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Maturity Model as a Driver for Circular Economy Transformation

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Abstract: The movement of manufacturing organisations towards a circular economy sets the scene for extensive industrial change. This change is not simply a continuation of current business; instead, it brings up multiple questions concerning ways of thinking, modes of operation, and the very foundation of a business. Manufacturing organisations are experiencing uncertainty regarding how to address this transformation due to its multi-faceted nature. Maturity models are seen by some as a tool for assessing and guiding manufacturing organisations when it comes to complex and multi-faceted agendas, such as that of the circular economy (CE). Maturity models provide scaffolding in the form of presentation of a desired evolution path from which manufacturing organisations can define reasonable and desirable plans for engagement with the circular economy. This study adopts the cumulative capability perspective in developing a CE maturity reference model that explicates the circular transformation by noting six discrete maturity levels across six organisational dimensions: value creation, governance, people and skills, supply chain and partnership, operations and technology, and product and material. The progression of circular maturity is explained by the principles of expertise and the systems perspective. The explication of CE transformation across dimensions and levels provides a boundary object for organisations, i.e., a scaffolding for moving from its current zone of development to its proximal zone of development.

Keywords: maturity model; circular economy sustainability; transition; dynamic capabilities; systems perspective

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1. Introduction

The idea of the CE has gained traction over the last decade in academia, within industry, and with policymakers due to its financial and environmental benefits [1]. Firstly, resource scarcity is threatening current living standards; the consumption of resources is estimated to triple by 2050 [2]. Second, moving towards the CE is estimated to increase the European Union's GDP by 0.5% while creating 700,000 jobs [3]. Lastly, the realisation and anticipation of legislative changes has led to organisations engaging in circular transformation, either to be on top of sustainability demands or to avoid being constrained into operating within the anticipated future legislative landscape.

Despite the well-argued reasoning for adopting CE practices, CE principles have proven troublesome for organisations to implement, as reflected in the explicit research attention on the barriers to adopting CE practices (e.g., [4]). Ref. [5] finds, through surveying manufacturing organisations in the UK and EU, that most organisations have little to no awareness of the concept of CE. This results in a poor understanding of its benefits, and a risk-averse attitude wherein the focus is kept on existing operations. Thus, there have been calls for further research to direct attention to organisations' circular transformation. The authors of [6] call for adopting a systems perspective, i.e., understanding the boundaries and interdependencies between the system components, such as product

design and the business model, to foster the implementation of CE principles. This call comes from the observation that current CE research is fragmented and lacks insight into the CE's implementation in the industry [1]. Similarly, [7] calls for research on elevating the understanding of how to implement CE practices for value generation and capture. In addition, [8] suggests that critical assessments are required to aid the implementation of CE business models, while [9] specifically calls for research into assessment tools and internal capability mapping assessments. To mitigate the many barriers to implementing CE practices, recent research focuses on assessing the current levels of circularity (e.g., [10]), for which CE maturity models are being developed, both in academia (e.g., [11]) and in grey literature (e.g., [12]). However, most of these assessments do not take a systems perspective; they focus on assessing certain geographical regions [10], organisational sizes [13], or fragments of the CE, e.g., circular product design [14]. Furthermore, the assessment outcomes give limited guidance to organisations; they provide numeric assessment scores while providing little to no guidance on how to progress further with CE transformation.

Therefore, this study aims to address the aforementioned calls for research by adopting a systems perspective in guiding organisations in their CE transformation using assessment tools—in this case a maturity model. The objectives are as follows:

- To identify organisational dimensions of the circular economy.
- To identify circular economy maturity levels from the microeconomic perspective.
- To propose, from a systems perspective, a maturity model for the circular transformation for the manufacturing organisation.

The model creates a transparent overview of the CE from organisational, technological, and business perspectives. By defining organisational dimensions in the model, abstract and intangible perceptions about the CE are particularised into tangible areas of improvement. The emphasis on transparency, i.e., insight into what constitutes higher circular maturity in the individual dimensions, allows organisations to develop their circular activities accordingly.

The remainder of the paper is structured as follows: Section 2 outlines the research method for this study; Section 3 presents the theoretical foundation for CE maturity, highlighting the extant literature addressing the circular transformation, i.e., CE dimensions and levels that constitute the foundation on which the maturity model is developed; Section 4 presents model development, where the explicit focus is on specifying the nature of each CE dimension for each CE level; Section 5 discusses the findings, focusing on the difference between exploration and exploitation activities, which create a major gap in the circular transformation of organisations; and Section 6 presents the concluding remarks of this study.

2. Materials and Methods

The study adopts a resource-based view (RBV), which states that the accumulation and configuration of resources are the foundation for organisations for gaining a competitive advantage [15]. When these physical and intellectual resources are non-substitutable and difficult to imitate, the organisation has a longer-lasting competitive advantage [16]. Within the RBV, the cumulative capability model argues that improvements can be achieved concurrently on multiple fronts as improvements reinforce each other across performance measures [17].

In discussing CE transformation, the cumulative capability perspective is adopted in the belief that the achievement of sustainability performance should not come at the expense of the performance of other measures (such as cost and quality); rather, it holds cumulative potential. The authors of [18] support, from a macroeconomic perspective, the idea that the pursuit and achievement of high sustainability performance can be achieved in tandem with other performance measures (e.g., cost-efficiency and flexibility, as highlighted in their study). As such, CE transformation, which for most in the industrial landscape is a transformation from linear principles to circular principles, is a "brownfield" task of building on top of existing capabilities.

