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Manuscript Draft

Manuscript Number:

Title: Circular business models and transition tools: A systematic literature review

Article Type: Full Length Article

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Circular business models and transition tools: A systematic literature review

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Abstract

This article maps the current knowledge of circular business models and transition tools. To achieve this purpose, it uses a systematic literature review (SLR) to synthesise information from several original studies and systematise the findings. SLR was also used to examine concepts that could be interpreted as synonyms for the main idea; it would be possible to add other synonyms to the list, but initial attempts did not help to increase the findings already identified. Case studies testing some or most of the tools indicate that the authors are cautious, that the few larger companies that focus on the circular economy are unknown to the authors, or that the authors wish to take care of their own transition. The SLR revealed that 'regeneration' and 'exchange' are often not compatible with the tools from the ReSOLVE framework principles. Essentially, there are no rules and only a few approaches or models are available.

Keywords: circular business model; circular economy; business model; systematic literature review; ReSOLVE framework

1. Introduction

The circular economy (CE) clearly presents many challenges to traditional linear business models. The added focus on sustainability does not always help to solve the problems that the CE aims to address. A conceptualisation of the circular business model (CBM) is lacking in the academic literature. In fact, few authors have provided a clear CBM concept. Linder and Williander (2017, p. 2) defined a CBM as 'a business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings.' Thus, a CBM implies a return flow to the producer from users, though there can be intermediaries between the two parties. The term CBM, therefore, overlaps with the concept of closed-loop supply chains, and always involves some 'recycling' principles or strategies.

Geissdoerfer et al. (2018) identified the CBM as a subcategory of the sustainable business model and characterised CBMs as creating sustainable value, employing proactive multi-stakeholder management, and having a long-term perspective, as well as closing, slowing, narrowing, intensifying, and dematerialising resource loops. Geissdoerfer et al. (2017) searched for similarities and differences between sustainability and the CE. They also summarised warnings about the negative impacts of the CE: a) circular systems will incur specific costs; b) the necessity of coping with the technical impossibility of really closing the circle; and c) recycling will be accompanied by growing demands on energy; the negative impact of this demand will be higher, especially in the form of the greenhouse gas emissions, than the overall environmental effect of acquiring the material from conventional sources such as mining.

Despite the lack of conceptualisation, the topic of CBM has attracted scholarly attention, since it has become clear that the shift to a CE demands an understanding of how companies can introduce circularity into their business models (Lewandowski, 2016). This means a change in several building blocks of a company's business model, particularly value propositions, channels, resources, and activities; it may mean changes in the whole model as well as the development of a new one(s). To this point, Nuβholz (2017) argued that 'the key difference of circular business model elements, compared to linear ones, appears to be the embeddedness of a circular strategy in the offer, which can alter material flows.'

The implementation of CE principles would affect all the building blocks of the business model framework, since CE principles change the logic behind value creation, delivery, and capture. Other than remanufacturing and recycling and other value recovery practices (e.g. Verstrepen et al., 2007), four terms are most often associated with the CE and CBM. To a certain extent, they reflect the contents of the ReSOLVE framework: product service systems (PSS), consumer (customer) acceptance, sharing (and collaborative economy), and internet-of-things (IoT) or industry 4.0. These terms reflect, more or less, the specific features of CBMs. There are many interdependencies among the contents of those terms; however, they can exist independently in practice. For instance, Kjaer et al. (2018, p. 666) argued that 'PSS are often mentioned as a means to enable a transition from a linear to a circular economy.' The provision of services within PSS is more and more dependent on the different functionalities enabled by industry 4.0 and IoT (Bressanelli et al., 2017). Use-oriented PSSs are often related to sharing and collaboration business models (Annarelli et al., 2016).

The main goal of this article is to map the current knowledge about CBMs and tools for the transition. To achieve this goal, we used a systematic literature review (SLR) and systematised the results according to several sets of criteria: business model content, i.e. components or elements of business models; the ReSOLVE framework combined with six business strategies for slowing and closing loops, as suggested by Bocken et al. (2016), and the strategy for narrowing the loops; and extended boundaries of analysis and adapted approach types and types of work (Pieroni et al., 2019).

2. Existing reviews on circular business models and tools for the transition

A comprehensive review aiming to systematise the state-of-the-art of available approaches supporting a circular-oriented or sustainability-oriented business model innovation process was presented by Pieroni et al. (2019). The approaches are systematised in three streams. The first stream, based on Teece's dynamic capabilities-based view, is divided into three categories: (1) sensing: approaches that help to identify opportunities and generate new business model ideas; (2) seizing: approaches that systematically design and test new business model concepts or configurations; and (3) transforming: approaches that help to build new competencies and implement organisational renewal. The second stream, based on three business model innovation characteristics, includes boundaries of analysis (organisational, inter-organisational, and societal), abstraction level (aggregated, moderated aggregated, and details), and time-related view (static and dynamic). The third stream, based on the approach type, covers conceptual framework, guideline manuals, process model, cards/serious game, visualisation tools, and simulator/software.

