction) or to the target customer (in the form of a

value proposition valued higher than the value assigned to the monies asked in return). This also explains why Kyocera has not been successful.

4. The Principle Business Models

Given the high level definition of a business model stated above and restated as: *How an organization creates value by acquiring and developing resources that are then deployed in a resource transformation system driven by an identifiable monetary opportunity realised by providing a value to paying parties that exceeds the value these parties assign to the money asked for in return.* We can start to look at the components more in detail.

Resources fall in the five categories (as outlined in Table 7) and can be both tangible and intangible.

Table 7. Resource Categories [137].

	Resource Category				
	Monetary	**Physical**	**Relational**	**Organisational**	**Competence**
Definition	Money or monetary equivalent resources	All physical manifestations including plant, equipment, energy and electricity	All relationships held by individuals as representatives of organisations	All results of human endeavours that remain in, and are owned by, the organisation when the employees have gone home and that you cannot find on the balance sheet e.g., Brands, Processes, Software, Information, *etc.*	Competence residing in individuals
Tangible Example	Cash	Building, Energy	Contractual Relationships	Documented information	Exam results
Intangible Example	Unutilised borrowing Capacity	Location, Exergy	Trust Preferred status	Corporate culture	Tacit knowledge

The resource transformation system is the firm specific transformation of resources into each other with the use of other resources in journey from lower to higher value in the eyes' of the paying customer. Examples of such transformation are illustrated in the Table 8.

A "green" business model must have an effective resource transformation system e.g., each transformation should add value to the complete transformation system as opposed to subtracting value. In addition, the more important the transformation the higher the value adding should be and the resources that form the basis for the firm's competitive advantage should be the originators of the highest value adding activities.

Table 8. Examples of resource transformations [137].

		Transformation into the following resource				
–	–	**Monetary**	**Physical**	**Relational**	**Organisational**	**Competence**
Transformation Originating in the following resource	**Monetary**	Putting money on the bank to gain interest	Procurement of raw material or equipment	Investing in relationship building	Investing in software, brand building, information, *etc.*	Investing in competence development or in people with higher or more appropriate competence
	Physical	Selling products	Mixing chemical A with chemical B to get chemical C	Strengthening relationships through superior aesthetic design or through chemical dependency e.g., tobacco	Developing new products requiring new production processes	Taking into use new equipment requiring new competence to operate
	Relational	Monetising relationships like in e.g., shopping TV where the good seller pays the TV channel to get access to the viewers	The power exerted by big customers to get free sample products developed by tier one suppliers	Word of mouth	The quality system that is implemented for free by the large customer into the valuable small supplier to assist them reduce quality variability	Co-learning in e.g., joint research projects
	Organisational	The additional price you can charge because of brand or IP	Process drive production in e.g., the process industry (the recipe that if followed generates the product)	A customer relationship management system that increases customer loyalty when put to use	Automated software development	Automated training
	Competence	Monetising competence (frequently through man-hours as a proxy)	The creation of a prototype or a work of art	The conversion of a non-relationship into a relationship by e.g., a salesperson	Documenting a process so that it can be repeated by others	Apprenticeship or personal training

The key questions to ask in order to maximise the profit pools are, given that all inputs have been minimised:

Capturing and monetizing

- What opportunities for energy capturing exist and how can the captured energy be monetised e.g., reduction of energy needed for own processing, provision of water carried heat to other buyers, provision of generated electricity to the grid?

- What opportunities for water capturing exist and how can the captured water be monetised, e.g., reduction of water needed for own processing, provision of water to other buyers, provision of water to the utility provider?
- What opportunities for physical waste capture exist and how can the captured waste be monetised e.g., reduction of material input for own processing, provision of waste as a raw material in its captured form to other buyers, value adding to the captured waste before providing it as an input to other buyers?
- What opportunities for information capture exist throughout the processing and how can the captured information be monetised e.g., used to optimise the existing processing activities in real time, performance information to equipment suppliers or raw material suppliers, value adding to the captured information before providing it as an input to other buyers?

Servitization and services

- How can the physical output of the processing be complemented by value adding services (servitization) or substituted for services (e.g., product sales to product rental)?
- How can the product act as an information collector for information that in value added form can underpin further service offerings and better design of next generation offerings?