The concept of maturity proposes a suitable structure for explicating the elements of CE transformation and how they relate to organisational change. Maturity models define anticipated or desired evolution paths in simplified ways [19] while assuming that the development of mature performance can be defined as taking a predictable and desirable path [19,20]. This desirable path is constructed from the feature of gradation, resulting in ordered, discrete levels representing a hierarchical concept system [20] that allows for descriptive, prescriptive, and comparable models [21]. The maturity model's function is to define structured and evolving capability progression across maturity stages [22], each of which enables the subsequent level [23]. This argument is grounded in the thinking on proximal learning by [24]. By using maturity models, organisations can identify their current zone of development, which is required to define their proximal zone of development, i.e., their desirable engagement of development. This identification of an organisational point of departure is an essential determinant for sustaining a competitive advantage, especially for established organisations that face the challenge of adopting the cumulative capabilities perspective in order to recognise that the existing business system has ongoing relevance with regard to CE transformation.

The concept of maturity progression for the CE domain can be explained through the following two principles: expertise [25] and the systems perspective [26].

The principle of expertise concerns the presence of structures and the level of heuristics that rationalise the organisational efforts towards adopting CE practices. When an organisation has low levels of maturity, it learns about and understands the concept of CE, which allows it to act according to CE principles by following systemised scaffolding, such as fixed guidelines, and targeting codified requirements, e.g., legislation. However, these actions discard contextual contingencies due to the organisation having an oversimplified understanding of the domain. As maturity increases, contextual awareness is developed, which allows for more appropriate actions. However, a lack of boundaries leads to an overwhelming solution space, in which the trade-off among options is difficult to grasp. Higher levels of maturity, i.e., greater expertise, create an intuitive situational understanding, allowing for swift decision-making for which scaffolding in the form of guiding structures becomes increasingly unnecessary [27].

CE principles can be embedded in an organisation in a variety of ways, from a narrow way—represented by silo thinking—to a wide and deep way, i.e., adoption of the systems perspective [26]. When an organisation has a low level of maturity, CE principles appear in silos across the organisation when being addressed for legal purposes (level none) and when the concept is introduced and discussed at management levels (basic level). Similarly, as CE principles become part of explorative activities such as the design and execution of pilot projects, they remain within the silo of the project. When an organisation has a higher level of maturity, CE principles are adopted more widely, as systematisation and integration require aligning CE principles across the organisation and with its external partners. Lastly, when an organisation is at the highest level of maturity, a complete decoupling of value creation and resource consumption is achieved by adopting a comprehensive systems perspective.

2.1. Methodological Foundation

This maturity model is based on the methodological design for conceptual models, as defined by [28]. Relative to empirical research, conceptual model development has a greater creative scope as it does not have data-related limitations [29]. Therefore, emerging domains for which little empirical data are available, such as the CE, can be explored to a greater extent. In doing so, the paper distinguishes between method and domain theories, allowing for the conceptual integration of different theoretical domains. Domain theory is an area of study that can be defined by a set of constructs, theories, and assumptions [30], while method theory represents, or adopts, a "meta-level conceptual system for studying the substantive issue(s) of the domain theory at hand" [31]. For this study, the theoretical field of CE is the domain theory, while the theoretical field of cumulative capabilities, including

maturity models, comprises the method theory. Hence, the theory of maturity models was adopted to create novel insights into the domain of the CE. In doing so, deductive reasoning was used, through the chosen method theory lens, to explain the relationships and constructs among the key variables in the domain theory [30].

2.2. Research Design

Figure 1 depicts the model development approach, starting from a literature search to identify the related research agenda and issues reported academically and from industry, which brought about the motivation for and aims of this study. Subsequently, a literature review was conducted to identify the dimensions and levels used for describing the CE at the organisational level, in the extant literature. This step was perceived as the first step in a two-step process encompassing the literature review and the model development. To guide this search in the literature, the primary keywords used were "circular economy", "maturity model", and "assessment tool". The search was conducted in Google Scholar and the Scopus databases. Reviewing the complete body of literature concerning maturity models for CE was not within the scope of this study; rather, the review sought to generate an overview of existing CE dimensions and levels to lay the foundation for the development of this CE maturity model. Hence, not all papers found using the search terms were actively utilised for this study. The findings from this search were then synthesised in the first iteration of the model development, in which the dimensions and the levels of the maturity model were defined, as explicated in Section 3. This led to the second iteration of the literature review. For this iteration, the emphasis was on populating the model, which in its current form consists of two axes: dimensions and levels. For this stage, the literature was revisited with the purpose of gathering insights into what constitutes each dimension in each maturity level, and the snowball principle was adopted. Hence, references utilised in the identified literature, with a specific focus on the individual dimension, were reviewed to extract the required information. This information is synthesised in the model development—Section 4—in which the model is populated, and the principle of maturity is accounted for, in each of the identified dimensions.

