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Materials to resources—innovating economic agency in a circular economy

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Abstract: Understanding the circular economy (CE) is vital for sustainable innovation. By realizing cyclic material flows in a market context, CE can prevent environmentally harmful take-make-dispose market-outcomes. However, theoretical endeavors in CE have focused on conceptualizing material flows on a system level without the theoretical understanding of the link between materials and economic activity. This is a detrimental gap, as the CE literature explicitly expresses the aim of linking economic behavior to material flows and their environmental outcomes. We structure this link by theorizing why materials flow in the market by building on the literature in sociology, economics, and marketing. We explain the materials to flow with the process between human and non-human actors, leading to material–resource or material–waste conversions. Based on these conversions, we build a model for materials in economic agency and show why material conversions render the well-established dichotomy of linear and circular flows meaningless in a market context.

Keywords: Circular economy; materials; material flows; resources; economic agency; value creation; economics; market

1 Introduction

In the last decade, the Circular Economy (CE) has emerged as a prominent approach to carbon neutrality (Türkeli et al., 2018), resource efficiency (Ghisellini, Cialani and Ulgiati, 2016), industrial ecology (Zaoual and Lecocq, 2018), and as an overall framework for the global transition to sustainability (Hopkinson et al., 2018). CE aims to conceptualize systems of material use where, instead of ecologically unsustainable linear extract-produce-use-dump material and energy flows (Frosch and Gallopoulos, 1989), the flows are organized in a cyclical way, preventing the excessive dump and thereby diminishing the long-term cost to the natural environment (Korhonen, Honkasalo and Seppälä, 2018). As implied by the concept itself, the CE literature explicitly expresses the aim of understanding material flows in the context of economic activity (see, e.g., Kirchherr, Reike and Hekkert, 2017; Murray, Skene and Haynes, 2017; Prieto-Sandoval, Jaca and Ormazabal, 2018) characterized by resource integration and value creation through the act of exchange (Vargo and Lusch, 2004, 2016). However, by far, theoretical

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endeavors in CE have focused on conceptualizing material flows in economic systems (e.g., reduce, reuse, recycle, repair, refurbish, remanufacture, repurpose, recover; Reike, Vermeulen and Witjes, 2018), leaving the link between flows and economic activity unaddressed. Considering the explicitly expressed aim of CE, this is a detrimental gap.

In this paper, we contribute to this gap by theorizing why materials flow in the market. By utilizing the literature in sociology, economics, and marketing, we build on the theory of material agency (e.g., Latour, 1996; Pickering, 1993), the institutionalist theory of resources (e.g., De Gregori, 1987; Zimmermann, 1951), and the theory of value creation (e.g., Grönroos and Voima, 2013; Vargo and Lusch, 2004, 2011). By merging these established streams, we conceptually show that, in the context of economic activity, *material flows happen due to two kinds of material conversions: material–resource conversion, or material–waste conversion. Material conversions are inter-agential processes between human actors and material substance. These processes either bring to light the capabilities that define the functional relationship to material, rendering it to a resource, or they lead to an absence of function in the relationship, rendering the material to waste.* Both conversions cause materials to flow, as economic actors either want to buy resources to create value or buy services to dispose of the waste, to avoid opportunity costs of dysfunctional materials. We further build on our reasoning by structuring the model for materials in economic agency and we illustrate our theorizing with empirical observations gathered on material flows in contemporary CE settings. Finally, we examine our theory building in light of CE principles by showing why *material conversions render the well-established dichotomy of linear and circular flows meaningless in the market context,* and discuss how this should be accounted by future CE research.

This paper builds three theoretical contributions. First, we provide the explanation for material flows in the market by structuring the concepts of material–resource and material–waste conversions. Second, we utilize these concepts to structure the model of materials in economic agency, to explain the intertwined nature of material and human entities in economic activity. Third, we show why understanding material conversions renders the dichotomy of linear and circular flows meaningless in the market context, and we discuss what this means for the future of CE research. As economic activity accounts for a great proportion—as do social (Padilla-Rivera, Russo-Garrido and Merveille, 2020) and environmental (Goodland, 1995) activity—of the outcomes of materials, our work contributes to all contexts of material flows in the CE literature: social, environmental, and economic.