Singh et al. (2019) identified 145 best practices or approaches to resource efficiency and the CE in order to reduce energy and material demand in the product sectors. Approaches include durable product design, enhanced repair and upgrade services, and product take-back models; the approaches provide important insights into planning more circular business to resource efficiency. Lieder and Rashid (2016) summarise the outcomes of their review of the CE categorised according to the three perspectives: resource scarcity, environmental impact, and economic benefits. Frameworks, tools, models, and methods for decision making according to these perspectives and selected based on their possible applicability for the transition and shift towards the CE, in general, are introduced in Table 1. They differ in depth and breadth, focus, and areas of interest, and they range from very general and probably rather abstract to very narrow and specific.

Pieroni et al. (2018) conducted a comprehensive review of the literature with the purpose of exploring the existing methods aimed at supporting the development of CBMs and their level of consideration of and/or integration with product design processes. They identified 10 methods that fulfil more or less the integration of CBM development and product design. The authors concluded that the weaknesses of the methods from the list reside in their relatively high levels of abstraction, a lack of 'how-to' guidance or methodological support, and the lack of a more holistic perspective and a connection to commercialisation and operationalisation.

3. Methodology

According to Denyer and Tranfield (2009, p. 672), SLR is 'a specific methodology that locates existing studies, selects and evaluates contributions, analyses and synthesizes data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known.' SLR comprehensively identifies, appraises, and synthesises all the relevant studies on a specific topic and helps to identify gaps and diversity in current research (Petticrew and Roberts, 2006; Correia et al., 2017). Essentially, SLR aims to synthesise the knowledge from multiple original studies.

No unified process for SLR exists; authors differ in the number of steps and in the details of each step. For this paper, based on Correia et al. (2017) we defined five phases: (1) problem formulation and question identification; (2) literature search; (3) evaluation of research; (4) research analysis and interpretation; and (5) presentation of results. This set of phases represents a process that is replicable, transparent, objective, unbiased, and rigorous.

The term 'tools' is used in this text for simplification when dealing with the purpose of the SLR. The SLR concerns tools that may help companies, and specifically both demonstrators, in their move towards CBM. As Geissdoerfer et al. (2017) noted in their comparison of sustainability and CE, no clear and unified opinion on a clear dividing line between these two approaches exists; nevertheless this report concentrates on the tools that were invented, developed, and created primarily for the CE.

This approach enables a focus on the potential specificities of the tools. However, it also can eliminate some important and beneficial approaches that have not been presented as more general or applicable also for the CE. Thus this SLR considers tools and we also searched for the concepts that can be understood as synonyms for the core idea. This means that frameworks, methods, models and modelling, approaches, strategies, schemes, patterns, and roadmaps entered the review. We are aware that even more synonyms could be added to the list, such as tactics, ways, procedures, mechanisms, and practices, but our initial attempts did not expand the existing results.

We used *innovation* and *change* as well as *transformation*, *transition*, *shift*, and *adaptation* in the search in order to cover as many as possible terms for the process from an existing business model to a circular one or to a more circular one. We omitted the term *improvement*, which – despite its importance – does not reflect the real procedural needs of both demonstrators. Improvement is a natural part of most of the tools we detected. For simplification, we use the term *transition* to represents all possible synonyms in the following text.

3.1. All synonyms have been taken into account during the documents review

There are several reasons that an SLR on the tools for companies that are moving towards a CE is needed. First, the tools that are available for the change or innovation of linear business models may have limited value for the far more complex solutions in the CE (Nuβholz, 2017). Second, even recent literature indicates and stresses the lack of tools that can either support particularly large and traditional manufacturing businesses in increasing their understanding of the consequences of CE business model transitions (Lieder et al., 2017) or enable and accelerate transition as well as identify and tap the potentials of transition at the company, inter-company, and/or whole network level (Lieder and Rashid, 2016; Leising et al., 2018). The body of knowledge about tools for the transition of business models towards circularity is immature; it is mostly conceptual and covers individual company business models, mostly niche market pioneers and rarely (if at all) mass-market incumbents and relevant network stakeholders of the whole ecosystem (Diaz Lopez et al., 2019; Parida and Wincent, 2019). Parida and Wincent (2019) also highlighted that most existing research focuses on the business model itself rather than on the process of transformation and offers a static view of a reality that is actually very complex and dynamic.

One supporting argument may be that the existing literature on the CE has been developed outside of management and organisational theory (Lahti et al., 2018). However, management and organisational theory is built largely on the investigation of the practices (of the management processes, managerial mindset, cognitive schemes, and conceptual representations); very few companies have yet managed the transformation towards a circular business (Lieder and Rashid, 2016; Lahti et al., 2018; Parida and Wincent, 2019).