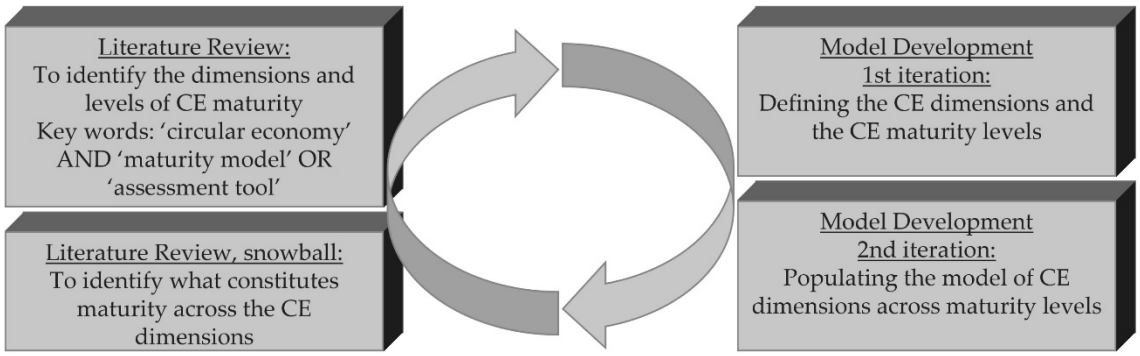

Figure 1. The research procedure for the model development.

3. Literature Review

Table 1 presents an overview of the literature identified and is concluded by realising a saturation of CE dimensions and levels in the extant literature. At first glance, the existing literature contained a wide variety of CE dimensions and levels. While their formulations differ, the meaning and content of the dimensions and levels were coherent across studies. This inconsistency in formulation can be interpreted as conceptual immaturity in the research domain, an issue that is often reported in extant literature (e.g., [9]). Hence, including more literature in the search would not have provided novel insights into the dimensions or the levels of CE.

Table 1. Existing CE dimensions and maturity levels *.

Reference	Purpose of Study	Dimensions	Levels
[32]	Develop a circularity and maturity firm-level assessment tool	Resource recovery, waste management, resource consumption, business model, cooperation and industrial symbiosis, strategy and vision, environment management, eco-design, direct logistics, reverse logistics, marketing and communication, GP, employee satisfaction and participation, training, supplier selection and auditing	0–100%
[11]	Develop a CE readiness self-assessment tool	Organisation, strategy and business model innovation, product and service innovation, manufacturing and value chain, technology and data, use, support and maintenance, take-back and end-of-life strategies, policy and market	
[33]	Study the barriers hindering the implementation of CE practices	Financial, institutional, infrastructural, societal, technological	
[34]	Model the decision-making variables for recovering EoL products	Reverse supply chain, product/service design, business models, end-of-life (EoL) recovery, product/service use, and policy	
[35]	Propose a framework containing the taxonomy of CE strategies for enabling CE innovation	Reinvent, refuse (the paradigm), rethink and reconfigure, revolution replaces (business model), restore, reduce and avoid (raw materials and sourcing, manufacturing, product use and operations, logistics, energy), recirculate (parts and products, materials)	
[36]	Identify enabling factors and strategies for structuring circular business models	Sales model, product design/material composition, IT management/data, maximising the use of recycled materials/components, operations strategy, HR/incentives	
[37]	Review obstacles, catalysts, and ambivalences for CE implementation	Expected economic and other benefits, the threat for business-as-usual, managerial support and existing management systems, legislative and regulative aspects, design and technical aspects, the importance of collaboration, customers and demand, companies' existing knowledge and learning, uncertainty of expectations and outcomes, linear economic model embedded, shortage of resources	
[38]	Review challenges for supply chain redesign for CE	Economic and financial viability, market and competition, product characteristics, standards and regulation, supply chain management, technology, users' behaviour	

Table 1. *Cont.*

Reference	Purpose of Study	Dimensions	Levels
[39]	Study the degree of CE implementation in Basque SMEs		Legal requirements, responsibility assignment, and training, systematisation, ECO2, eco-innovative products and services, environmental management leader
[40]	Analyse the implementation of CE in Amsterdam		Drafting the circular economy program, building circular initiatives, scaling up, mainstreaming
[41]	Propose waste management system of CE processes	Governance, economy, social, environmental, technology	Traditional, common, organised, integrated, smart
[42]	Propose methodology for studying complexity in maturing closed-loop supply chain		Understanding, CLSC goal setting, no-regrets intervention, transition map to a CLSC, anticipative and adaptive steering
[12]	Company-level assessment tool revealing level of achieved circularity	Enablers (strategy and planning, innovation, people and skills, operations, external engagement), outcomes (products and materials, services, plant, property, and equipment assets, water, energy, finance)	A–E grades
[43]	Assessment tool for comparing organisational practices against circular objectives	Core elements (priorities regenerative resources, stretch the lifetime, use waste as a resource), enabling elements (rethink the business model, team up to create joint value, design for the future, incorporate digital technology, strengthen and advance knowledge)	

* Not all studies include both dimensions and levels.

3.1. Dimensions of the Circular Economy

The dimensions found in the extant literature are presented in studies of the barriers to CE (e.g., [33]) or on product categories or when proposing CE maturity models (e.g., [11]). Despite the varying purposes of defining CE dimensions, their general properties can be synthesised into a coherent set of dimensions: value creation, governance, people and skills, supply chain and partnership, operations and technology, and product and material.

First, the *value creation* of circular activities is discussed both from the perspectives of financial viability [38] and the environment, e.g., water and energy management [12], where embedded, linear economic models [37] are creating constraints.

There is a need for *governance* to facilitate value creation. This is frequently discussed in terms of strategy and planning [12], business model [34], and managerial support and existing management systems [36].