2 Materials in economic agency and value creation

We start our theory building by examining value creation and materials in the context of CE. We then focus on value creation in market contexts and deepen our understanding by explaining the role of materials as manifestations of resources in market exchange. We conclude the section by presenting our conceptualization of material–resource/waste conversions and theorizing how materials "become" resources.

Materials and value creation in a circular economy

In the time of growing concern about our environment, the circular economy (CE) has gained wide traction among scientists and practitioners, who have viewed it as an operationalization by which businesses can aim for a sustainable future (e.g., Kirchherr,

Reike and Hekkert, 2017). By synthesizing the varying scientific definitions presented, we may define CE as *an economic system or model interested in how materials that are meaningful for societies are used and transformed within economies over time (Blomsma and Tennant, 2020) in such a way that the highest utility or value of products, components, and materials can be extracted throughout the material lifecycle (Zacho, Mosgaard and Riisgaard, 2018) in order to maximize ecosystem functioning and human well-being (Murray, Skene and Haynes, 2017). CE reconsiders the way human society is interrelated with nature at the micro, meso, and macro levels (Prieto-Sandoval, Jaca and Ormazabal, 2018) and bases the circular business models on the principles of reducing, reusing, recycling, and recovering materials to accomplish sustainable development in environmental, social, and economic terms (Kirchherr, Reike and Hekkert, 2017)*.

As expressed by the CE definition, the perception of value in CE is pluralistic, including environmental, social, and economic value. Thus, the core of practicing sustainable business is to achieve a competitive advantage by delivering to the customer such value that now also includes social and environmental dimensions alongside the economic ones (Yang et al., 2017). In other words, the concept of value should be reconsidered in CE and the complexity of sustainability understood for achieving sustainable value (Kristensen and Remmen, 2019). This sustainable value related to materials is to be created and preserved in closed systems as long as possible (Zacho, Mosgaard and Riisgaard, 2018). Indeed, value in CE is linked to material flows in an inseparable way. There are different value levels related to the resource-efficiency in flows of materials (i.e., used goods to be incinerated, raw materials to be recycled, goods to be remanufactured and goods in use to be reused; Zacho, Mosgaard and Riisgaard, 2018).

The generally shared core concept of CE is the cyclical closed-loop system where the economy has no net effect on the environment by being circular, i.e., restoring damages caused during resource acquisition and generating waste as little as possible (Murray, Skene and Haynes, 2017). Indeed, CE deals ultimately with resource cycling and is a "Resources Circulated Economy" (see Yang and Feng, 2008, 814). The shared common basis of circular business models seems to be that the models substitute primary material input with secondary production, extend the lifetime of products through longer lifespans and a second life, and concentrate on material recycling (Nußholz, 2017). In other words, value in CE is embedded in materials, and CE aims for creating environmental, social, and economic value through cyclical flows of materials.

However, this paper concentrates explicitly on the economic value that we still argue to be the requirement for any business to prosper (see, e.g., Ranta, Aarikka-Stenroos and Mäkinen, 2018), be it circular or some other economic model. In CE, business models are tailored material feedstock-wise to enable the recovery of the specific feedstocks, which also differentiates the related value capture and creation strategies (Valve, Lazarevic and Humalisto, 2021). The fundamental challenge of implementing CE principles for companies is "to rethink their supply chains [in order to develop diverse reverse cycles], and as a consequence the way they create and deliver value through their business models" (Lüdeke-Freund, Gold and Bocken, 2019). This means a need to integrate business models that consider the value creation architectures of firms with circular strategies that aim for resource efficiency through circular resource flows (Nußholz, 2017).

Yet, CE business studies have not explicitly concentrated on the related economic value perspectives and value creation logic to answer how to execute environmentally friendly yet profitable businesses in CE (Ranta, Aarikka-Stenroos and Mäkinen, 2018). To

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promote a more circular economy, it is still necessary to study how business models interact with and reorganize material circuits (Valve, Lazarevic and Humalisto, 2021).