Finally, there has not been an SLR mapping the tools for the transition, transformation, or adaptation of business models for the CE. Table 2 show the strings used for the search in three databases (Web of Science – WoS, Scopus, and Proquest), the types of documents, and the results.

The same search string was used in Google Scholar. The search revealed 47,000 documents (from this database, only the first 100 documents were analysed for the purposes of this review). The first screening was based on the titles, abstracts, and keywords to assess the compliance with the research aim and research question. After that screening, 85 documents from WoS and Scopus remained for further analysis, but 8 documents had to be excluded because the text was not available. In the next step, 77 documents were subjected to the content analysis of the full text. From Proquest, 22 unique documents enriched the outputs of the initial review of titles, keywords, and abstracts. Of those 22 documents, 12 documents were added into the sample for the next step. The Google Scholar search generated 11 documents; however, after the abstract scanning, only 6 remained for the whole text review. During the review of the documents, a snowball technique was adopted; through the citations made by the authors of the included studies, a further 9 documents were added to the final sample. This number includes theses and tools designed by some organisations and institutions.

Finally, 104 documents were examined thoroughly in accordance with the research purpose. This examination helped to exclude 69 documents that – despite promising abstracts, titles, and keywords – were irrelevant for the purpose of the SLR, because they did not contain any transition tools, or the tools were extremely simple, or the document quality was rather low, or their character was too speculative and the reasoning was insufficiently relevant. In the end, only 35 documents and almost all of the academic articles involved, to some extent, tools that we considered relevant. This finding confirms conclusions from the literature about a sizable deficiency in the methodological support for CE transition. During the SLR, additional articles were found in the literature for designing CBMs that contained a review of existing tools. The next subchapter introduces this overview briefly.

4. Results of systematic literature review

In order to provide an empirical illustration of our proposed methodology, we arranged the following classification according to the business model components: value proposition (VP), customer/stakeholder segment (C/SS), customer/stakeholder relationships (C/SR), channels (CH), key processes (KP), key resources (KR), key partners (KP), cost structure and negative impacts (CS+NI), revenue streams and positive impacts (RS+PI), or whole model (WM). These classifications help to understand the importance of the specific features of the components and the ways they can be evaluated, changed, created, designed, or developed as new features into a circular model with concrete tool for CBM innovation.

4.1. Tools for transition

The ReSOLVE framework, circular loops, and business strategies help to classify tools to be adopted as suitable for the specific circular business target or orientation. The following abbreviations will be used in the text: regenerate (R), share (S), optimise (O), loop (L), virtualise (V) and exchange (E); and slowing and specific strategies/value recovery processes for slowing (Sl –xxx), closing (C -xxx), and narrowing (N). The extended boundaries represent specific business functions (BF), organisation (O), network (N), (eco)system (eS) and society (S) and assigning the 'tool' to some of these categories makes it possible to see the level of complexity regarding the organisation of processes within a circular business. The last approach types are adapted into the: conceptual framework (CF), conceptual method (CM), guideline (G), process (P), process model/method (PM), game (Gm), visualisation tool (VT), software simulation (SS), and (statistical) mathematical modelling (MM). The role of this categorisation is only in offering a better overview and for the evaluation of the applicability in concrete situations (considering, for instance, time or competencies or other available resources). Type of work is purely theoretical (conceptual) (T), theoretical and tested in 'laboratory conditions' (TTL), theoretical and tested or verified in a real environment (TTR). No purely empirical tool was found in the literature.

The last criterion evaluates the maturity of the tool based on the practical application and verification. We use a scale from 1 to 5 from the least mature (1) to the most mature tool (5), being fully aware of the very subjective nature of the evaluation. Abbreviations are shown in brackets to mean that their indication is not of 100% value. Most of the existing tools are conceptual, and they exist in the form of a proposal, despite the fact that some of them have been tested in a ‘laboratory’ environment or during interviews with practitioners. Only a few were tested in a more complex form. The results are shown in Table 3.

4.2. Value proposition (VP)

The checklist can be used to evaluate the promise fulfilment and relationship maintenance with consumers in the CE. The main drivers (main factors that influence the behaviour of three CE solutions) can serve as a checklist for the design of the value proposition of the access-based PSS and for the consumer segmentation (Camacho-Otero et al., 2018). The framework can be applied at multiple points while designing new products ‘to increase the likelihood that “emotion building” features are integrated into an end product’ and so to support prolonging the life of products instead of promoting or being passive within a throwaway society (Haines-Gadd et al., 2018). With nine themes, the authors developed 38 strategies incorporated into the product design.