Following the need for change in the governance structure is a call for managing *people and skills* [12] to strengthen and advance knowledge [43], through HR incentives [36] such as managing organisational learning activities [37].

The importance of collaboration [37] can be defined as the external dimension of *supply chain and partnership*, which is highlighted in the literature both as an external engagement [12] for acquiring knowledge and as an operational lever to team up and create value [43].

From an internal perspective, the *operations and technology* argue for the relevance of digital technologies [43] and data as means for take-back and end-of-life strategies [11], such as operating R-strategies [35].

Lastly, *product and material* are widely discussed as what enables all other dimensions through their design and composition [36]. Eco-design [32] is a lever to enable optimised product and service design and use [34]. Table 2 recaps and defines the dimensions.

Table 2. Dimensions of the organisational circular economy.

Dimension	Definition
Value Creation	The models utilised for generating and capturing value from CE activities (e.g., sales models, take-back programmes, life-extending services) and environmentally positive performance (e.g., resource and emissions savings and regeneration).
Governance	The strategies and plans for the circular transformation (e.g., resource allocation, circular awareness, and engagement on different hierarchical levels).
People and Skills	The mindset and skills (both internally and with external partners) required for enabling and acting on the circular transformation (e.g., circular competencies, learning, and training culture).
Supply Chain and Partnership	The stakeholders external to the organisation required for the exchange and optimisation of materials, products, and activities (e.g., shared visions and activities, engagement with external experts).
Operations and Technology	The equipment and systems in place for performing CE activities (e.g., machinery and tools, systems aiding the scheduling and identification of appropriate treatment according to value potential).
Product and Material	The characteristics of the products that enable circular strategies and activities (e.g., extended life cycle, simple disassembly, and refurbishment).

3.2. Levels of Circular Transformation

The levels are defined in studies focusing on assessment tools/maturity models (e.g., [11]) or the assessment of CE implementation in specific geographical regions (e.g., [39]). From comparison of existing levels of CE implementation, the following set of coherent CE levels can be defined: none, basic, explorative, systematic, integration, and regenerative.

Initially, with no circular maturity (level *none*), the focus is on complying with legislative boundaries to minimise costs imposed by the legislative penalties [39]. Aside from the legislative focus, no other emphasis or desire to develop circular capabilities exists in the organisation.

Once the agenda of CE makes its appearance in the organisation, at the *basic* level, organisations actively engage in transformation by focusing on creating an understanding of the CE domain [42] and by defining organisational needs and strategies, i.e., drafting their CE program [40].

Next, at the *explorative* level, organisations start experimenting by building circular initiatives [40] within CE dimensions. At this level, the intention of building circular initiatives is not to create economic or environmental value; rather, it is to uncover the potential and value of CE to build knowledge [39].

This is followed by the *systematic* level, where the exploration is transformed into exploitation as activities are incorporated into daily operations along with responsibilities and the structured development of resources [39,41]. Achieving this level of maturity is usually the most invasive for the organisation, as it involves making "no-regrets interventions" [42]. Initially, this will conflict with the existing operations, which are designed and optimised for the linear economy, i.e., the organisation will experience inertia as a barrier to transformation.

This relationship and conflict between the old and new are discussed in Section 5. Subsequently, *integrative* activities within and across organisational boundaries are in focus; here, collaboration is the main driver for more effective and efficient circular operations [41].

Beyond the level of integration, the outlook is unclear or "out of sight", as [40] puts it. This level should be interpreted as the optimal circular organisation that acts as the guiding star. This is the point at which the organisation has achieved absolute decoupling of value creation and resource consumption. This is referred to as the *regenerative* level.

Table 3 recaps and defines the dimensions.

Table 3. Levels of organisational maturity for the circular economy.

Dimension	Definition
None	There is no presence of circular awareness, elements of circular economy in strategies, or related activities in the organisation. Only legal requirements, e.g., for waste handling, are in place.
Basic	The need for CE appears in the organisation, and discussions about how and where to act are happening. Few, unintentional CE principles generate value.
Explorative	Demonstration projects and pilots are initiated across different functions in the organisation to prove the value of the circular economy and to test organisational capabilities.
Systematic	Means for pursuing CE are implemented, by design, throughout the organisation. Successful pilots are implemented, and scaling is initiated.
Integrative	Circular initiatives and ambitions are aligned throughout the organisation and its critical supply chain.
Regenerative	The organisation is truly engaged in the circular economy and is regenerative and restorative by intention and design.

4. Model Development

The maturity reference model contains prescriptive properties to guide organisations engaging in circular transformation. These properties give organisations insight into what constitutes higher CE maturity relative to the organisation's current maturity level. In other words, the maturity reference model enables the organisation to identify its current zone of development and, thereby, define its proximal zone of development [24], i.e., the next desired maturity level. Due to the multifaceted nature of the CE, it is necessary to explicate the nature of each CE dimension at each CE maturity level for the maturity model to be an operational reference model for organisations. This explication, correlating with CE dimensions and levels, is presented in Table 4 and is further elaborated in Sections 4.1–4.6. Additionally, a visual conceptualisation of the maturity model is depicted in Figure 2.