Minimal resource use, minimal rework, maximal refurbishment/re-use/recycling

- How can the product be designed for minimal resource use in production and operation and also for minimising rework before sold as used and be prepared for its components once disassembled embarking on separate journeys of use in other value chains and finally for ease of recycling?
- How can the used product be captured for return to enable refurbishment/re-use/recycling before resold/sold into other value chains/recycled?

In addition, the following standard business model questions need to be asked (modified from [4]):

- Who are the target customer segments, target consumer segments and other definitive stakeholders?
- What is the value proposition and product-service-system or solutions offering for each of the target customer segments, target consumer segments and other definitive stakeholders?
- How will the target customer segments, target consumer segments and other definitive stakeholders capture value from the offering?
- What competitive advantage does the offering enable or contribute to within the target customer segments, target consumer segments and other definitive stakeholders?
- What are the value attribute, attribute preference and attribute performance for each of the target customer segments, target consumer segments and other definitive stakeholders in the three value domains of instrumental, extrinsic and intrinsic?
- What requirements must be fulfilled by the target customer segments, target consumer segments and other definitive stakeholders in order to be able to benefit from the offering?
- How should the product-service-system/solutions offering be implemented at the target customer segments, target consumer segments and other definitive stakeholders to ensure the targeted benefits (value)?

- What role do we play in the industrial symbiosis structure as well as the industrial eco-system in which we are part when it comes to the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are the key present and future technologies underpinning our product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are the key design approaches underpinning our product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are the key art approaches underpinning our product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are the key emotional state generating approaches underpinning our product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are our outgoing logistics and distribution channel choices for each of the target customer segments, target consumer segments and other definitive stakeholders for each of the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What are our incoming logistics and supply chain choices for each of the target customer segments, target consumer segments and other definitive stakeholders for each of the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What relationship width, depth and frequency are desirable for each of the target customer segments and other definitive stakeholders for each of the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What value configuration (value chain, value shop, value network) and associated transaction and coordination cost choices do we make?
- What resources, competitive advantage and resource deployment structure (IC navigator) do we require for an optimal approach towards each of the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering?
- What cost structure have we committed to due to the above choices and what are the identified management objectives for the associated economic value-added drivers?
- What revenue models with focus on accessing multiple profit pools grounded in the product-service-system or solutions offering, energy offering, water offering, waste-to-input offering and information offering and how can we maximising the number of revenue streams with the appropriate pricing logic combinations aimed at achieving an economic value added for the business exceeding the revenue stream from its primary offering (the hallmark of a good business model).

If the above questions are answered the basis for a profitable business model is created.

5. Limitations of This Study

The limitations of this study are linked to the very limited empirical data available as well as lack of common definitions of terms in both the business model literature and in the circular economy linked literature. This means that the findings should be seen as a hypothesis for empirical testing.

6. Conclusions

The primary issue around creating a profitable circular value chain is one of business models rather than strategy, primarily dependent on the common social dilemma situation and the need to monetise multiple value added "waste" streams and, hence, the need to access multiple profit pools, some of which may have to be created by the company. This will normally mean that it is practically impossible to realise the global benefits that are inherent in circular value chains. The dilemma can be expressed in simple terms as:

Mankind has many problems and they will normally not be solved until they become the problem of one man or one organisation since mankind has no address nor bank account and hence, cannot provide an incentive for a firm to solve the problem. This is why, e.g., malaria was not solved until it became the problem of the Bill Gates Foundation in spite of the solution having clear net benefits to mankind. This is also why the absolute majority of today's environmental problems can be solved already with today's available technology but there is no one problem owner that is willing and able to pay for the solution in spite of its clear benefit to mankind, and hence, no implemented solution is forthcoming.

These complex boundary conditions requires a rigours approach to developing the business model where many different questions have to be clearly answered since the scope of the business model is both broader and more complex than in the traditional linear model. These questions are outlined in the article above and addressing them will provide for both the development of a potential business model as well as verify if it is economically feasible before implementing it.

This article provides a unique contribution in that it synthesises the theoretical and empirical insights from the business model innovation domain with the theoretical and empirical insights from the circular economy domain.

The implication for research is the need to develop a better taxonomy in the domains discussed in this article as well as a need to empirically test different circular economy business models.

The implications for managers is that circular economy type business models must capture and monetize every conceivable resource whilst offering services in every loop identified in the circular economy framework. If this is not done, it is likely that the circular economy business model will be financially non-viable.

Conflicts of Interest

The author declares no conflict of interest.

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