Resources as a basis for value creation in markets

To understand material circuits in a market context, we first need to capture their relevance in the context of market value creation, which has largely been recognized as the main driver for actors to participate in market exchange (Sheth and Uslay, 2007). To put in other words, actors participate in exchange for getting access to something they deem valuable to them. When compared to pluralistic value conceptualization in CE (social, environmental, economic) (Yang et al., 2017), value creation in a market setting can more simply be explained by customer value (i.e., what can I get as a customer, or what can our company provide to our customers) (Grönroos and Voima, 2013; Teece, 2010). Although the dichotomy between actors who produce (producers) and actors who consume (consumers) is well established, both kinds of actors are fundamentally driven by their pursuit of value creation. Consumers purchase products and services to satisfy their needs (Houston and Gassenheimer, 1987). Companies, on the other hand, acquire means of production and resources to produce products and services that they can sell for profit (Wernerfelt, 1984).

Early classical and neoclassical economics conceptualized the relation of materials and value creation similar to that of CE. Value was seen to be embedded in matter, either as an inherent property, or created through manufacturing. Value was then exchanged to a monetary amount of value (i.e., price) and transferred from provider to customer with the material body (see, e.g., Marshall, 1890; Say, 1821; Shaw, 1912; Smith, 1776). However, in later, vastly marketing-dominated discussion, the understanding of value creation in economic activity has developed drastically. In the current paradigm of value creation, value is not perceived as a property of the matter but rather as something to be created in use (Eggert et al., 2018; Grönroos and Voima, 2013). This automatically emphasizes the customer's role in value creation. Customers are no longer seen as passive receivers of value embedded in physical products, but as active creators of value by using the products (Vargo and Lusch, 2004). This means that value creation is then not only dependent on the provider's capability to create a product or service, but also on the customer's capability to use the product or to participate in the service as intended (Grönroos, 2011; Vargo and Lusch, 2008).

The capability of using something for something is the definition of a resource. Resources are not things or stuff or materials but capabilities that define a functional relationship between human and non-human substance (De Gregori, 1987; Zimmermann 1951). As all products and services are, in essence, outcomes of purposefully applied capabilities, they fundamentally manifest a set of interdependent functional relationships (i.e., a set of resources). For example, consider a factory assembly line, in which each person uses his/her knowledge to carry their part of a process leading to a finished product. Furthermore, products and services have an intended purpose planned by the provider. To put in other words, products and services have potentially functional relationships between them and the user/participant. These potentially functional relationships are more often referred to as value propositions (Teece, 2010) or as potential value (Grönroos and Voima, 2013). Users of the products and participants of the service then realize the functionality of the relationship (or more familiarly, they realize the value) by bringing in their capabilities to use a product for their purpose, or their capabilities to participate in a service (Grönroos and Voima, 2013; Vargo and Lusch, 2004). This renders all economic actors as resource integrators (Vargo and Lusch, 2008,

2011, 2016). To understand material flows in markets, we next focus on the relationship between materials and resources.

Resources are not, they become

As defined earlier, resources are not materials themselves but the capabilities to use materials for a given purpose (i.e., capabilities that define functional relationships) (De Gregori, 1987; Zimmermann, 1951). As resources, by definition, have use, so are they also prone to flow in markets, as economic actors need them to create value. In other words, economic actors participate to exchange to access resources, that can then be used to the purposes the actors have capabilities to identify. We also emphasize that "resource likeness" (i.e., the existence of a functional relationship) is not an inherent, fixed property of a material but emerges through time in inter-agential processes between humans and materials (Jokinen et al., 2021), in which humans learn how a given material could be used (Zimmermann, 1951). In this paper we call this process the *material–resource conversion.*

Materials can also lose their resource status, either with a change in material properties or a change in the capabilities that defined the functional relationship to the material (De Gregori, 1987). We refer to this as the *material–waste conversion* and define waste as an opposite of a resource, as *an absence of capabilities defining function in the relationship.* Like the *material–resource conversions,* also the *material–waste conversions* can explain material flows. Unlike the *material–resource conversions*, where material flow is based on identified ways of using the material, in *material–waste conversion* economic actors are willing to exchange for service that promises to dispose of such material. Although waste is often approached through its material properties or place of origin (Huysman et al., 2017), we argue that, in the market context in which actors aim for value creation, the absence of function in the relationship to material is the fundamental defining factor. This brings economic actors to a situation where the inability to identify the use brings to the material an opportunity cost, compared to usable material that could occupy the same space. This creates a motivation to dispose of the material.