A choice-based method conjoint analysis is beneficial for breaking down CE value propositions and identifying the extent to which particular service-related attributes and product-related attributes contribute to overall customer utility (Lieder et al., 2018). The framework that makes it possible to design products and services to encourage desired circular behaviours is based on the design for behaviour change and the behaviour change wheel (Wastling et al., 2017).

4.3. Customer/stakeholder segment (C/SS)

The checklist of the main factors that influence perception and acceptance of the use of loop solutions using what is used in the VP component (Camacho-Otero et al., 2018). Emotional Durability Design Nine uses the same framework with VP applicable for characterising segments (Haines-Gadd et al., 2018).

4.4. Customer/stakeholder relationship (C/SR)

The checklist used in VP can also be used to evaluate the promise fulfilment and relationship maintenance with consumers in the CE (especially in the access-based PSS) (Camacho-Otero et al., 2018). Emotional Durability Design Nine with VP is applicable for building and maintaining relationships (Haines-Gadd et al., 2018). The model may identify and influence 'pro-circular behaviours' of customers (Muranko et al., 2018).

This tool is for creating future product strategies for CE PSS. The tool visualises the points within a product's lifecycle at which stakeholders are able to intervene in the product's expected journey. CIM contains concentric rings that make it possible to indicate the degree to which an organisation is able to control consumer interventions, with decreasing ability moving away from the centre of the map. At the narrowest level of detail, CIM offers 18 discrete phases of intervention. The tool can also be used for portraying how a particular product lifecycle moves in and out of an organisation's control (Sinclair et al., 2018).

4.5. Key resources (KR)

Asif et al. (2018) proposed an infrastructure for access-based PSS for the washing machine that incorporates various features and properties (e.g. predictive maintenance, ticketing, etc.). A simple framework/checklist for evaluating two categories of digital technologies (IoT and big data and analytics) as the enablers of increasing resource efficiencies, extending the lifespan and closing the loop (Bressanelli et al., 2018). The Circular Material Library should work as a tool to support industrial symbiosis, open to the different stakeholders and to promote the use of recycled materials (Virtanen et al., 2017).

4.6. Key partners (KP)

Franciosi et al. (2017) suggest that a periodic preventive maintenance model establishes the optimal maintenance period for each system component, minimising conventional, environmental, and social costs generated by maintenance interventions and making it possible to choose the most suitable parts from a sustainability perspective. A simple checklist with the summarised key processes enabling closing and slowing the loops (and to some extent also narrowing the loops) (Mestre and Cooper, 2017). This is a proposal of hybrid systems called an ‘Upgradable Product-Service System (Up-PSS)’ that combines upgradability with optimised maintenance, valorisation of end-of-life parts and with the servitisation of the offer. The system can be used as a checklist for practices within PSS when upgrading is needed and as a typology of upgrades (Pialot et al., 2017).

4.7. Cost structure and negative impacts (CS+ NI)

Aguilar-Hernandéz et al. (2018) explained environmentally extended input-output analysis (EEIOA) for circularity interventions, covering the main benefits and problems with the input-output analysis for four circularity scenarios and presenting the process of using this method for the CE. The multi-method simulation technique for the economic and environmental performance of the circular product system is a comprehensive agent-based model and a multi-method-based simulation technique that incorporates various categories of inputs from the external and internal environment, causalities, and inter-dependencies to measure and evaluate different economic and environmental dimensions of the circular product service system performance (Asif et al., 2016). Guidelines for the process of LCA consider the specificities of three different PSS. The guidelines reflect relatively detailed inputs and different requirements from the actors (Kjaer et al., 2018).

This is a simple analytical tool allowing manufacturers to quickly evaluate and compare the potential attractiveness of a circular business model – selling and leasing. ‘The tool shows which parameters drive profit and TCO and permits an easy sensitivity analysis’ (van Loon et al., 2017). The framework consists of an environmental value propositions table (EVPT) and a step-by-step approach towards an evaluation process; the framework can be used for planning and designing new CE business models or for assessing the environmental benefits and the contribution to sustainability; the framework, contents of the EVPT, and the approach has been tested with one recycling company and two real estate companies (one is the real estate company Homie) (Manninen et al., 2018).

A list of several methods and tools for measuring environmental impacts described by Pajula et al. (2017) includes the life cycle assessment (LCA), carbon footprint measurement, tracking of greenhouse gas (GHG) emissions, the water footprint – a tool for assessing potential water-specific environmental impacts of water use associated with a product, process, or organisation, and the handprint – a measurement of the positive changes of actions and the beneficial impacts created within the life cycle of products, services, processes, companies, organisations, or individuals.

4.8. Whole circular model (WM)

The framework may be suitable for evaluating the transition towards circularity, as it considers macro, meso, and micro environments (Antikainen and Valkokari, 2016).