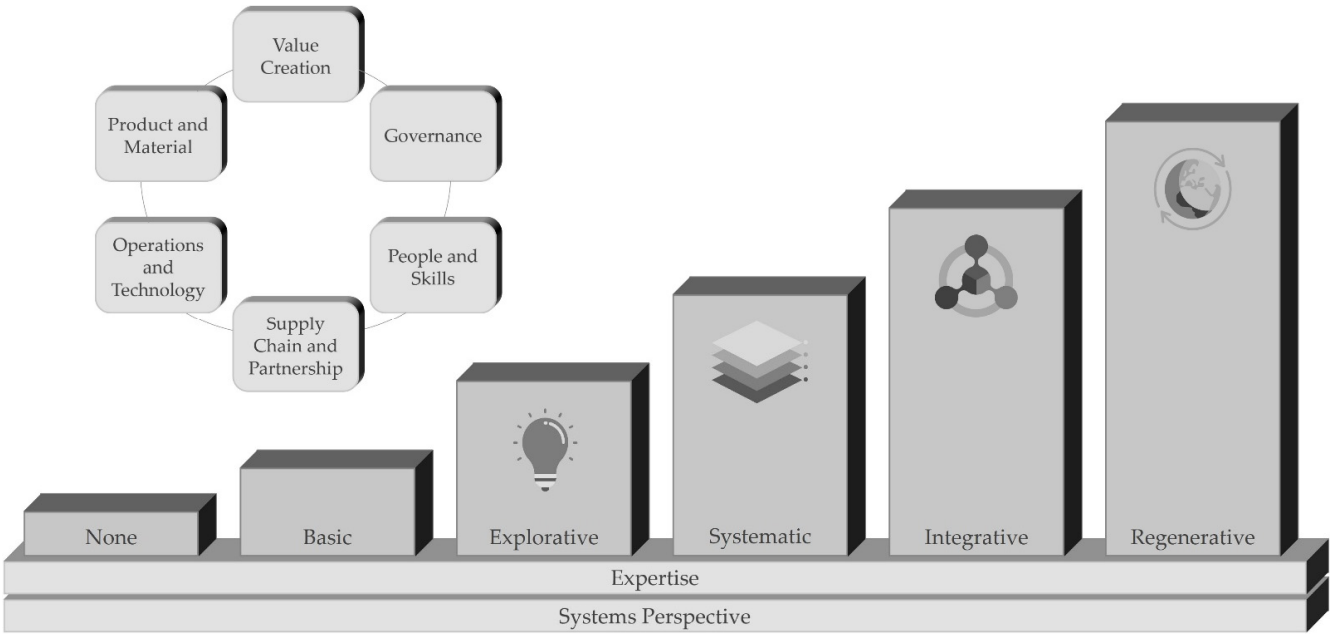

Figure 2. The circular economy maturity model.

Table 4. Circular economy maturity reference model.

	Value Creation	**Governance**	**People and Skills**	**Supply Chain and Partnership**	**Operations and Technology**	**Product and Material**
None	No value is created from CE activities. Waste and emissions are only a concern when imposing cost.	No attention is paid to the circular agenda, and it is not present in the strategy.	No skills for CE are present in the organisation, nor is training for CE in place.	No CE-related engagement with business partners or knowledge institutes.	No activities related to CE are taking place internally or in the supply chain.	The product and its materials are not designed or optimised for CE.
Basic	Waste management generates income. Emissions and waste reductions are achieved through simple "Avoid and Reduce" initiatives.	Simple initiatives emerge sporadically in the organisation. CE has no critical role in the strategy.	No formal training. Few knowledgeable and/or curious resources.	No activities with an explicit focus on CE. Simple environmental improvements with economic benefits are realised.	Simple changes are made to operations to reduce waste and emissions. Operational principles (e.g., just-in-time) are in place to avoid waste.	Product performance and material composition are optimised from traditional cost and quality perspectives.
Explorative	Value is generated through learning and experience in explorative activities regarding CE principles. Sustainability still imposes a trade-off with the traditional performance measures from a lack of appropriation.	Few organisational resources are (partially) allocated to CE. CE is present in the corporate strategy, but it is not operationalised.	Search for knowledge results in sporadic learning activities for dedicated resources. CE is in focus when recruiting.	Explorative projects are executed with a single external partner. Few, one-off, engagements with knowledge institutions take place.	Simple workstations are set up to explore disassembly for R-strategies. Due to the lack of formal procedures, activities in operations and supply chain are hand-held.	Explorative activities around "Design for X" and real-time product health are performed for future product releases. The recycling quality of existing products and materials is tested.
Systematic	Value generation and capture increase as appropriation of CE increases. Trade-offs among performance measures persist from long time lag of previous decisions.	CE is incorporated into the organisational design while the CE strategy is operationalised with defined objectives and activities.	Formal training and knowledge dissemination for critical employees occurs.	Projects with external partners and knowledge institutions are formalised.	Circular processes are formalised alongside existing forward operations. Investments are made to meet expectations of efficiency and effectiveness.	New products and materials are designed for narrowing, slowing, closing, regenerating, and connecting circular strategies.