As an action, material–resource/waste conversion takes place in the interaction of material and human agency where the material in question is given a status of resource or waste by humans. In this action, materials have their own voice (see Russell, 2018) and ways to resist and reshape the practices of humans (Fatimah and Arora, 2016). Materials "do not have agency by themselves, if only because they are never by themselves" (Sayes, 2014), but materials are temporally emergent (see Pickering, 1993) in the dynamic spatio-temporal relations between material and human agency (Malafouris, 2008). This means that material is never a neutral distinct actor observable as such; when confronted by humans, a material unveils itself though different representations based on how humans experience it. Thus, human actors, being unable to definitively know the contours of material agency in advance, need to continuously explore (Pickering, 1993).

As humans have intentions toward materials (usually an intention toward capturing some essence of the material), they try to align the material toward this goal, i.e., to manipulate materials to work as humans' allies (Fatimah and Arora, 2016). This process of conversion happens between the humans and material agency that are in a temporally emergent dialogue of resistance (i.e., "occurrence of a block on the path to some goal" as nonhumans resist the control by humans) and accommodation (i.e., human actors revising their action as trying to overcome or avoid those resistances), where human agency tries to capture and control the material agency toward its goals (cf. Pickering's (1993)

"mangle of practice"). In this dialogue, the two agencies are "interactively stabilized over time" through mutual adjustments (cf. Pickering's (1995) "dance of agency"). Based on how well the material in question becomes our ally, i.e., aligned with our goals, in this interaction, the material is converted into resources (material aligning with humans' goals) or waste (material misaligned with humans' goals), depending on the meanings defined by humans.

3 The model for materials in economic agency

In this paper we argue that two kinds of different material conversions conceptualize the fundamental explaining phenomena behind material flows in the market: *material–resource conversions* and *material–waste conversions.* In this section, we structure our argument to the model of materials in economic agency. Table 1 summarizes key concepts discussed in this paper and utilized in our model.

Table 1 Key concepts for understanding materials in economic agency

Concept	*Definition*	*Implication to materials*
Economic agency	Dynamics between actions and actors that aim to value creation (Sheth and Uslay, 2007) by integrating resources through participating to exchange (Vargo and Lusch, 2004, 2016)	Materials take part in economic agency together with human and other non-human elements (e.g., technology).
Value creation	The act of integrating resources for the given purpose (Vargo and Lusch, 2004, 2016). The value is determined in the process of integration (i.e., in use) by the user and in relation to what was expected prior to the use.	Materials take part in value creation by manifesting the resources.
Resources	Capabilities that define function in relationships between human and non-human substance (adapted from De Gregori, 1987; Zimmermann, 1951).	Resources can manifest through materials (De Gregori, 1987). Resources are not materials themselves, but the capabilities to find the use for given materials.
Waste	The absence of capabilities that define the function in relationship between a human and non-human substance.	Waste comprises materials that do not serve any purpose to us, but with which we are forced to interact.

To summarize our reasoning for why materials flow in the market, a visual model of materials in economic agency is provided in Figure 1. The model shows how a material enters the circle of agencies (*the arrowed circle in the figure*) when there forms an interaction between a human actor(s) and the representation of the material. In this interaction, the representation of the material receives meanings based on which humans give the material either the status of resource or waste. This process, where the material becomes a part of economic agency (*the square in the figure*), we call conversion. Economic agency in turn refers to the humans creating value by integrating resources and

abandoning wastes (*the smaller circle in the figure*). To further explain and validate our conceptual model, next we apply the model in an empirical case, namely, zero fiber.