According to Bocken et al. (2018), the purpose of the cycle is to help in designing or redesigning for any sustainability-oriented business models that utilise IoT strategies. The framework combines a level of control between product and user, sustainable design strategies, IoT strategies (capabilities), and other strategies. This is a relatively comprehensive tool for designing new and redesigning existing business models, both for sustainability and circularity (Bocken et al., 2019a). Its comprehensiveness lies in many aspects the model involves and in the mutual linkages.

The framework combines four IoT strategies (monitoring, control, optimisation, and autonomy) connected to/focused on either user or product and other non-IoT strategies (not listed) with seven sustainable design strategies considering the level of control (with the user or product) (Bocken et al., 2019b). The roadmap contains four phases with individual objectives for every phase, a checklist for the important issues in every phase, and a checklist of the key activities and the expected outcome (Frishamar and Parida, 2019). The UIW-framework is used as a template for system implementations of practices to develop a product service system and to support a systematic adaptation to changing needs by developing business models and technologies to support collaborative efforts (Granholm and Grösser, 2017).

This is a proposal of a conceptual framework for circular business network governance with some roots in the balanced scorecard method (Janssen and Stel, 2017). It is a brief proposal to use the cascading of materials in product life management (Kalverkamp et al., 2017). The tool or framework consists of the following building blocks: visions, actor learning, network dynamics, and business model innovation. The tool is suitable for managing key processes and activities, key partner relationships and mutual value creation, delivery, and capture in inter-organisational, network, or whole social system setting (Leising et al., 2018).

The model and tool help to identify proper marketing and pricing strategies to obtain best fit demand behaviour (Lieder et al., 2017). The approach integrates socio-demographic and buying behaviour factors of customers (relative preferences of product attribute prices, environmental friendliness, and service-orientation), product utility functions, social network structures, and inter-agent marketing communication in order to comprehensively describe behaviour at the individual customer level. The BECE framework is also a method and methodology that integrates the backcasting strategic planning approach with the process design in the framework of a circular economy (Mendoza et al., 2017). This means that three CE principles, the ReSOLVE framework with added action IMPLEMENT and developed individual actions with iReSOLVE, and four basic CE frameworks create the playground to develop a circular business model.

Mentink (2014) suggested the method and methodology to develop a circular business model.

Nußholz (2017) provided a circular business model mapping tool that can help: a) to identify which interventions are used and which are not; a holistic overview on possible interventions could indicate opportunities to potentially capture more of the embedded value and organise value-adding activities; b) to examine whether the configuration of business model elements is suitable for efficiently supporting the additional cycles, such as whether *value propositions* are compelling for users in additional cycles or whether *key resources and capabilities* are present to manage the different cycles; c) to unravel a larger variety of phenomena compared to the traditional business model canvas, e.g. *key partners*, *costs*, and *revenues* for each cycle; and d) to show interdependencies between the interventions and how shaping business model elements in one intervention enables value creation from other interventions.

The process model of ecosystem transformation towards a CE paradigm contains two steps with individual activities: ecosystem readiness assessment and ecosystem orchestration mechanisms (Parida et al., 2019). The methodology includes the evaluation tool for five different values created (and captured) in CBM, a visual tool, and the value metric checklist. 'The value circle evaluation scheme assists companies in operating their CBM through an improved understanding of their potential to create value, from a multi-stakeholder perspective' (Ritika, 2017).

4.9. Retention streams, benefits, positive impacts

Tools for revenue streams or benefits are almost non-existent. This might be due to the early stage of existing circular businesses or due to the conscious or unknown problems with capturing intangible benefits, which is probably more typical for circular business in the early period. The same situation is with segments (either customers or other relevant stakeholders). Only two tools fall into that component. The article by Chamberlin and Boks (2018) was not included as it does not contain any tool, even in the form of a checklist. 'Soft tools' prevail. This is not negative, as transformation or transition of the social system as a business requires soft tools.

Aguilar-Hernandéz et al. (2018) used environmentally extended input-output analysis (EEIOA) for circularity interventions that can apply also for revenue streams and benefits. The two-stage dismantling planning method considers both preserving functional value of components and increasing profitability by applying suitable dismantling technologies (Cong et al., 2017). In this paper, disassembly is defined as preservative disassembly, which means that components are kept intact during disassembly.

Nevertheless, softness could be in more harmony with more complex elaboration. As evident from the Table 3, frameworks represent the majority of tools and a very big share of them are really only outlines of real frameworks. The case studies through which some or most of the tools were tested show that the authors are probably cautious or those few bigger companies that turn their attention towards the CE are either not known to the authors or they want to take care for the transition themselves. In most cases, small companies and/or start-ups cooperated in the research.

5. Discussion

The overview shows that the ReSOLVE framework principles of ‘regenerate’ and ‘exchange’ are not often equipped with tools. There are basically no guidelines and only few process models or methods exist. One comment should be added here – there are several tools and toolkits in the form of games, including online games, but these are only sporadically studied in the literature. There are almost no tools that could be used for the IoT or cloud manufacturing and IT platform based business models.