Table 4. *Cont.*

	Value Creation	Governance	People and Skills	Supply Chain and Partnership	Operations and Technology	Product and Material
Integrative	The focus of appropriation is turned outwards, targeting supply chain optimisation. Multiple circular loops are generating value, for which internal processes and design are effective.	The CE strategy focuses on the supply chain while CE is well-established internally.	CE competencies are part of employee DNA. Formal training with supply chain partners is operationalised.	Infrastructure enabling the exchange of physical and digital resources is well established.	Advanced technology is implemented for automating supply chain information flow for optimising the physical flow of materials and products.	Product health data are available throughout the supply chain, enabling prolonged life cycles and maintaining products in circular loops.
Regenerative	Value is generated from optimised use and cascades between all circular loops.	CE is embedded in the strategy and management of the organisation.	CE competencies are strategically prioritised throughout the organisation and with external partners.	The supply chain facilitates a seamless flow of materials, waste, and information.	Internal and supply chain processes are designed for CE to provide effective and efficient processing of products and materials.	Products are designed for CE, hence material use is minimised while product life cycle is maximised.

4.1. Value Creation

Value creation consists of two elements: value generation and value capture. Value generation refers to generating value from what was previously perceived as waste and is often referred to as R-strategies [35]. Value capture refers to the ability to quantify (e.g., monetarily or emissions-wise) the value generated by R-strategies, i.e., the internal capacity to operationalise the desired R-strategy or the external readiness for such products in the market [44]. Value creation for the CE balances exploration and exploitation, which translates into learning performance value. Due to the novelty of the CE for established organisations, it is of value to capture learning and experience during the circular transformation [45]. In the early levels of maturity, environmental and economic value expectations are lowered in order to open up space to learn from experimental activities. The activities allow the development of learnings and of a baseline for environmental performance. Subsequently, as maturity grows, the focus on value creation shifts towards economic and environmental exploitation of the changes implemented according to CE principles [46].

4.2. Governance

Governance concerns the presence of the CE in strategising and the allocation and organising of resources. Strategising includes the addition of CE principles to strategic intentions, alongside the current strategic focus of the organisation. In the early maturity stages, the presence of the CE in the strategy is not linked to operational performance; rather, the emphasis is on uncovering the potential of CE principles through explorative activities such as proof-of-concept projects [47]. As maturity increases, CE principles take a more operational form in the strategic directions, while its efforts are tied to (primarily) quantifiable goals. Organising concerns the introduction and integration of CE resources into the organisation. Initially, this involves organising the allocation of resources to drive the investigation of CE principles. The emphasis is on allowing for learning and experimentation (i.e., exploration) without expecting immediate performance improvements [48]. As learning accumulates, the emphasis is broadened to include the desire to achieve positive performance changes (i.e., exploitation). This calls for ambidexterity in the organisation, i.e., the capability to simultaneously pursue exploration and exploitation; here, horizontal

linkages are required in the organising structure to bridge the explorative and exploitative activities [49].

As CE interventions spread throughout the organisation, and ultimately its supply chain, the managerial scope should include programme management as well as project management. In programme management, the level of analysis is elevated from the individual project to the organisation and its major parts. In adopting programme management, a systems perspective is adopted, as the various topical and focused themes are addressed coherently, instead of there being individual and isolated themes in a project [50].

4.3. People and Skills

Two levers are present within this dimension: the training of and knowledge sharing by existing human resources and the acquisition of new human resources with the desired qualities [51]. The very early stages of CE transformation are driven by a few curious and potentially knowledgeable resources, but no formal training and knowledge-building about the CE is in place in the organisation. These resources may seek to develop their own CE skills to develop their sustainable agenda further. Once CE is making its presence felt in the organisation—e.g., in organisational strategies—organised efforts to educate existing human resources on the principles of the CE becomes a logical next step. Organisations should emphasise building absorptive capacity, with a focus on developing and applying acquisition, assimilation, transformation, and exploitation [52].

4.4. Supply Chain and Partnership

This dimension concerns the level of circularity across organisational borders, both in the activities controlled by the focal company and the engagement with external partners. Circular supply chain activities have reached critical importance in the CE. Both the reverse supply chain, i.e., value-recovering activities, and the green supply chain, i.e., focusing on the environmental performance of the supply chain, are prerequisites for achieving a circular supply chain [53]. Collaboration with external partners is essential in achieving the circular supply chain, and the maturity of these activities is reflected in performance [54]. Low maturity in supplier management is characterised by internal governance and supplier screening, while high maturity is characterised by inter-organisational collaboration and collective initiatives [55].

4.5. Operations and Technology

Lack of standard operating procedures, the use of general-purpose tools, and lack of automation are typical traits of low maturity, and lead to costly operations [56,57]. Similarly, product and use data availability is crucial for achieving high maturity, as it enables proper treatment of EoL products and, thereby, optimal re-engagement of the product. Data can be utilised for their descriptive capabilities, i.e., the provision of insights into what has happened, and predictive and prescriptive capabilities, i.e., application of past data (knowledge) to determine future events, and action and judgements taken [58]. Without data availability, the process of treatment and re-engagement is disturbed by media breaks and manual decision-making, causing delays and inefficiencies.

4.6. Product and Materials

Product and materials are the main objects around which circular activities revolve. Therefore, their design plays a fundamental role in enabling circularity, through prolonging the lifetime of the products or by recycling materials [59]. When there is low organisational maturity, product design and the materials used to create the products are constraining to circular activities; there may be a lack of alignment across product categories and generations and a lack of emphasis on circularity, e.g., disassembly and repair, in the product design. Increased homogeneity of materials [14] and design simplicity [60] are key principles in initial efforts to improve maturity in this area. With high maturity, the concept of sustainable product design is adopted, e.g., "Eco-Design" or "Design for X" [14],

in which environmental impact and ease of engagement for the product's entire lifetime are considered, including in the areas of materials, manufacturing, use, logistics, and end-of-life. Furthermore, the role of technology is increasingly important in developing higher maturity, i.e., introducing intelligence to products, extending life cycles through health monitoring, predictive maintenance, and self-optimising performance.