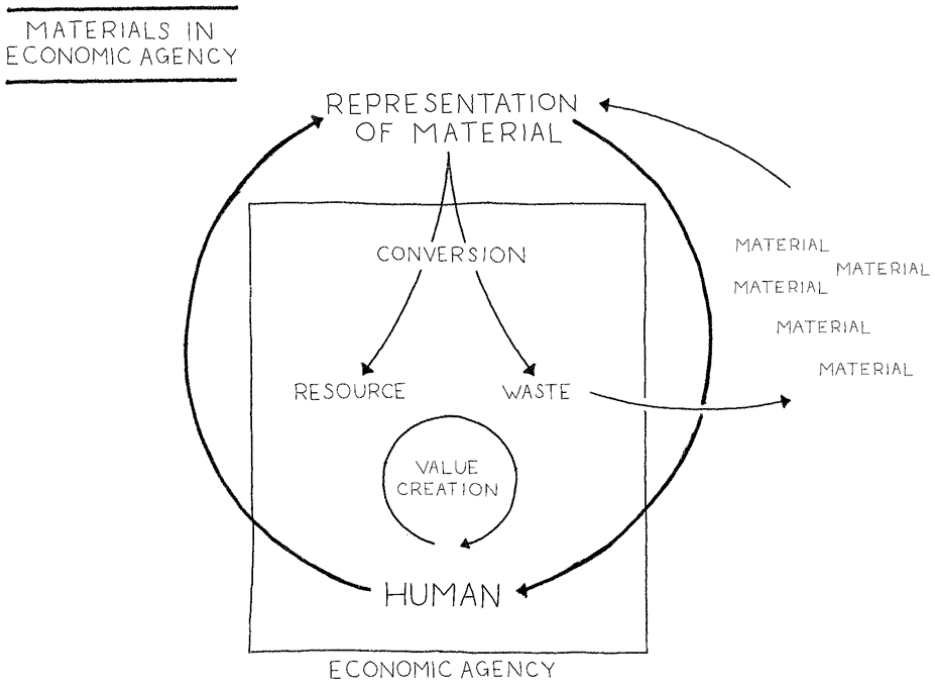

Figure 1 The model of materials in economic agency.

In the City of Tampere (Finland), there lays approximately 1.5 M m3 of sedimented zero fiber in the bay of Lake Näsijärvi. Zero fiber is a by-product of cellulose manufacturing, usually viewed as not having business potential, which is why a pulp mill previously legally disposed of the fiber at the bottom of the bay. After the fiber has been "a part of" the Lake Näsijärvi for decades, the City of Tampere has now become interested in the fiber as it limits the lake's value for the planned suburban area and poses a future risk of greenhouse gas emissions. Here, the zero fiber (or actually the representation of it as "potentially usable material") enters the cycle of agencies as humans start to have intentions toward it (*arrow from materials to representation of material in Figure 1*).

The city, various companies, and research institutes are now trying to find ways to remove the zero fiber from the lake and utilize it in a profitable way. This creates an interaction between human and material agency where humans interact with different representations of the zero fiber (*the arrowed circle in Figure 1*). This is to say, humans seldom identify the whole essence of a material, and we interact with the material through our experiences of it. Moreover, the interaction between the zero fiber and humans unveils new characteristics of the material, i.e., new representations of it.

As the actors are interested in the business potential of the zero fiber, the fiber potentially enters economic agency (the *square in Figure 1*; note that the square highlights how we now concentrate only on one dimension of agency; we do not consider environmental or social agency related to human–material interaction here). This entering happens through a process of conversion (the *two-headed arrow in Figure 1*) where several humans and

representations of the material interact as humans perform various pilot studies, tests, and studies with the zero fiber, aiming to find those representations for which humans possess capabilities to find a use. For example, there have been studies on the suitability of the fiber for composting, biogas production, incineration, and biological conversion into chemicals. One notable attempt has been to desiccate the fiber (90% of the sedimented fiber mass lifted from the lake is water) and in this way shape it into a resource for further processors. Ultimately, the process of conversion leads to humans giving the material a resource or waste status based on how well the representation of the material is aligned with humans' goals and capabilities.

The economic agency manifests itself when humans interact with the material, now experienced as a resource or waste, and create value with it (*the small circle in Figure 1*). When a material is experienced as a resource, it manifests some capability that some humans are interested in utilizing. As an example, there have been pilot studies where the zero fiber has been processed into biogas, i.e., the fiber manifests a capability of producing biogas. If a material is experienced as a waste, humans do not have capabilities to utilize it and want to abandon it because of the costs (e.g., storage costs of the material) and the opportunity costs related to it. This was the case in the first place when a pulp mill disposed of the zero fiber in the lake. When the waste is abandoned and the interaction between it and humans ends, it becomes a material in nature, outside the realm of human interaction—as the zero fiber has been for decades in the bay of Lake Näsijärvi.

Finally, materials in economic agency can be part of an ongoing interaction in which a resource can become new resource(s) or waste. This happens through the circle of agencies where interaction with the resource can result in new representations of materials that enter the economic agency. Also, waste that has exited the economic agency and become non-interacting material can return to the circle of agencies as different representations and eventually become a resource. As a hypothetical example, if the zero fiber were to be processed into biogas, the process residues that are waste for the biogas plant could be reconsidered as resources by biofertilizer producers.