Based on the review, several tools seem to be appropriate for both demonstrators.

Experimentation (Bocken et al., 2019a) with relatively mature methodology is very effective for building and maintaining the organisational and inter-organisational culture and pro circular commitment and enthusiasm. Experimentation and other tools that involve more stakeholders and support sharing, have mutual goals and views, and open the space for mutual strategies play a pivotal role in any change management. The BECE framework, a process model for ecosystem transformation, and Emotional Durability Design Nine can also be very beneficial for such social movements.

The only problem is that both demonstrators are from global mass-market manufacturing and existing experimentation and other tools that help to connect different stakeholders in a one-time window are very challenging if not impossible to apply. Simulation (mathematical or statistical) tools are from the other end of the spectrum, but necessary for large global enterprises with mass production. Another example is visualisation, especially in complex and dynamic environments. Visualisation tools are helpful in any case. The SLR did not detect any special tool for one of the demonstrators and their business, although some tools seem to be focused on consumers and mass consumer goods. The scarcity of tools for logistics and supply chains and for digital infrastructure management is somewhat surprising.

6. Conclusion

The review of CBMs reveals that there are still many unknown areas, or insufficiently known issues. Case studies mapping CBM development, implementation, and testing of large companies for several years are almost non-existent. There is a lack of a more complex understanding of how CBMs of large companies work and of the circumstances for the concrete functioning. The ownership question must be investigated more.

Our results show that there is no transition device that is truly suitable for all types of testing instruments. More testing and developing of CBMs and tools for transition are needed. This paper confirms that SLR has not been able to design and test business model concepts or configurations systematically.

The method we developed, based on the review of several tools, looks useful for both demonstrators in building and maintaining the organisational and inter-organisational culture and pro-circular commitment and enthusiasm. We understand that problems arise from the growth of mass markets worldwide, and current research and other methods that connect different actors are difficult to introduce.

A new issue is also emerging for empirical streams of scientific discourse. It is necessary to evaluate short-term and long-term outputs, outcomes, and results of implementing circular business cycles and tools for transition. There are some conventional methods such as correlation and regression analysis using big data or large firm datasets, or new methods such as randomised quasi experimental design.

Some methodological challenges must be addressed, particularly in the fields of social sciences such as economics and public policy. There will be a strong demand for new methodological approaches to correct effect estimations, solutions for endogeneity, and external validity problems of empirical analysis. Our review focused primarily on CBMs, but the issues of public policy, institutional environment, taxation, and incentive mechanism design remain important. Both practice and research are challenged to gain deeper and broader insights into the business life in a CE.

Acknowledgement

This work was supported by the European Research Framework H2020 research project Resource-efficient Circular Product-Service Systems (ReCiPSS).

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Table captions

Table 1. Review of CE categorized.

Table 2. Result of search queries in databases.

Table 3. Results of systematic literature review.

Table 1.
Review of CE categorized.

CE Categorized	Frameworks, tools, models and methods for decision-making
Resource scarcity	Approach for multi-scale integrated analysis of societal metabolism Multi objective pinch analysis eco-industrial park assessment Promotion of a generic CE concept
Environmental impact	Sustainable supply chain networks as a suitable means of designing closed-loop production systems The model that allows for the analysis of the flow of Waste Electrical and Electronic Equipment (WEEE) through the reverse chain from the point of collection through to final disposal
Economic benefits	Combination of substance flow analysis approach with resource productivity indicator The theoretical framework of corporate sustainability development (CSD) drivers Stocks and flows model for the dynamic assessment of material demands resulting from infrastructure transitions Indicator for “reuse potential” to help both material and waste managers sort out decisions about the technical feasibility of reusing discards Unified CE index System under the condition and trend of green supply chain management Physical input and monetary output model for industrial symbiosis evaluation Hybrid material and energy flow analysis approach at the company level Extended economy-wide material flow analysis model Extended lifecycle assessment (LCA) tool for resource efficiency and more specifically waste management at the end of life products A discontinuous three-stage model of industrial symbiosis drawing on biological, ecological, organizational and systems theory CE indicator system Exploration of methodological issues encountered in the application of LCA to various research questions arising from industrial symbiosis Model for CE evaluation

	Implementation framework for CE Three-level education framework to meet the theoretical and technological needs of CE implementation A new approach called Ecological Sanitation
The intersection of the three perspectives	A methodological framework to measure target and planned resource-conserving and environmental-friendly development Analysis of emerging integration of business value and environmental returns in the context of China's CE Approach to prevent waste and other global impacts based on pre-cycling, CE policy and recycling insurance

Tabel 2 Result of search queries in databases.