5. Discussion

The barriers and challenges related to circular transformation for organisations have been widely studied (e.g., [13]), existing circularity has been widely assessed (e.g., [10,14,61]) and assessment tools have been proposed (e.g., [11,32]). Despite the already extensive attention on circular transformation, recent research has called for further support for organisational adoption of CE principles. Specifically, creating a uniform CE taxonomy, developing CE indexes for assessing and supporting organisations in their transformation, and investigating the required internal capabilities (e.g., through the resource-based view) for the CE organisation (e.g., [8,9]). Therefore, this paper proposes a maturity model for the circular transformation, which specifically addresses the critical intersections between the organisation, technology, and business. The proposed model explains what constitutes circularity and contains prescriptive properties through distinguishing between six organisational and six maturity levels. The defined maturity dimensions and levels, based on existing research, propose a step towards a CE taxonomy. Such a reference model acts as the scaffolding that organisations need to move from their current zone of development to the proximal zone [24], i.e., to improve their circular maturity. It is grounded in the cumulative capability perspective in that it recognises the importance and sustained relevance of the existing business system, rather than advocating for radical reorganisation.

For this discussion, there is a need to distinguish between two types of organisation: "born circular" and "legacy" organisations. Each has a different point of departure moving towards becoming a CE organisation. According to the RBV, the transformation from the linear economy to the CE imposes a shift into what constitutes a competitive advantage. Hence, the resources and capabilities required to sustain competitive advantage change.

"Born circular" organisations, as the name suggests, exist on the premise that they operate according to the principles of the CE and that they are designed accordingly, from or near their founding. These organisations play a disruptive role in the economy, as their "greenfield" design allows for leveraging innovativeness, know-how, and capabilities to unlock novel business potential. This can be seen in previous instances where organisations are born global (e.g., [61]) or born digital (e.g., [62]). However, novel business potential is not to be confused with competitive advantage. Recent studies show that the long history of optimisation of the linear economy proves difficult for the CE to overcome, e.g., as the virgin material cost is cheaper than using recycled materials [1].

Conversely, legacy organisations existed before the emergence of the CE and, hence, are not designed according to its principles; rather, they operate according to the linear economy. This type of organisation faces a challenge in transforming into a CE organisation. The resources and capabilities that gave these organisations a competitive advantage in the linear economy are at risk of becoming rigidities [63] in the CE. Hence, changes in the organisational landscape require a redesign to fit with CE principles.

A major difference between the two organisational types is their point of departure for CE transformation. The "born circular" organisations are leapfrogging [64], i.e., they are "skipping" the lower levels of circular maturity. In other words, they are born out of a commercial idea in which they lack constraints such as existing structure, design, etc. The legacy organisation faces a transformational task: it must move from creating value by consuming resources to initially pursuing a relative decoupling, then pursuing an absolute decoupling between value creation and resource consumption [65].

While assessment tools and maturity models primarily concern what constitutes organisational circularity, they provide little guidance concerning approaching the transformation; this is highlighted as a gap in the extant literature (e.g., [7]). When engaging in

CE transformation, legacy organisations face the challenge of balancing the exploitative activities of the linear economy and exploring the potentials of the CE, i.e., they are required to adopt ambidexterity. The strategies of ambidexterity—i.e., simultaneous and balanced deployment of exploration and exploitation strategies—are fundamentally contradictory, as they require different organisational structures, including different processes and strategies [49]. In the early stages of CE transformation (i.e., maturity levels "none", "basic", and "explorative"), the two strategies can be kept separate, reducing interference between them. However, once the explorative activities are to be converted into exploitative activities (i.e., as part of the move to systematic maturity level), the legacy organisation faces a conflict between linear economy principles and CE-driven activities, which can lead to a performance dip, as discussed later. Figure 3 conceptually illustrates this conflict between the two strategies in relation to the proposed CE maturity levels. The illustration presents a graph that moves along the development of circular maturity (x-axis) and the level of conflict with the legacy business (y-axis). This conflict relates, among other things, to the need to change organisational structures, which temporarily imposes a trade-off relationship between sustainability measures and classic performance measures (e.g., [1,56]).

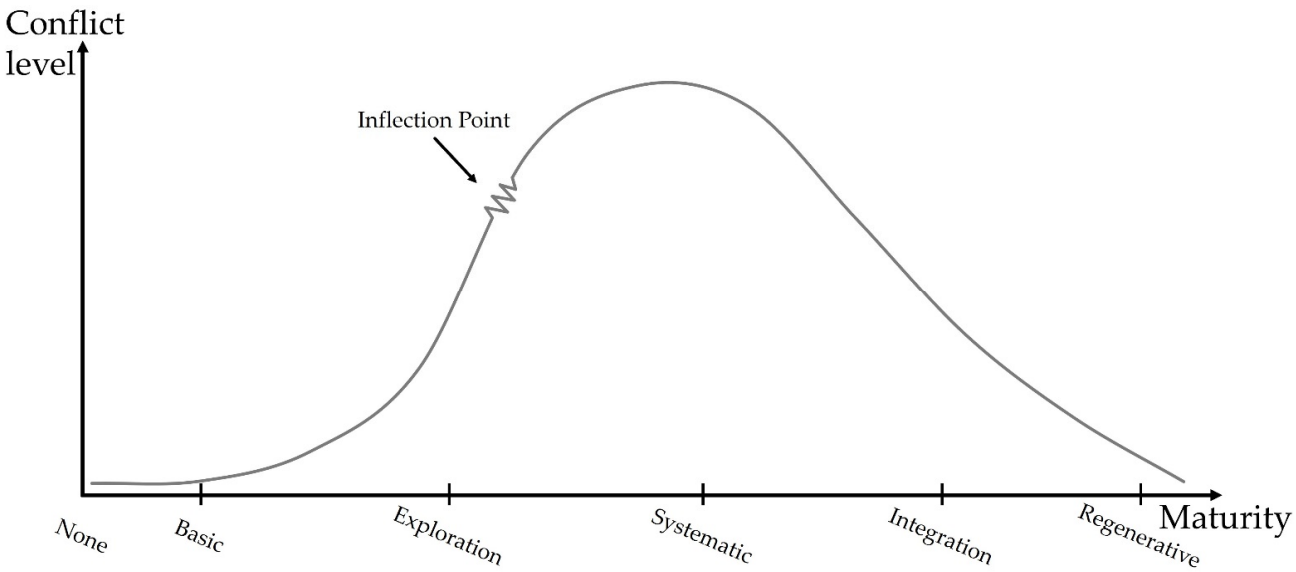

Figure 3. Conceptual visualisation of the inflection point experienced by legacy organisations in their transformation to the CE.

Consequently, organisations are stuck at a relatively low CE maturity level as CE-related activities are kept independent from the legacy organisation in the form of learning activities or pilot projects. Organisations stuck at this level are at risk of turning their core competencies into core rigidities; [63] describes organisations emphasising exploitation with limited attention to translating the learnings from the exploration strategy into exploitation. To reach a higher level of CE maturity, organisations must surpass the inflection point by balancing the explore and exploit strategies for the CE by exposing CE principles to variation-reducing processes [49] that allow the exploitation of operational and environmental value.

In CE transformation, especially when the inflection point is passed, organisations are at risk of experiencing a performance dip [66]. This performance dip is a consequence of the embeddedness of organisational dimensions [67], and the magnitude and length of the dip are affected by the transformation process. To meet this challenge, the theoretical perspective of dynamic capabilities, an extension of the resource-based view [16], is relevant due to its emphasis on building competitiveness in changing environments, such as the CE environment [68]. Recent studies have found coherence between the practices, i.e., skills, processes, procedures, and activities, conducted in relation to CE transformation and the

principles of dynamic capabilities, i.e., sensing, seizing, and reconfiguring [69]. On the subject of a successful process of change, Danish philosopher Søren Kierkegaard [70] stated:

> "If one is truly to succeed in leading a person to a specific place, one must first and foremost take care to find him where he is and begin there".

This quote has resonance with the principle of dynamic capabilities—the ability to scan internal and external opportunities and threats, in this case, with regard to CE transformation [68]. As previously exemplified, organisations adopting CE principles are not, currently, guaranteed to achieve competitive advantage. Therefore, transformation must carefully balance opportunities and threats. The use of the maturity model supports such a balancing act (i.e., it provides scaffolding), as its prescriptive properties allow the organisation to adopt the systems perspective in considering long-term goals and aiding the process of sensing as a means for more appropriate seizing and reconfiguration activities.

6. Conclusions

This paper proposes a maturity model for CE transformation. The model is microeconomic in focus, i.e., it considers the individual organisation. The model is characterised by six dimensions for applying the principles of CE within organisations: value creation, governance, people and skills, supply chain and partnership, operations and technology, and product and material. Furthermore, the model proposes that there are six levels of CE maturity: none, basic, explorative, systematic, integrative, and regenerative.

6.1. Theoretical and Practical Implications

The research outlines the dimensions for CE from a systems perspective. The dimensions noted may serve as a foundation from which fellow researchers can investigate CE transformation. Additionally, this study approaches CE transformation from the cumulative capability perspective, thereby indirectly calling for further research in approaching CE transformation from the same perspective, i.e., transforming organisations by changing and adding to their existing capabilities.

The implication of this research for practitioners concerns the need to guide CE transformation. The maturity reference model serves as a tool for structuring CE maturity progression by enabling the definition of the zone of proximal development for the individual organisation. According to the cumulative capability perspective, the model invites practitioners to approach CE transformation from a systems perspective while building on existing capabilities.

6.2. Future Research

There are two dimensions to the proposed future research on this maturity model. First, there is great empirical research potential in applying this maturity reference model as a tool for guiding CE transformation in organisations. Secondly, each of the six dimensions holds great potential for further research. The dimensions are already addressed in the extant literature, yet their relationship to the six maturity levels and interrelationship with other CE dimensions can be explored further.

6.3. Limitations

The adoption of the methodological approach is a limitation of this study. The lack of empirical grounding may prove a risk to the model's industrial relevance in its current form. Furthermore, while the proposed maturity model is not "one size fits all," its industry-wide applicability is questionable. Therefore, it is expected that the model will need adjustment or expert facilitation to accommodate the individual industrial setting. Additionally, the model could be supported by the development of quantitative methods, such as multicriteria analysis or the use of the Likert scale in a potential questionnaire, to aid assessment.

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