4 Discussion

In this paper we have explained how the materials flow in the market by structuring the concepts of material–resource and material–waste conversions and we have utilized these to build the model of materials in economic agency by which to explain the intertwined nature of materials and economic activity. When reflecting on our reasoning from the CE objective to create circular material flows (Murray, Skene and Haynes, 2017), we come to the crucial realization of temporality, introduced by the linearity or circularity of the material flow. For the flow to be determined as linear or circular, it needs to have its history in the market system. While circular flows have existed and continue to exist in markets (Yang and Feng, 2008, p. 814), linear flows require an end point to their history; in the CE literature this is usually referred to as dumping (Frosch and Gallopoulos, 1989) or disposing (Moreno et al., 2016). From the perspective of market dynamics, materials are used as instantiations of resources (De Gregori, 1987). And, by integrating resources actors create value in the present moment of use (Grönroos and Voima, 2013; Vargo and Lusch, 2016). When looking from the temporality viewpoint, this means that the history of the material is embedded in current material properties. Naturally, market perspective cannot blindly deny that we might still acknowledge the history that materials have. In fact, many brands quite liberally introduce their raw material sources and production phases, as this knowledge can manifest a valuable resource for their customers (for a

detailed discussion on knowledge and brand as a resource in value creation, see, e.g., Chandler and Vargo, 2011). Furthermore, as materials are not destined with ever existing/non-existing functional relationships with human actors (De Gregori, 1987; Zimmermann, 1951) and we can only unclearly, if at all, predict the future (Kahneman and Tversky, 1973), it makes little to no sense to destine certain flows to be linear—let alone label linearity to an economic model of any sort (for linearity as an economic model, see, e.g., Ghisellini et al., 2016; Ness, 2008).

While we argue that the linear–circular dichotomy makes no sense from an economics perspective, we cannot emphasize enough how it makes complete sense from the environmental and social perspectives. Materials can have drastic and long-lasting effects on both social and natural environments in all phases of their flow, leading the history of material to matter in a very literal, and also in a future-defining (Huysman et al., 2017) sense. From this viewpoint it is also reasonable to identify flows that appear linear at certain times, and although the interaction between material and human actors may have ended, the material continues to exist in the natural environment.

Furthermore, it is highly important to emphasize that markets are deeply intertwined with both social and natural environments (Goodland, 1995), to the point where natural environments, as well as cultural and legal institutions, directly influence the materials that can manifest resources and how the integration of given resources can be organized (Ranta et al., 2018). Moreover, knowledge of the outcomes of materials in nature or society can manifest important resources for economic activity, and thereby greatly affect resource integration in market systems.

Academics in the field of CE are left with the immensely complex task of understanding the link between materials and value creation in three systems: environmental, social, and economic (Yang et al., 2017). As individuals and materials simultaneously exist in all of these, the outcomes of one system are also shared with the other two. However, as previously discussed, the ways to conceptualize value creation as well as the fundamental understanding of what constitutes a value, drastically differ among these systems. While the theoretical tools to identify, let alone to understand, the interrelated dynamics these differences constitute are yet largely missing, we hope that this work helps to bridge this gap by focusing on the links between value and materials in the context of economic agency.

This paper has built a total of three theoretical contributions. First, we provided the explanation for material flows in the market by structuring the concepts of material–resource and material–waste conversions. Second, we utilized these concepts to structure the model of materials in economic agency in order to explain the intertwined nature of materials and humans in economic activity. Third, we showed why understanding material conversions render the dichotomy of linear and circular flows meaningless in the market context, and we discussed this from the perspective of CE research. As economic activity accounts for a great proportion of outcomes of materials, as does social (Padilla-Rivera, Russo-Garrido and Merveille, 2020) and environmental activity (Goodland, 1995), our work has contributed to all contexts of material flows in the CE literature: social, environmental, and economic.

From a practical perspective, we address our contribution to regional development professionals and policy makers who are balancing between the environmental, social, and economic prosperity of their area of responsibility. Understanding the link between materials, value creation, and economic agency enables decision-makers to identify

operation models early on that might later fail due to their economic unsustainability. Furthermore, our work helps business developers and C-level managers in charge of creating circular business model innovations to better understand the business potential of material flows and resources.

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