Database	Search strings	Interpretation
Web of Science	(TS = ("business model" AND "circular economy" AND ("tool*" OR "method*" OR "approach" OR "strateg*" OR "model*" OR "framework" OR "scheme" OR "roadmap" OR "pattern*" OR “mechanism” OR “practice*”) AND ("**trans***" OR “**innov***” OR “**chang***” OR “**shift**” OR “**adapt***”)) AND LANGUAGE: (English) DOCUMENT TYPES: (Article OR Book OR Book Chapter OR Proceedings Paper) LANGUAGE: English Indexes=SSCI, CPCI-SSH, BKCI-SSH, ESCI	The documents were checked for the presence of keywords in the search string in Topics (encompassing titles, keywords and abstracts) (“TS=” operator). This query generated **87** hits.
Scopus	TITLE-ABS-KEY ("business model" AND "circular economy" AND ("tool*" OR "method*" OR "approach" OR "strateg*" OR "model*" OR "framework" OR "scheme" OR "roadmap" OR "pattern*”) AND ("**trans***" OR “**innov***” OR “**chang***” OR “**shift**” OR “**adapt***”) DOCUMENT TYPES: (Article OR Book OR Book OR Book Chapter OR Conference Paper OR Review OR Article in Press) LANGUAGE: English	The query had identical structure/function as above. This query generated **196** hits.
Proquest	ft("business model" AND "circular economy" AND ("tool*" OR "method*" OR "approach" OR "strateg*" OR "model*" OR "framework" OR "scheme" OR "roadmap" OR ”pattern*" OR “mechanism” OR “practice*”) AND ("**trans***" OR “**innov***” OR “**chang***” OR “**shift**” OR “**adapt***”)) DOCUMENT TYPES: Scholarly journals OR Conference Papers&Proceedings LANGUAGE: English	250
Result	*From 87 document found in Web of Science and 196 documents found in Scopus 70 pieces are the same. Proquest detected 64 new documents. This means that **269 documents in total** from both databases entered the first screening.* “**trans***” aims to search for both transition and transformation processes towards circular business models; **“innov***” aims to search for the innovative (…) or innovation in the endeavour of companies to cope with the CE challenges; “**chang***” aims to search for changing and/or changes in and “**adapt***” for adaptation of parts or of a whole current business model; the same logic is also with the “**shift**” search keyword.	

Table 3 Results of systematic literature review.

Topic, (Authors, Year of Publication)	ReSOLVE framework	Specific strategies	Extended boundaries	Last approach	Type of work	Maturity of tool
Value proposition (VP)						
“Checklist” (and a design tool) of the main factors influencing the perception and acceptance of circular solutions, (Camacho-Otero et al., 2018)	S, O, V	Sl	BF, O, N	CF	TTL	2-3
Emotional Durability Design Nine, (Haines-Gadd et al., 2018)	S, O, L	Sl, (C), (N)	BF, O, N, eS, S	CF, CM, P, PM, VT, (Gm)	TT(R)	4
Conjoint analysis (general statistical method), (Lieder et al., 2018)	O	(Sl)	BF, O, N. S	MM	TTR	4-5
framework “design for circular behavior”, (Wastling et al., 2017)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, CM, P, PM, VT	TT(R)	2-3
Customer/stakeholder segment (C/SS)						
“Checklist” of the main factors influencing the perception and acceptance of circular solutions, (Camacho-Otero et al., 2018)	S, O, V	Sl	BF, O, N	CF	TTL	2-3
Emotional Durability Design Nine, (Haines-Gadd et al., 2018)	S, O, L	Sl, (C), (N)	BF, O, N, eS, S	CF, CM, P, PM, VT, (G)	TT(R)	4
Customer/stakeholder relationship (C/SR)						
“Checklist” of the main factors influencing the perception and acceptance of circular solutions, (Camacho-Otero et al., 2018)	S, O, V	Sl	BF, O, N	CF	TTL	2-3
Emotional Durability Design Nine, (Haines-Gadd et al., 2018)	S, O, L	Sl, (C), (N)	BF, O, N, eS, S	CF, CM, P, PM, VT, (G)	TT(R)	4
The Pro-Circular Change Model (P-CCM), (Muranko et al., 2018)	(R), (S), (O), L	Sl, C, N	BF, O, N, S	CF, VT	T	1
Consumer Intervention Mapping (CIM) Tool, (Sinclair et al., 2018)	(R), S, O, L, V, E	Sl, C	BF, O, N	CF, CM, VT	TTL	2
Key resources (KR)						
ICT infrastructure for PSS, (Asif et al., 2018)	S, O, L, V	Sl, C	BF, O, N		CM, P, T	2-3
Conceptual framework for mapping functionalities of digital technologies to enable CE transition, (Bressanelli et al., 2018)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, (S)	CF	TT(R)	1-2**
Circular Material Library, (Virtanen et al., 2017)	S, O, L, V	Sl	BF, O, N, eS, S	CM, P	T	2-3
Key processes (KP)						
Predictive maintenance model, (Franciosi et al., 2017)	S, O, (L), V, (E)	Sl, C, (N)	BF, O, N, eS, S	CM, MM	TTR	3-4
“Checklist” for key processes (strategies) enabling closing and slowing the loops, (Mestre and Cooper, 2017)	R, S, O, L, V, E	Sl, C, (N)	BF, O, N, eS, S	CF, P, VT	TT(R)	1-2
“Typology of upgrades” and “checklist of practices” for the upgradable PSS, (Pialot et al., 2017)	S, O, L, V, E	Sl, C, N	BF, O, N, (eS)	CF, P, PM	TTR	2-3
Cost structure and negative impacts (CS+ NI)						
Environmentally extended input–output analysis (EEIOA) for circularity interventions, (Aguilar-Hernandéz et al., 2018)	R, S, O, L, V, E	Sl, C, (N)	BF, O, N, eS, S	PM, MM	TT(R)	4
Multi-method simulation technique for the economic and environmental performance of the circular product system, (Asif et al., 2016)	S, O, L, (V) (E)	Sl, C, (N)	BF, O, N, (eS)	CF, CM, P, PM, SS, MM	T	4
Guidelines for life cycle assessment of product service systems, (Kjaer et al., 2018)	R, S, O, L, V E	Sl, C, N	eS	CF	TTL	3-4
Analytical calculation-based tool for assessment of the two BM ways of value capture, (Van Loon et al., 2017)	S, O	Sl	BF, O, N	CM, MM	TTL	3-4
Framework for evaluating the environmental value propositions of CE business models, (Manninen et al., 2018)	R, S, O, L, V E	Sl, C, N	eS	CF	TTR	3

List of several methods and tools for measurement of the impacts on the environment, (Pajula et al., 2017)	R, S, O, L, V E	Sl, C, N	BF, O, N, eS, S	CF, CM, PM	T	3
Whole circular business model (WM)						
Framework for sustainable circular business model innovation, (Antikainen and Valkokari, 2016)	R, S, O, L, V, E	Sl, C, N	O, N, eS, S	CF, VT	TTR	1-2
Circular business experiment cycle, (Bocken et al., 2018)	R, S, O, L, V, E	Sl, C, N	O, N, eS, S	CF, P, VT	TT(R)	2-3
The ecology of business models experimentation map, (Bocken et al., 2019a)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, P, PM, VT	TTR	3-4
A framework to support PSS design to encourage sustainable behaviour using IoT strategies, (Bocken et al., 2019b)	(R), (S), O, L, V, (E)	Sl, C, N	BF, O, N, eS	CF, VT	TT(L)	2-3
A roadmap for circular business model Transformation, (Frishamar and Parida, 2019)	R, S, O, L, V, E	Sl, C, N	O, N, eS, S	CF, P, PM	(TTR)*	2-3
The use-it-wisely (UIW) approach, (Granholm and Grösser, 2017)	R, S, O, L, V, E	Sl, C, N	N, eS	CF, P, PM	TTR	3
Tool for orchestrating value networks, (Janssen and Stel, 2017)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, (P)	T(L) (R)?	1***
Cascade use methodology, (Kalverkamp et al., 2017)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CM, (P)	T(L) (R)?	1***
Collaboration tool for CE, (Leising et al., 2018)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, P, PM	TTR	2-3
Agent-based modelling approach, (Lieder and Rashid, 2017)	S, O, V	-	BF, O, N	SS, MM	TTL	3
BECE framework, (Mendoza et al., 2017)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, CM, P, PM, VT	TTL -(R)	4
Business cycle canvas, (Mentink, 2014)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, P, PM, G, (Gm), VT	TTL -(R)	2-3
Circular business model mapping tool, (Nußholz, 2018)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, P, PM	TTR	2-3
Process model of ecosystem transformation toward a circular economy paradigm, (Parida et al., 2019)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, P, PM	TTR	3-4
Evaluation tool "Value-Circle", (Ritika, 2017)	R, S, O, L, V, E	Sl, C, N	BF, O, N, eS, S	CF, CM, P, PM, VT	TTR	3-4
Retention streams, benefits, positive impacts						
Environmentally extended input-output analysis (EEIOA) for circularity interventions, (Aguilar-Hernandéz et al., 2018)	R, S, O, L, V, E	Sl, C, (N)	BF, O, N, eS, S	PM, MM	TT(R)	4
Two-stage dismantling planning method for value recovery, (Cong et al., 2017)	S, O, L, E	Sl, C, N	BF, O, N, eS, S	CM, SS, MM	T, TTL	3

*created on the empirical research; **potential; ***some potential

***conflict of Interest Statement**

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: