

The role of a boundary object in legitimacy-making strategies for food waste innovation: The perspective of emergent circular supply chains

Abstract

Purpose: Circular economy advocates innovations that upcycle wastes in food supply chain to generate high added-value materials. These innovations are not only disruptive and green but they are often initiated by startups, leading to the emergence of novel open-loop supply chains connecting actors in food and non-food sectors. While earlier research has highlighted the need to seek legitimacy for disruptive innovations to survive and grow, little is known about how these innovations occur and evolve across sectors. This paper aims to elaborate this mechanism by exploring the function of the circular economy as a boundary object to facilitate legitimacy-seeking strategies.

Design/methodology/approach: An exploratory multiple-case research design is adopted and features food waste innovation projects with multi-tier supply chains consisting of a food producer, a startup and a buying firm. The study is investigated from the legitimacy and boundary object lenses.

Findings: The findings proposed a framework for the role of a boundary object in enabling legitimacy-seeking strategies for novel food waste innovations. Firstly, the interpretative flexibility of the circular economy affords actors symbolic resources to conduct *manipulation strategy* to achieve cognitive legitimacy. Secondly, small-scale work arrangements enable *creation strategy* for the new supply chain to harness moral legitimacy. Finally, pragmatic legitimacy is granted via *diffusion strategy* enabled by scalable work arrangements.

Originality: This paper provides novel insights into the emergence of food waste innovation from a multi-tier supply chain perspective. It also highlights the key role of the boundary object in legitimacy-seeking process.

Keywords: Circular innovation, food waste upcycling, boundary object, legitimacy, institutional theory

1. Introduction

A sustainable food supply chain calls for better management of food waste owing to its significant volume and repercussions (Sgarbossa & Russo, 2017). In recent years, the circular economy has been widely advocated to open up sustainable pathways for utilising food wastes as valuable bioresources (Farooque et al., 2019; Nayak & Bhushan, 2019). Consequently, growing efforts have been made to explore the potential of turning food wastes into a range of high-value-added biomaterials, also known as regenerative materials, that can be used in a wide range of sectors, such as nutraceutical, pharmaceutical, fashion and plastic industries (Teigiserova et al., 2019; Provin et al., 2021). These efforts often manifest in innovation projects involving diverse stakeholders in food and non-food sectors with an outlook of establishing novel open-loop supply chains (Farooque et al., 2019). Interestingly, these projects are often spearheaded by young ventures, also known as startups, to bring about radical changes to existing businesses in the circular transition (Bauwens et al., 2020; Henry et al., 2020). For example, Vegea, an Italian startup, in collaboration with the wine sector and fashion brand, H&M, pioneered innovations to produce grape leather from winery wastes (Fisher, 2021). Similarly, Orange Fibre connects juice manufacturing with the fashion sector by converting orange pulp into fibres in partnering with high-end fashion brands, such as Salvatore Ferragamo (EU, 2018).

Despite the urgent need to tap into biowaste resources in times of resource depletion and over-reliance on synthetic resources (EMF & McKinsey Company, 2012), launching food waste innovation and further developing it into a commercially successful supply chain remains highly challenging. Technological difficulties, inconsistent quality issues, logistical challenges (Donner et al., 2021; Guldmann & Huulgaard, 2020), poor market structure, unfavourable taxation and policy support and hesitance to work with wastes (Do et al., 2021) are widely cited as reasons for low uptake of food waste innovations in practice. In such an unfavourable context, it is important to understand how this radical innovation occurs and then progresses to give rise to its emergent circular supply chain.

Innovation research highlights that innovations, particularly radical ones, need legitimacy to arise and develop, and diverse strategies have been suggested for innovators to gain legitimacy. Legitimacy can be acquired by institutional work conducted by actors such as individuals or firms to create, maintain or disrupt institutions to render legitimacy (Lawrence and Suddaby, 2006, p. 215). However, this stream of research treats legitimacy as a unitary concept without much development on the three dimensions of legitimacy (pragmatic, moral and cognitive) (Suchman, 1995; Meyer & Rowan, 1977). Research has begun to explore behaviours to target each of these three dimensions such as conformance, selection, manipulation (Suchman, 1995), creation (Zimmerman & Zeitz, 2002), and tolerance seeking (Van Dijk et al., 2011). Despite these efforts, researchers of both institutional work and legitimacy-seeking behaviours have not offered a complete understanding of how legitimacy can be won across multiple sectors.

To fill this void, this study borrowed the concept of a *boundary object* (Star & Griesemer, 1989) that holds explanatory power in collaborative works across sectors. Specifically, the circular economy is argued to exhibit characteristics of a boundary object that enable collaborations without initial consensus, and thereby facilitate legitimacy-seeking responses across field boundaries (Star & Griesemer, 1989; Star, 2010). This study aims to elaborate the mechanism through which a boundary object facilitates legitimacy-seeking strategies by actors from food and non-food sectors using real-world case studies. This is also a response to the call in Sehnem et al. (2019) for more empirical studies of circular innovations with the use of management theories. Accordingly, this study aims to answer the following research question:

How does the circular economy concept as a boundary object trigger and facilitate legitimacy-seeking strategies for food waste innovations?

To answer this question, a multiple-case method was adopted featuring three food waste innovation projects from the perspectives of multi-tier supply chain actors, consisting of a food producer, a startup and a buying firm in the garment sector. These novel chains were established to convert food wastes into plant-based fibres that replace virgin and synthesised materials.

The remainder of the paper is structured as follows. The theoretical background and literature review are presented in Section 2, followed by the research method in Section 3. Section 4 will provide a detailed description of empirical findings while Section 5 compares and contrasts these findings with those of the extant literature. Finally, Section 6 outlines conclusions, theoretical and practical implications and future research directions.

2. Theoretical background and literature review

The theoretical background is organised into three sections. First, an overview of the literature on food waste innovation is provided, followed by an overview of key dimensions of legitimacy and legitimacy-seeking strategies as well as their relevance to the innovation literature. The final section defines the boundary object and outlines its role in facilitating legitimacy-seeking strategies.

2.1. Food waste innovation and the emergence of the circular supply chain

One of the most heralded practices in the transition toward the circular food system is food waste innovation, also known as *upcycling*, *valorisation* or *waste biorefinery*, which advocates the conversion of food waste into high-value biomaterials (e.g., food-grade compound, bioplastics) (Donner et al., 2020). These plant-based biomaterials can reduce the reliance on fossil-based materials while being safely returned back to the biosphere, which contributes to a regenerative loop (Ellen MacArthur Foundation, 2012). The waste biorefinery literature has progressed in two major research streams. The first line of enquiry underlines the unlimited potential of food waste to contribute to a bioeconomy transition. These studies are devoted to unravelling a plethora of technological innovations that make food waste upcycling possible (e.g., Nayak & Bhushan, 2019; Teigiserova et al., 2019). A body of research in this stream has also begun to conduct techno-economic analysis to evaluate the economic and environmental implications if food waste is being converted into food-grade or feed-grade products at the regional level (e.g. Cristóbal et al., 2018). These studies are mainly conceptual or developed at the laboratory scale and underline the need for radical technological advances while calling for empirical research on industrial-scale projects (Caldeira et al., 2020).

The second stream of research provides practical case studies to demonstrate how food waste innovations are implemented in practice (e.g. Joshi & Visvanathan, 2019; Ojha et al., 2020). While the number of studies in this stream is disproportionately smaller than the first stream, they embody the early attempt of practitioners to operationalise the waste biorefinery concept and demonstrate how food waste, if being utilised at scale, offers an alternative and enables movement away from an over-reliance on greenhouse gas intensive alternatives, including petroleum-based fibres and animal sources. However, none of these studies has looked at these innovations from the supply chain perspective to explore the emergence of a novel supply chain structure existing alongside conventional linear chains, nor do they answer how these innovations occurred in the first place and how they evolved in practice. These questions are timely and pertinent as circular innovations such as waste biorefinery are radical, involve cross-sectoral actors, and do not tend to deliver immediate economic returns. Consequently, it is important to understand how food waste innovation can win support when in competition with conventional efficiency-oriented innovations.

This study adds to the first stream of research by providing empirical evidence of three real-world cases focusing on radical technological advance that converts food waste to bio-textiles. At the same time, it provides an answer to the underexplored question in the second stream of research by focusing on the evolution of waste biorefinery and its associated circular supply chain.

2.2. Legitimacy and legitimacy-seeking strategies

Legitimacy concept was originally introduced by Suchman (1995) and refers to the judgments of the extent to which an entity or its actions are “desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions” (p.574). Legitimacy is widely argued to be the key explanatory factor for the success and demises of innovations, particularly radical ones like innovations for the circular economy as analysed above (Meyer & Rowan, 1977; Zimmerman & Zeitz, 2002). As legitimacy is neither given nor purely emergent, prior studies have explored the mechanisms and strategy of gaining legitimacy. The following provides three dimensions to evaluate legitimacy, so-called legitimacy evaluation dimensions, and different strategies that were undertaken to align these dimensions in extant literature.

2.2.1. Legitimacy evaluation dimensions

It is imperative for a novel circular supply chain to be perceived as ‘legitimate’ in its ecosystem in order to get access to critical resources including financial, human, material resources, and regulatory support (Bergek et al., 2008; Markard et al., 2016). Such legitimacy perception is reflected in three core dimensions: pragmatic, moral, and cognitive legitimacy (Table 1) (Suchman, 1995, p. 577). Firstly, pragmatic legitimacy that rests on a self-interest orientation reflects the judgments about whether an organisation’s behaviour or activity benefits its immediate audiences (exchange legitimacy) or aligns with its own goals and interests (influence legitimacy). Secondly, moral legitimacy refers to a normative evaluation of rightness with respect to consequential, structural and procedural aspects. In other words, it is an evaluation of whether outputs, procedure, structure and leaders that relate to a given activity are appropriate in a socially constructed value system. Thirdly, cognitive legitimacy provides the perception of whether the organisation is comprehensible and inevitable (also known as taken-for-granted). Pragmatic and moral legitimacies rest on discursive evaluations that often take place in the form of explicit public discussions. Hence, organisations can win both legitimacies by promoting these discussions. In contrast, cognitive legitimacy does not involve substantial legitimacy judgments and is, hence, not subject to active evaluations (Tost, 2011). Cognitive legitimacy is passively accepted and unquestioned.

Table 1: Legitimacy and its components

Legitimacy evaluation dimensions	Legitimacy sub-dimensions	Description (Suchman, 1995)
Pragmatic legitimacy <i>(based on self-interest calculations of immediate audiences)</i>	Exchange	Judgement about whether an activity benefits its immediate audience
	Influence	Judgment about whether an activity aligns with stakeholders’ own goals and self-interests
Moral legitimacy <i>(based on a normative evaluation)</i>	Structural	Evaluation of whether an organisation has the right structural characteristics
	Procedural	Evaluation of whether an activity embraces socially accepted techniques and procedures.
	Output	Evaluation of whether an activity generates socially desirable outputs in terms of e.g. quality and value.

Cognitive legitimacy (rests on affirmative backing and mere acceptance)	Comprehensibility	To be coherent and understandable to its audience To be predictable, meaningful, and inviting by aligning with prevailing cultural models
	Taken-for-grantedness	To submerge the possibility of dissent so that alternatives become unthinkable.

Source: Authors own work

2.2.2. Legitimacy seeking strategies

Prior studies proposed a range of strategies to win legitimacy. The earliest attempt was made by Suchman (1995) who proposed three strategies: *conformance*, which involved adapting to fit in the local ecosystem; *selection*, based on seeking the favoured environment that renders legitimate status; and *manipulation*, which included getting rules, norms, scripts, values, and logic changed. These strategies can be enacted differently for three dimensions of legitimacy. For example, in the selection domain, firms may recruit friendly audiences to gain pragmatic legitimacy while seeking certifications to gain cognitive legitimacy. Similarly, in the manipulation domain, firms may use persuasion tactics to gain moral legitimacy while pursuing standardisation to grant cognitive taken-for-grantedness. In later years, *creation* was added as the fourth legitimacy-seeking strategy in the case of institutional voids where no prior norms, values and beliefs exist (Zimmerman & Zeitz, 2002). Kuratko et al. (2017) further ranked these four strategies in a continuum from less to a more strategic level and established the relationship between the innovation types and pertinent strategies. Researchers have found a better fit between radical innovation with more strategic legitimacy-seeking strategies such as manipulations and creation. If a radical innovation involves the creation of new technology and a new market, the creation legitimacy-seeking strategy provides the optimal cost-benefit trade-offs. Apart from the deliberate actions of actors, legitimacy can also be sought and sustained via an abstract object such as a dominant design (Aldrich & Fiol, 1994). However, this line of inquiry has received much less attention in the extant study of novelties such as food waste innovation. This study adds to the understanding of this under-explored research stream by examining the role of an abstract object such as the circular economy concept in the process of seeking legitimacy for circular innovation and its emergent supply chain.

The supply chain management literature suggests that legitimacy is crucial in the adoption of sustainable practices (e.g. Glover et al., 2014; Ahmed & Shafiq, 2022). For example, Glover et al. (2014) revealed how the UK's dairy supply chain legitimises its sustainable practices via normative, coercive and mimetic behaviours. However, these efforts exclusively focus on an existing supply chain that is striving to legitimise a new practice. Legitimacy is also used in these studies as a single construct rather than specifying its three dimensions. It is unclear how cognitive, moral and pragmatic legitimacies can be achieved by actors in the novel open-loop chains. In addition, the majority of studies take a static view of legitimacy and disregard how a particular strategy-seeking behaviour can interact with and reinforce another behaviour to allow for the achievement of multiple legitimacy outcomes (Bunduchi, 2017). Hence, a dynamic view of the evolution of legitimacy-seeking behaviours and outcomes is suggested by Bunduchi (2017), and this study contributes to advancing this line of inquiry.

2.3. Boundary objects and legitimacy-seeking works

The concept of a boundary object was originally proposed by Star and Griesemer (1989) to examine the nature of collaborations without (initial) consensus. A boundary object that resides in the shared space across multiple communities of practices (e.g. sectors) fosters collaborations thanks to two dominant traits: interpretation flexibility and work arrangements (Star, 2010). *Interpretation flexibility*

derives from the ill-structured aspect that allows it to be recognisable by actors belonging to multiple domains but can be flexibly interpreted in each domain. In this vein, a boundary object is seen as a signifier that conveys vague or abstract meaning for common use and a concrete meaning for individual use (Carlile, 2002). This allows the boundary object to act as a communicative tool or a means of translation for multiple perspectives, which fosters the willingness of actors across domains to engage in collaborative works despite their idiosyncratic interpretations. *Work arrangement* refers to joint actions to standardise the ill-structured aspect of the object. Star (2010) argued that for an object to act as a boundary object, actions need to be taken toward it. Hence, the boundary object is considered a set of work arrangements in which actors can unite conflicting viewpoints without constraining diversity, identify blind spots, appreciate the richness, alleviate tensions and reframe their beliefs through perspective-taking and decontextualization. Hence, the circular economy concept is argued to bear two traits of a boundary object as its conceptual ambiguity (Geissdoerfer et al., 2017) makes it become ill-defined for common use (interpretation flexibility), but its wide-recognition following the EU's Circular Economy Action Plan (CEAP) in 2014 (European Commission, 2020) foster and accelerate joint actions to standardise it for local use (i.e., work arrangement).

In recent years, the boundary object lens has gained fertile ground in environmental studies where interdisciplinary works from a diverse set of stakeholders in both scientific and non-scientific worlds are prevalent (Levesque et al., 2019). Employing boundary objects as a theoretical lens, scholars are interested in unravelling the instances where a particular object can operate as a boundary object to enable knowledge integrations and interdisciplinary collaborations (Lundgren, 2021). However, the majority of these studies treat the boundary object as a peace-making tool with the mere aim of reconciling disparate viewpoints and managing tensions (Hanson et al., 2020). Its power goes far beyond that as it can be employed to undertake legitimacy-seeking work and institutional work (Sajtos et al., 2018). This aspect is nevertheless far less recognised in scientific studies (Sajtos et al., 2018). This study advances this stream of research by exploring how the emerging circular concept as a boundary object can be used to undertake legitimacy works.

3. Methodology

The emergence of waste biorefinery is a little-observed phenomenon that would be expected to see more often in the future. This has called for an exploratory study and a case study research design is adopted as it allows to capture a thick description of an emergent and complex phenomenon using rich and profound data from different sources (Barratt et al., 2011; Eisenhardt, 1989). Case study is also suitable for theoretical elaboration following abductive reasoning to allow a general theory to be reconciled with the contextual idiosyncrasies emerging from the cases (Ketokivi & Choi, 2014). Furthermore, a multiple-case design is desirable as it enhances the external validity of the findings, which leads to a more grounded, robust and generalisable theory compared to a single case (Yin, 2018). Hence, a multiple-case research design is adopted.

3.1. Research context and case selection

The study focuses on exploring the emergent circular supply chain that involves food-to-biomaterial conversions in the food and garment sectors in the EU context. The setting is pertinent as garment sectors have over-relied on fossil fuels and are in urgent need to search for alternative biobased materials as advocated by Ellen MacArthur in the shift of consumable products from technical to biological loops (Aschemann-Witzel & Stangherlin, 2021). Meanwhile, the EU has been at the forefront of the circular economy transition after the introduction of the CEAP in 2014 (European Commission, 2020). This is an active area for food waste innovations between startups and existing firms to

accelerate circular transition (Bauwens et al., 2020). Thus, selecting food and garment sectors in the EU context provides a rich setting to observe the emergent circular supply chain phenomenon.

Table 2: Case sample description

	Descriptions	Food producer	Startup	Buying firm
<i>Case 1</i>	A multi-tier network that involves in a 12-month project from April 2019-April 2020	A large frozen food manufacturer that discharges vegetable peels that often go to animal feed production.	An EU-based startup that upcycles vegetable peels to create fashion accessories, the pilot factory is in operation in 2018	A small UK-based accessory brand specialises in affordable handmade products. It had \$24.6 million in sales.
<i>Case 2</i>	A multi-tier network that involves in a 12-month project from August 2018-August 2019	An agriculture food association that generates a huge volume of crop wastes that are often burnt or left rotted in field.	An EU-based startup that upcycles crop wastes into vegan leather, operated in 2016.	A global mid-range fashion brand. It had more than \$4 billion in sales.
<i>Case 3</i>	A multi-tier network that involves in a 18-month project from July 2020-Dec 2021	A food producer that generates agricultural leftovers previously discarded as fertilisers in huge volume.	An EU-based startup that upcycles agricultural leftovers into vegan leather, operated in 2016.	A mid-range fashion brand that is looking for alternative low-impact materials. It had \$75 million in sales.

Source: Authors own work

The sample consists of innovations engendered by three circular supply chains. Specifically, each supply chain involves a triadic network consisting of *a food producer* as a supplier of waste material, *a startup* as a technology provider to upcycle waste, and *a buying firm* as an off-taker to test the market viability of biowaste-based materials. Case sampling follows two theoretical sampling principles, where additional cases are chosen to predict similar results (literal replication), or produce contrary results but for predictable reasons (theoretical replication) (Eisenhardt, 1989; Yin, 2018). In terms of literal replications, cases were chosen using three similar criteria: (i) they involve innovations that maximise the value retained from wastes in line with the circular economy and are radically different from prevailing food-to-energy practice in the market, (ii) they involve cooperations and collaborations among new and non-traditional actors, startups and food producers, (iii) these projects were all formulated following the CEAP in 2014. In terms of theoretical replications, three cases are selected that filled conceptual categories that show the presence of variance in the relational outcomes. While the relationships of actors in cases 1 and 2 are short-term and transactional, case 3's relationship is becoming a long-term and sustained partnership. Finally, the sample size of three is also suggested by prior research as an appropriate number to achieve an in-depth understanding of the phenomenon under study and strikes a suitable balance between complexity and volume of data (Eisenhardt, 1989; Barratt et al., 2011). The description of these three cases is provided in Table 2. The unit of analysis in this study is the relationship of a multi-tier network consisting of a food producer, a startup and a buying firm from the pre-, during and post-pilot phases.

3.2. Data collection

A simple research protocol (Appendix 1) was developed that specified the aim, theoretical background, and data collection plan before carrying out this study. The interview schedule, the events to be observed and the documents to be requested and reviewed are also detailed (Yin, 2018). Data collection was completed in three phases and iteratively carried out with a data analysis process. Data collection is halted when a satisfactory level of theoretical saturation is reached (i.e., when no more new insights emerge if additional data is collected) (Eisenhardt, 1989).

For each tier in the circular supply chain (food producers, startups, and buying firms), the interviewees were carefully chosen to be the most knowledgeable individuals who engage in the relationship building and management of the novel circular supply network. A total of 19 semi-structured interviews were conducted, which allowed for both structuring discussion and facilitating the discussion of emerging themes (Saunders et al., 2019; Charmaz, 2014). Example interview questions for food producers, startups and buying firms are provided in Appendix 1. The researchers were careful to allow informants to supplement their answers with emergent contextual insights. All interviewees were contacted before the interviews with the brief, and the interview durations were between 45 and 60 minutes. Appendix 2 provides the details of each supply chain participant and each interview included in this study. The interviews were audio-recorded and transcribed verbatim. Results were summarised against the role of informants in the supply chain, identifying comparative answers and common patterns as well as alternative explanations.

The interview transcripts form the core data source, but this is supplemented by secondary archival data and public materials in order to triangulate the findings and avoid retrospective bias (Golden, 1992). Archival materials provided background information on the startups and the sustainability trajectories of the participants and included materials such as partnership agreements, marketing documents, or newsletters. This allowed for a better understanding of the context for emerging innovations alongside public materials such as press releases or academic publications.

Finally, informal talks and close dialogue with experts in circular networking events are also important to ensure the validity of this study. These events were both online or offline in both food and textile sectors to allow the researchers to discuss the preliminary results and exchange conversations with practitioners.

3.3. Data analysis

Data were analysed in two steps: within-case analysis and cross-case analysis. In the first step, each case was analysed individually following a six-step thematic analysis process proposed by Braun and Clarke (2006) to construct a coding structure and write up the story for each case. As this study does not aim at theory building but theoretical elaboration, thematic analysis is preferred to the grounded theory method for its flexibility (Saunders et al., 2019). Thematic analysis is also suitable for abductive reasoning where researchers have a prior understanding of existing theoretical constructs while being open-minded to novel insights from collected data (Dubois & Gadde, 2002). The coding process started with open coding where data that were broken down into small and manageable parts such as phrases, sentences or paragraphs were inductively affixed to the first-order codes. These inductive codes were then clustered into second-order themes (axial coding) using labels from theoretical constructs of the boundary object and legitimacy theories. In doing so, first-order codes that were grounded in the data could empirically substantiate the aggregated themes that were derived from theories such as manipulation or creation strategies. When the inductive code did not fit a higher-order theme, a new theme was created, such as diffusion work. The identification of unexpected codes

and themes is a key part of theory refinement (Eisenhardt, 1989). These codes were iteratively refined by travelling back and forth between data, literature and theoretical insights until arriving at a final coding structure that provided a robust and comprehensive theoretical picture. The resulting data structure (Figure 1) consists of 17 first-order categories, eight second-order themes and three theoretical dimensions: ‘boundary object’, ‘legitimacy-seeking behaviours’, and ‘legitimacy outcomes’.

A cross-case analysis was then conducted by comparing the narratives of individual cases to identify and match patterns across the sample (Yin, 2014). Written summaries and descriptions of observed patterns allow for the discovery of the interdependencies of categories and themes. A theoretical framework was then formulated to expound the unique nature of how actors legitimise innovations across sectors.

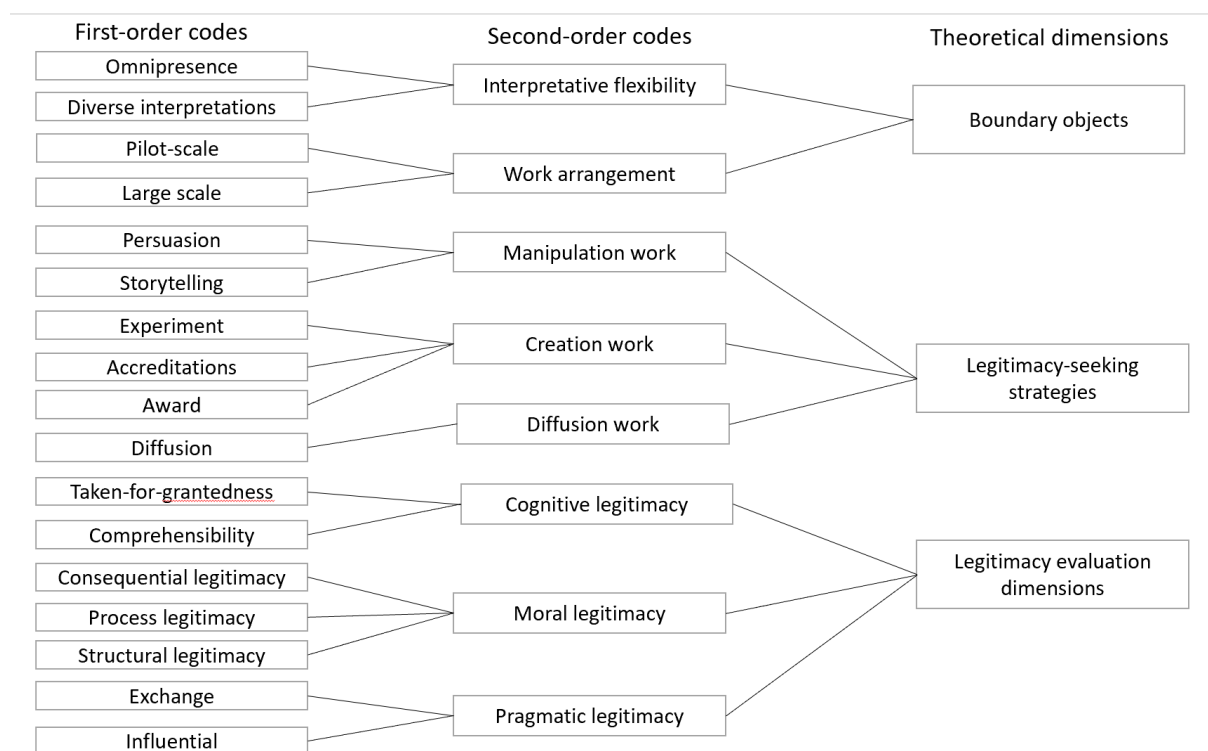


Figure 1: Coding structure

Source: Authors own work

3.4. Research quality assurance

Measures were taken to ensure research quality in terms of validity (construct, internal and external validities) and reliability (Yin, 2018). Construct validity that refers to the use of suitable measures for the concept under study was assured by collecting and triangulating data from multiple sources (interviews and secondary sources e.g., internal documents provided by the interviewees, website, published reports) in data collection and analysis phases. External validity that reflects the generalisation of findings was enhanced by replication logic in the case sampling process as specified above. Internal validity that aims at the causal relationships between variables and results was ensured by applying abductive reasoning to iterate between data and theory to avoid researcher bias, and a pattern-matching technique in cross-case analysis to identify and highlight similar and dissimilar

patterns across cases. Transcripts and case reports were also sent to the interviewees for validation and authenticity checking. Finally, reliability was assured by a rigorous data collection process following clear case sampling criteria, interview protocol and a formal coding process supported by qualitative data analysis software, NVIVO. As some of the emergent codes are grounded in the data, the full set of codes was circulated among the research team for confirmation. In case of disagreement, group discussions were arranged until reaching an agreement.

4. Findings

This section provides a summary of how the boundary object facilitates legitimacy-seeking strategies for food waste innovations. Section 4.1 provides a summary of key aspects of the boundary object perceived in three cases. Section 4.2 outlines the way in which actors seek legitimacy; this is followed by the legitimacy judgment outcomes (Section 4.3). Appendix 3 presents examples of empirical evidence.

4.1. Circular economy as a boundary object

Table 3 summarises the perspective of interviewees in three cases on how the circular economy has been employed as a boundary object prior to, during and after the pilot project.

Prior to the pilot project, the interpretative flexibility traits of the circular economy concept that include omnipresence and diverse interpretations were detected by all actors in three cases. All interviewees confirmed their familiarity with and strong advocacy for the circular economy before they participated in this project, demonstrating the omnipresence of the concept. Interviewees described circular economy, food waste innovations and regenerative materials as “sensible choice of fashion”, “meaningful materials” [S2-1], “clear solutions”, “sustainable material revolution” [BF3-1], “fresh perspective on the sustainable future”, “revolutionary and fast-growing areas in science and technology” [S3-1]. However, the interviewees had dissimilar initial views on how circular economy could be interpreted and integrated into their operations. Some interviewees in buying firms took a broad view to associate circular economy with redesigning products, processes and supply chains. Others such as food producers in cases 1 and 2 narrowly linked the concept with waste recycling or the cradle-to-cradle concept. Some suggested that a circular economy opens up vast opportunities, but it depends on the decision-makers to decide what to do with it. According to S3-1, “There are so many things we can do with waste to make it circular. We need to decide what works and what does not given your circumstances and pivot your model”. Similarly, S2-1 expressed: “People openly talk about it [circular economy] but how to make it work. Food waste is so versatile and there are so many things we can do with it, but where should we start? Would this type of innovation work or should we follow something else?” This loose understanding of the concept was argued to bring actors together to start conversations, exchange thoughts and explore the most feasible possibility of operationalising circular economy in their contexts.

Table 3: Traits of circular economy as a boundary object

Aggregated theoretical themes	First order codes	References (novel actions from our empirical data marked by *)	Case 1	Case 2	Case 3
Interpretative flexibility	Omnipresence	Doolin and McLeod (2012)	x	x	x
	Diverse interpretations	Star and Griesemer (1989); Allen (2009); Star (2010);	x	x	x
Work arrangement	Small work arrangement	Star (2010); Sajito (2017)	x	x	x
	Scalable work arrangement	*	o	o	x

Note: (x) indicates the presence of this code is confirmed by all interviews in the case; (o) indicates the presence of this factor is not confirmed by all interviewees in the case.

Source: Authors own work

In the launch of the pilot project, actors in each case worked closely together to trial the usability of new material in a capsule collection. Actors were motivated to engage in a pilot short-term project to test prototypes of food waste-based materials in terms of market performance and technological compatibility. S3-1 explained: “You cannot seat behind the computer. Everything will work in the lab but fail to work in practice. You need to go out there and ask people to make it work.” BF1-1 justified the decision to join the project: “The project is a part of our ongoing commitment to innovation and a continuous search for more sustainable fashion”. Hence, interviewees indicated little hassle in setting up their pilot projects after the introduction of the CEAP in the EU legislation. S1-3 noted: “People are more willing to listen to us and want to work with us. Compared to several years ago, business is less conservative and ready to work on the solutions”.

After the pilot project ended, only case 3 was able to continue the relationship by signing an offtake agreement where the buying firm agreed to purchase a repeated volume of materials at a given price over a five-year horizon. Further, the buying firm’s existing material supplier also joined forces in this stage to provide expertise and capacity to streamline the startup’s development and commercialisation phase. Hence, this is labelled as the scalable work arrangement that aims to showcase the commercial viability of new materials in the mass market. S3-1 stated: “It is no longer a far-off idea, a dream that may one day be real. It is commercially viable today at the price comparable to the premium linear material in the market”. BF-2 added: “We decide to subsidise the massive costs to figure out how to make it at a commercial scale, at a comparable price to conventional materials”. In general, our findings added the structure of work arrangement, including both pilot and large-scale, as an important trait that allows the concept of circular economy to act as an effective boundary object in the circular transition.

4.2. Legitimacy seeking strategies

As all cases aimed at creating a futuristic material made of food waste that has not yet previously existed in the market, they need to enact strategies to acquire legitimacy status to get access to critical resources for their survival and growth (Table 4). The following provides different strategies undertaken in the three cases prior to, during and after the pilot project.

Prior to the pilot project, the three startups were found to rely on a manipulation strategy that included storytelling and persuasion to gain support from their stakeholders. In terms of storytelling, all three firms were able to create a ‘well-grounded’ built-in sustainable story and image to deliver to the stakeholders. They all work with waste and add value to these incredibly underutilised resources. All startups were established in incubators and received pitch training and other entrepreneurship training courses to enhance their ability to gain access to resources in their ecosystem. They were able to identify themselves as “circular-born startups” and use this hallmark to connect with their ecosystem. In terms of persuasion, the startup in case 3 convinced its supply chain partners that its innovation generates more sustainable impacts than the alternatives. Startups in cases 1 and 2 did not need to overly depend on persuasion techniques because they work with the waste streams that are currently not being utilised by other sectors, hence it is easier to convince food supply chain actors to provide them with their waste streams. Manipulation strategy enabled firms in our cases to initiate cross-sector collaboration projects at the pilot scale to validate the technological and market feasibility of the innovation.

Table 4: Legitimacy seeking actions by actors in each case

Aggregated theoretical themes	First order codes	References (novel actions from our empirical data marked by *)	Case 1	Case 2	Case 3
Manipulation strategy	Persuasion	Suchman (1996); Zimmerman and Zeitz (2002); Kuratko et al., (2017)			x
	Narrative/storytelling	Bunduchi (2017)	x	x	x
Creation strategy	Experiments	Konietzko (2020)	x	x	x
	Accreditations	*	x	x	x
	Awards/recognitions	*	x	x	x
Diffusion strategy	Diffusion	*	o	o	x

Note: (x) indicates the presence of this code is confirmed by all interviews in the case; (o) indicates the presence of this factor is not confirmed by all interviewees in the case.

Source: Authors own work

During the pilot project, actors in three cases acquired legitimacy by enacting the creation strategy such as using an experimental approach, accreditations, and awards. Specifically, in terms of experimentation, all three cases confirmed their adoption of a trial-and-error approach in the process of creating something pioneering that does not match existing norms and values in the market. They explored different solutions to test what works and what does not work until they can find a solution to fit their market. S2-2 noted: “You are creating new materials. You need to be creative. What works, what does not work. Sometimes we need to get the product out there and fix it later to save time and see if it makes market sense” [S2-2]. Similarly, S1-1 said: “Indeed, every part of our process is covered in R&D”. In terms of accreditations, actors strived for procedural legitimacy through a rigorous accreditation process. These are highly prestigious certifications for their eco-credentials, which signal high confidence in product performance, supply chain accountability and transparency not only on environmental terms but also social terms. All firms are certified B-Corp, and S2’s novel materials are also Cradle-to-Cradle certified to prove that their process is free from banned substances. Traceability has also been cited as a common accreditation needed in the cases. “We have worked in rigorous research and careful planning with our brand partner to ensure traceability of product and supply chain.” [S2-1]. Finally, in terms of awards, all three cases were found to be externally validated by sustainability and innovation awards in the field and get reputations as the pioneers of new and sustainable materials for the future. These awards allow them to overcome the liabilities of newness due to being associated with newly born ventures that often lack organisational structure and innovation capabilities.

At the end of the pilot project, case 3 decided to ramp up its production by using diffusion work to widespread the impacts of the pilot project to wider audiences. In the pilot project, new material was used to produce a single product line in a capsule collection at the premium price point. The material was locally validated in a range of parameters such as look, feel, permeability, durability, and the ability to scale. Upon favourable local validation results, the buying firm in case 3 decided to diffuse these impacts to the mainstream, not just limited to the niche product line, to validate the potential of producing at a commercial scale, level of compatibility regarding process and supply chain ramp-up. Unlike case 3, cases 1 and 2 chose not to pursue diffusion work. Instead, startups in the first two cases decided to work on different pilot projects with different partners and continue to explore the possibilities of upscaling their innovations.

4.3. Legitimacy evaluation dimensions

Legitimacy status of innovations is continuously evaluated and re-evaluated by actors directly involved in this project in consultation with leading experts in the textile sector. Table 5 encapsulates different outcomes of legitimacies that have been gained by three cases.

Prior to the pilot project, most evaluation works were primarily conducted at the cognitive level. Due to the novelty of innovations, actors relied on their cognitive beliefs to evaluate whether innovations were worth exploring and would fit their business development trajectories. Thanks to the circular built-in stories, all cases were granted a high cognitive legitimacy for their innovations. Buying firm in case 2 explained: “When we hear about their story [*startup in case 2*], we know immediately that this is the right thing to do, and we must take action” [BF2-2]. Similarly, buying firms in case 3 also related to the startup’s mission: “We understand that it is a bumpy road, but it is the only way to the future, and we want to be a part of that journey, pioneering the achievement” [BF3-1]. In general, buying firms and food producers boldly expressed their support for the circular transition and supporting startups with these innovations is one step closer to their circular journey. As a result, all three types of innovation were granted cognitive legitimacy in terms of comprehensibility and inevitability.

During the pilot project, actors sought to evaluate the moral legitimacy in terms of output, procedural and structural elements. Buying firms in this stage are the main decision makers who work with startups to customise materials to fit their needs and evaluate the new materials. Only case 3 received alignments in all three elements of moral legitimacy. Specifically, new material’s performance is desirable in terms of touch, look, comfortability and durability. Although the price remains relatively high, it fits the market segment of this brand at the current price point. The production process is free from harmful solvent. More importantly, there is a significant structural alignment in this case’s network as this new material supply is aligned with buying firm’s strategy to end animal-derived product by 2025. The buying firms in the first two cases did not satisfy with either price or quality of the new materials. Interviewees reported uncertainty if these materials are ready for the mainstream and effectively compete with existing materials such as genuine leather or fossil-based leathers, of which production processes have existed for nearly a century. “The material is 30% cheaper than real leather but premium compared to other vegan leathers in the market. And the material did not give a genuine leather feel and look” [BF2-1]. In particular, startup and buying firm in case 1 cannot find structural alignment due to limited budget allocated for sustainability transition in the buying firm. This can be attributed to the fact that the buying firm is an affordable accessory brand with local footprint.

At the end of the pilot project, only Case 3 is expected to generate pragmatic benefits in form of favourable economic return (exchange) and early access to high-quality materials (influence) to the actors in the network. “We are continuously getting queries from all levels of the market from multinationals to a specialist store, vegan producers, early adopters” [S3-2]. It is supported by the yearly LCA measurement and a list of sustainability-driven indicators. On the contrary, actors in cases 1 and 2 subjected their relationship development to the future cost perspectives of the materials.

Table 5: Legitimacy evaluation dimensions

Aggregated theoretical themes	First-order codes (adapted from Suchman, 1995; Tost, 2011)	Case 1	Case 2	Case 3
Cognition	Comprehensible	x	x	x
	Taken-for-grantedness	x	x	x
Moral	Procedural	x	x	x
	Structural	o	x	x
	Output	o	o	x

Pragmatic	Exchange	o	o	x
	Influence	o	o	x

Note: (x) indicates the alignment is confirmed by all interviews in the case; (o) indicates the misalignment is confirmed by at least one interviewee in the case.

Source: Authors own work

5. Discussions

This section discusses empirical findings in relation to extant literature to answer the research question. In doing so, this paper theorises the role of boundary object in fostering the legitimacy-seeking strategies for food waste innovations, as conceptualised in Figure 2 and further explained below. Figure 2 illustrates the interplay between object, actions and outcomes where a boundary object, facilitated by its traits, assists the effectiveness of manipulation, creation and diffusion strategies in reaping favourable cognitive, moral and pragmatic legitimacy outcomes. The results in this study indicate that despite drawing on the same object, each case took a customised approach to operationalise the object and achieve dissimilar legitimacy outcomes. More specifically, although all three cases used manipulation work to gain cognitive legitimacy, only case 3 was evaluated to be morally and pragmatically legitimate. Case 1 and case 2 still struggle to fully align their moral legitimacy, particularly in terms of output aspects so that their plant-based products are favourably perceived in the market. The findings also highlighted the differences in the level of engagement of actors in each case. Startups were found to take active roles in all manipulation, creation and diffusion strategies to achieve three forms of legitimacy. On the other hand, other supply chain partners were more involved in the creation and diffusion strategies to garner moral and pragmatic legitimacy in their ecosystem. In general, Figure 2 depicts the resulting theory of the legitimacy-seeking process via boundary object, emphasising the relationships between different traits of boundary objects and different strategies to target three types of legitimacy.

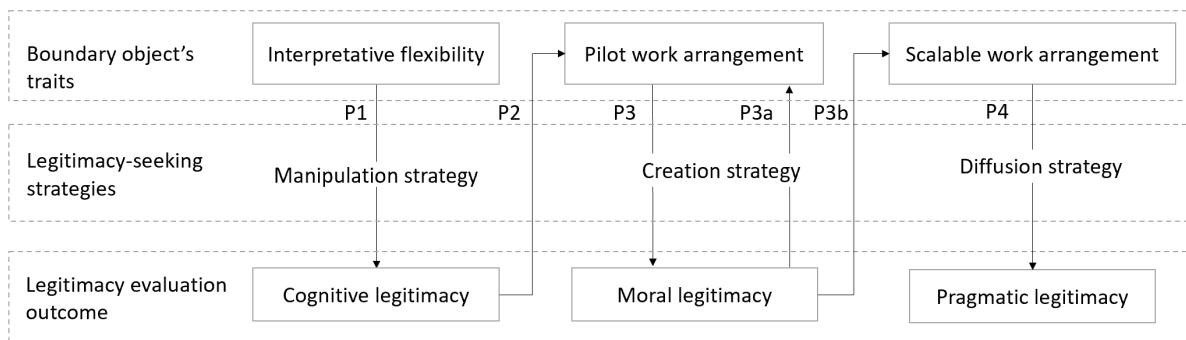


Figure 2: The process by which a boundary object facilitates legitimacy-seeking strategies (Note: P stands for the proposition)

Source: Authors own work

Prior research shows that gaining legitimacy is crucial for the survival and growth of innovations and that innovators resort to a variety of actions to seek legitimacy in its three dimensions (pragmatic, moral, cognitive) (Suchman, 1995; Bunduchi, 2017). This study adds to prior literature by illustrating how these actions can be facilitated via the lens of boundary objects to target cross-sectoral legitimacy. Drawing on the nascent context of food waste innovations that exclusively relies on joint actions of actors in food and non-food sectors (Provin et al., 2021; Farooque et al., 2019), this study adds a nuanced understanding of how food waste innovations are triggered and evolve into the novel open loop supply chains, and how a boundary object facilitates this process. More specifically, in this

context, by activating the power of circular economy as a boundary object, businesses are found to be less resistant to embrace radical innovations such as food waste-based materials brought about by innovators, which results in collaborative works to materialise these innovations at scale. Without employing this boundary concept, these innovations would be otherwise considered farfetched or even impossible to think about.

Earlier research suggests that cognitive legitimacy is the most difficult legitimacy to influence, hence innovators are less likely to prioritise actions to gain cognitive legitimacy over pragmatic and moral legitimacy (Suchman, 1995). Conformance was also found to be the most common strategy to pursue cognitive legitimacy, followed by selection and manipulation (Bunduchi, 2017). The findings presented here show an interesting pattern that contradicts the prior studies. Specifically, in the context of innovations for the circular economy, cognitive legitimacy is the easiest pillar to influence using manipulation strategy (e.g. persuasion or narrative building) thanks to the omnipresence of a circular economy as a boundary object. By doing so, this study adds to the relationship between cognitive legitimacy and manipulation work by highlighting the facilitating role of a boundary object. Indeed, as cognitive legitimacy does not involve substantial legitimacy judgment (Tost, 2011), the inclusion of a boundary object that is well-perceived and accepted by society expedites the effectiveness of manipulation strategy. This is also consistent with the findings of Sajtos *et al.*, (2018) that the employment of boundary object tends to impact first on the cognitive-symbolic pillar. In addition, existing literature shows that manipulation strategy is highly suitable for innovation that substantially departs from existing norms and values and causes high uncertainty (Zimmerman and Zeitz, 2002; Kuratko *et al.*, 2017) and that manipulation gains cognitive legitimacy by preemptively altering existing ideas, practices and beliefs (Zimmerman and Zeitz, 2002). This study confirms these by showing all three cases successfully espoused manipulation tactics such as persuasion and storytelling to win cognitive status. Based on the above analysis, the first proposition is:

P1: The interpretative flexibility of the boundary object facilitates manipulation strategy to gain cognitive legitimacy for circular innovations.

This study adds insights into the boundary object lens, complementing prior studies (e.g., Star, 2010, Sajtos *et al.*, 2018) that have not yet established a link between two traits – interpretative flexibility and work arrangement – of the boundary object. The findings here show that gaining cognitive legitimacy is a key driver for actors across sectors to work together in coordinated arrangements in order to explore how the circular economy can be tailored to their business and supply chain operations. The shift in the cognitive pillar acts as a platform to enact conversations and find like-minded people who have the same mission to seek technological advances that replace all the harmful materials for a sustainable future. In doing so, this study added to prior research on the antecedents and deployment of circular innovations. In other words, it allows for answering why many innovation projects have begun to take off over the past few years. Put simply, cognitive legitimacy is the link that translates interpretative flexibility into work arrangements. Therefore, the second proposition is:

P2: Well-aligned cognitive legitimacy facilitates the initiation of small-scale work arrangements across sectors to materialise circular innovations.

Literature suggests that a creation strategy is needed for radical innovation to evolve. As these innovations are incongruent with established practices and hence subject to extensive scrutiny and constant judgments, sole reliance on manipulation work is not sufficient (e.g. Kuratko *et al.*, 2017). Instead, creation work is needed to generate “something that did not already exist in the environment” such as new rules, norms, values, beliefs or models (Zimmerman & Zeitz, 2002, p. 425). This study confirms this by providing empirical evidence of creation works using experiments,

accreditations, awards, and recognitions. In addition, the findings extend this discussion by establishing the link between creation works and moral legitimacy outcome in terms of procedural, structural and output dimensions, and by highlighting the significance of work arrangement in this linkage. Specifically, work arrangement offers a common ground for startups, food producers and buying firms to transcend their contextual boundaries to decipher a range of idiosyncratic meanings of circular economy in order to generate a tailored practice and its collective knowledge. The benefit of work arrangement has been supported in prior research using a boundary object lens (e.g. Star, 2010; Sajtos, 2018).

In addition, prior literature has not discussed the impact of work arrangements. This study adds to this by showing that not all work arrangements in a tailored practice such as food waste innovation have a similar impact on the effectiveness of creation work in achieving moral legitimacy. Specifically, only the pilot work arrangement in case 3 leads to a favourable appraisal of moral aspects of output, structure and procedure. By contrast, the arrangements in the first two cases yield dubious evaluations in either output or structural aspects of moral legitimacy. As a result, only case 3 achieved a well-aligned legitimacy when the project ended and moved into a larger work arrangement. No larger arrangement has been set in cases 1 and 2 after these projects ended. This also suggests that gaining favourable moral legitimacy evaluation is the key driver for innovations to scale up.

Therefore, the third set of propositions is:

P3: Small-scale work arrangements foster creation strategy to gain moral legitimacy for circular innovations in terms of output, procedural and structural alignments.

P3a: Misaligned moral legitimacy hinders the establishment of scalable work arrangements, and supply chain actors are likely to engage in multiple small work arrangements until moral legitimacy can be well-aligned.

P3b: Well-aligned moral legitimacy triggers the establishment of scalable work arrangements across sectors to diffuse circular innovation practice.

Prior research suggests that legitimacy-seeking strategies can be deployed simultaneously and sequentially to target particular legitimacy at a given time (e.g. Bunduchi, 2017). This study adds to this by showing the sequence of legitimacy-seeking behaviours by firstly employing manipulation strategy to target cognitive legitimacy, then creation strategy to gain moral legitimacy before moving to diffusion strategy to harness pragmatic legitimacy. The results here also show pragmatic legitimacy is the hardest pillar for innovators to demonstrate in the context of circular innovations due to high novelty and uncertainty of technology and output products. To achieve pragmatic legitimacy, actors need to engage in diffusion work in scalable work arrangements that involve multiple stakeholders and a high level of resource commitment to deliver economic, environmental and social impacts to wider audience. Of note, while the economic impact in terms of commercial viability of the project delivers exchange legitimacy to the participating stakeholders, the social and environmental values of the project allow participating stakeholders to earn influence legitimacy as the pioneers in this emerging arena. Hence, the final proposition is:

P4: Scalable work arrangement is a prerequisite for diffusion strategy to gain pragmatic legitimacy for a circular innovation.

6. Conclusions

The paper has adopted legitimacy and boundary object lenses to examine the mechanisms through which food waste innovation emerges and develops across sectors. Focusing on these theoretical

lenses has enabled an analysis of dynamic interactions among an object, actions and outcomes in the process of gaining legitimacy for innovations in the transition toward a circular economy.

6.1. Theoretical implications

This study offers evidence of real-world cases to the growing body of research on food waste innovation that is overwhelmed by conceptual papers, laboratory experiments and explorations of upscaling challenges. These cases indicate that highly radical circular innovations where food wastes can be used for biomaterials are happening and contribute to informing scholars and practitioners of best practices. Furthermore, while scholars emphasise weighing the benefits and impacts of food waste innovations, the questions regarding how these innovations have occurred and how they evolved to give rise to the circular supply chains have not yet been adequately answered. The framework developed here provides initial answers to such underexplored questions and expounds on the way in which circular innovations can compete with the linear ones that are devised to maximise firms' performance.

The framework proposed in this study also contributes to the legitimacy theory and boundary object literature in at least three ways. Firstly, it extends the research of Sajtos *et al.*, (2018) on boundary objects for institutional work by elucidating the role that an object plays in triggering and facilitating legitimacy-seeking behaviours in innovation. While the boundary object literature emphasises how grand concepts (e.g. sustainability or resilience) can be employed as a boundary object to reconcile disparate viewpoints and manage tensions (Franco-Torres *et al.*, 2020; Brand & Jax, 2007), this study shows that the power of a boundary object goes beyond a mere peace-making tool to allow the undertaking of legitimacy-seeking work.

Secondly, the framework advances the understanding of a range of legitimacy-seeking behaviours and types of legitimacy outcomes conceptualised in extant studies (Suchman, 1995; Zimmerman & Zeitz, 2002). Specifically, the findings identify three types of behaviours to seek legitimacy (manipulation, creation and diffusion) that can be deployed sequentially to target different legitimacy statuses (cognitive, moral and pragmatic, respectively). This further endorses the findings of Zimmerman & Zeitz (2002) and Kuratko *et al.*, (2017) that radical innovations such as circular biorefinery require more strategic and resourceful actions such as manipulations and creation than conformity or selection, and that manipulation alone is not sufficient. The diffusion strategy proposed here is supported by empirical data as the subsequent stage of creation strategy that allows circular innovation to evolve at scale.

Finally, the process-based framework proposed here is aligned with the call of Bunduchi (2017) for more studies that add time perspective to the legitimacy research by expounding the links between legitimacy behaviours and outcomes over the evolution of innovation projects. In the innovation for waste-based biorefinery, cognitive status can be achieved first using less resourceful strategies, followed by moral status. Pragmatic legitimacy is the hardest one to align with, which requires scalable and resource-intensive actions.

6.2. Managerial implications

This study provides important managerial implications for supply chain actors in terms of enhancing the effectiveness of food waste innovation projects. Specifically, *startups* who are key driving forces for circular transition with authentic commitment but limited resources should consider tapping into the power of the circular economy concept via its omnipresence and interpretative flexibility, to devise low-cost manipulation strategies via persuasion or storytelling in order to win cross-sectoral support in the cognitive pillar. This stands in contrast to the observations of innovation literature that actors

are most likely to demonstrate practices that maximise firms' performance (pragmatic legitimacy). This may be attributed to the fact that the circular economy is desirable by practitioners and strongly heralded by policymakers. Cognitive alignment subsequently gives rise to the launch of work arrangements with food waste suppliers and buying firms, which signals the early stage of circular transition. Reflecting on the findings, it is pivotal for the startups to be mindful in selecting brand partners who are sustainable or have clear commitments to be sustainable in the near future. *For food producers and buying firms*, these work arrangements start at a pilot scale to evaluate moral alignment in terms of procedural, structural and output compatibility. Actors are encouraged to actively join forces in the resourceful creation strategy here via a range of options (e.g. experiments, accreditations, awards and recognitions) to yield favourable moral alignments in order to scale up their projects. Finally, when scalable projects are initiated, pragmatic legitimacy can be finally acquired via the most resourceful diffusion work to reap commercial success and deliver sustainable value. The framework proposed here can guide actors in choosing suitable legitimacy-seeking strategies targeting different legitimacy outcomes in the process of establishing novel circular food-to-material chains. In a wider societal context, our findings indicated two existing barriers in the search for alternative sustainable materials are quality and scalability. Until new materials can be commercial produced at a price parity, collaboration in this area remains transactional and is likely to be for marketing rather than sustainability purposes.

6.3. Limitations and future research

This study is not without limitations, which leads to future research opportunities. Only three instances of food waste innovations to produce regenerative materials for the EU garment sector were examined. Future research could explore if the findings apply to other sectors or to other locations for a better understanding of contextual influences. For instance, actors in bioplastic or nutraceutical sectors work in countries where food waste innovations are valued differently. As this study is limited to a boundary concept, the findings could also be extended to other types of boundary objects such as models or tools that can be purposively created by actors and how they affect the legitimacy-seeking works. Meanwhile, given this research relied mainly on retrospective data, a longitudinal study is needed to examine interactions between boundary object, legitimacy actions and outcomes along the lifecycle of food waste innovations, particularly in the mature stage. Another fruitful line of research in legitimacy-seeking actions concerns the trade-off and dependencies among lower-order legitimacy-seeking strategies that target a particular legitimacy outcome. Finally, it would be interesting to explore the perspectives of other actors, e.g. policymakers, reverse logistics partners, and funders, in legitimising the circular ecosystem.

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Appendixes

Appendix 1: Research protocol

Case study protocol

Research purpose: This research aims to explore the role that circular economy concept plays in facilitating legitimacy-seeking actions in food waste innovations. Specifically, this study seeks to answer the following questions: How did actors initiate, implement and scale their innovation projects? Which role did the circular economy concept play in enabling these actions prior, during and after these projects?

Conceptual framework: This study is guided by boundary object literature (*Star & Griesemer, 1989; Star, 2010*) and legitimacy theory (*Suchman, 1995; Tost, 2011*).

Interview questions

Interview questions for startups

Please briefly introduce yourself and your company in its entrepreneurship journey.

Prior to the project, please explain how you engaged food producer and buying firm in this project. Which factors do these firms consider for deciding to engage? Did the popularity of circular economy influence this decision? If yes, in which way?

During the project implementation, how do you describe your role in this project? How would you evaluate the level of engagement of project partners? What are the goals of the project in terms of e.g. outputs, processes or contractual arrangements? Which challenges did you encounter in achieving these goals? How did you and your project partners overcome these challenges to achieving project goals? How do you evaluate the achievements of these goals?

After the project, are there any future work plans to continue this relationship? If yes (no), what are key factors moving (not moving) this project forward? Please describe your roles in the future work plans, if any. What are your next steps?

Interview questions for food producers

Please briefly describe yourself and your company.

Prior to the project, how did you treat food wastes? Why and how did you engage in this project? Were you aware of the circular economy prior to this project? If yes, how did you define this concept and describe its relevance in food waste management? Did this awareness and understanding impact on your decision to engage in this project? If yes, in which way?

During the project, how do you describe your role in this project? What are the goals of the project in terms of e.g., outputs, processes or contractual arrangements? Which challenges did you encounter? How did you and your project partners overcome these challenges to achieving project goals? How do you evaluate the achievements of these goals? Have these outcomes shifted your understanding of the circular economy and the way it is applied in your food waste management practice? if yes, in which way?

After the project, are there any future work plans to continue this relationship? If yes (no), what are key factors moving (not moving) this project forward? Please describe your roles in the future work plans, if any.

Interview questions for the buying firms

Please briefly describe yourself and your company.

Prior to the project, why and how did you engage in this project? Were you aware of the circular economy concept prior to this project? If yes, how did you define the concept of circular economy and describe its relevance in your business? Did this understanding impact your decision to take part in this project? If yes, in which way?

During the project, how do you describe your role in this project? What are the goals of the project in terms of e.g., outputs, processes or contractual arrangements? Which challenges did you encounter? How did you and your project partners overcome these challenges to achieving project goals? How do you evaluate the achievements of these goals? Have these outcomes shifted your understanding of the circular economy and the way it is applied in your business operations? if yes, in which way?

After the project, are there any future work plans to continue this relationship? If yes (no), what are key factors moving (not moving) this project forward? Please describe your roles in the future work plans, if any.

Appendix 2: Interview profile

Case ID	Participating firms	Interviewees	Job title	Years of experience
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Case 1	Startup	S1-1	Chief coordination manager	2
		S1-2	Chief executive manager	3
		S1-3	Production Officer	1
Case 1	Buying firm	BF1-1	Sustainability Manager	5
		BF1-2	Project Manager	2
	Food producer	FP1-1	Waste Management Operator	3
		FP1-2	Factory Operator	7
Case 2	Startup	S2-1	Chief executive manager	3
		S2-2	R&D Manager	2
	Buying firm	BF2-1	Procurement Manager	5
BF2-2		Sustainable Officer	4	
Case 2	Food producer	FP2-1	Sales Manager	6
		FP2-2	Waste Management Manager	3
Case 3	Startup	S3-1	Chief Executive Manager	4
		S3-2	Founder	7
	Buying firm	BF3-1	R&D Manager	3
BF3-2		Sustainability Operator	4	
Case 3	Food producer	FP3-1	Sales Manager	10
		FP3-2	Production Manager	11

Source: Authors own work

Appendix 3: A summary of sample empirical evidence

Aggregated theoretical themes	First order codes	Sample evidence from different data sources (interview, secondary data, notes during networking events)
Interpretative flexibility	Omnipresence	<p>“The business landscape has changed and people are recognising the benefits of going circular now” [BF1-1]</p> <p>“Having a circular loop improves our sustainability performance. We have done well in sustainable farming and production. Waste recycling would be the last piece in our sustainable picture” [FP-1]</p> <p>“I have to say that since 2015, it was not very difficult as the market really wake up and brands started looking for regenerative materials. And our solution was quite pioneer. It was actually the first plant-based material in the market” [S3-1]</p> <p>All firms issued circular economy guidelines or action plans in place (archival data)</p>
	Tailored use	<p>“Food waste is so versatile and there are so many things we can do with it, but where should we start? Would this type of innovation work or should we follow something else?” [S2-1]</p> <p>“We need to decide what works and what does not give your circumstances and pivot your model” [S3-1]</p> <p>“We are working with [startup case 2] on their prototype for a year now. It is not a linear process. You just need to be patient to find a solution that works” [BF2-1]</p>
Work arrangement	Small work arrangement	<p>“You cannot seat behind the computer. Everything will work in the lab but fail to work in practice. You need to go out there and ask people to make it work.” [S3-1]</p> <p>“This pilot project will allow us to evaluate the commercial value and technical performance of the protocol” [BF2-1]</p> <p>“It is the key for us to develop this partnership to platform ourselves into the bigger market.” [S1-2]</p> <p>“We take part in this exciting project to spearhead innovations for a sustainable future” [BF1-1]</p> <p>Project agreements provide detailed information on roles and responsibilities among parties and project goals (archival data)</p>
	Scalable work arrangement	<p>“We are excited to join this consortium to create a solution at scale” [BF3-1]</p> <p>“This collaboration aims to transform [wastes] into value at an industrial scale, giving a new life to the material previously seen as waste, and contributing to a circular economy” [S3-2]</p> <p>“What we are doing at the moment upscaling our production and the big customers they really need materials which are more transparent and more sustainable and we are really a very clear solution for them because it works” [S3-1]</p> <p>Five-year partnership agreement between S3 and FP3 [archival data]</p> <p>Draft agreement between S3 and BF3 [archival data]</p>
Manipulation	Persuasion	<p>“We have been knocking from door to door. The good news is businesses are now more open and willing to listen. But you still need to talk to them in a linear term to convince them that they make economically sense while delivering the impacts” [S3-3]</p>
	Narrative/storytelling	<p>“Big companies are seriously looking for regenerative materials and they are very thorough about what do they want to use and how do they want to use it, how they combine with other materials. We have real story with a product that works, which is important and our story comes along as a great solution for them” [S1-2]</p>

		<p>“Our business runs on a philosophy of cradle to cradle, we use waste material from agriculture and make something out of it. We got a very strong backstory and a product that works” [S2-2]</p> <p>“We have a vision to develop products and materials in which commercial success, is integrated with promote social, cultural, and obviously economic development and ecological development” [S2-1]</p> <p>“We are a biotechnology company, explore the frontier of biology and material science. We are fascinated with technology and make impossible possible” [S3-1]</p> <p>“We take inspiration from nature in order to save it... This offers a fresh perspective on the future of the sector” [S3-2]</p>
Creation	Experiments	<p>“We have an extremely talented group of people that are here full time so we have three different departments: biochemistry, polymer chemistry, and chemical engineers. So really every section of our process covered with R&D, which allows us to work very quickly in house” [S1-1]</p> <p>“We’re into the long run and obviously, all we do is try a lot and experiment with all possible applications we can go into.” [S2-3]</p> <p>“R&D is never going to stop. What we are working on the content of our materials with our partner. Our aim is to become 100% plant-based content”. [S3-1]</p>
	Accreditations	<p>“We have worked in rigorous research and careful planning with our brand partner to ensure traceability of product and supply chain” [S2-1]</p> <p>“We're certified B Corp so we're fully transparent” [S3-2]</p> <p>B-Corp accreditations were validated in B-Corp website [secondary data]</p>
	Awards/recognitions	<p>“What we are creating is a futuristic supply chain and we are proud to be recognised for our achievement by our business partners, large brands, NGO and government” [S3-1]</p> <p>“Our partnership with [the startup] is well received by our customers and welcomed by sustainable fashion community” [BF3-1]</p> <p>“Just last month, we were announced as one of the finalists of Innovation of the Year Award” [S3-3]</p> <p>Information on grants and awards was validated on public record [secondary data]</p>
Diffusion	Diffusion	<p>“When we started, there was no supply chain and now we are expanding to our supply chains to different parts of the world and this is the part we are working on to upscale the production” [S3-1]</p> <p>“We aim to scale it beyond where biomaterials are produced in museum pieces. We want to make materials for tens of millions of people can wear in this largest consortium up to date” [S3-2]</p>
Cognition	Comprehensible	<p>“I think people now understand waste is a resource and with technology and willingness, we can make it work for us” [BF2-2]</p> <p>“One thing that has been fantastic is that our supplier has been open with the fact that they are actually looking for a solution to valorise their by-products from food manufacturing. So they are a fantastic partner in terms of really addressing it as a problem and seeing our solution as an exact solution.” [S1-1]</p> <p>“People have been waded fabrics from plant for hundreds of years. We just revitalised this and take it to the next level at an industrial scale” [S2-2]</p>

	Taken-for-grantedness	“We understand that it is a bumpy road, but it is the only way to the future, and we want to be a part of that journey, pioneering the achievement” [BF3-1]
Moral	Procedural	“It was very challenging at first, but once we proved the concept in the pilot plant, it allowed us to raise capital to improve our process and move closer to a truly circular production” [S1-1]
	Structural	“Unlike most normal supply chains, you can go and buy raw materials. We have to put in the supply chain to get our materials (food waste). To get to where we are now, we have to deal with a range of producers, food retailers and waste management firm” [S3-2]
	Output	“Technically our product works. Our big customers are looking for the material that is transparent and sustainable. They’re very thorough as well. What do they want to use. How do they want to combine it with other materials, and we come along as a great solution for them” [S3-1]
Pragmatic	Exchange	“The materials demonstrate commercial success. It integrates social, cultural and obviously economic development” [BF3-2] “We believe that these novel biomaterials live up to high aesthetic and performance standards that is inherent in the sectors. They replicate the looks, features, colours of existing materials and can be used in many products from shoes, bags to cloths... They are supermaterial for sustainable future” [BF3-1]
	Influence	“The collaboration fits our sustainable development trajectory and our circularity journey. We want to not only reduce the impact but also create positive impacts.” [BF3-1] Materials are produced in state-of-the-art plant in responsible supply chain using 100% renewable electricity with 10 times reduction in carbon footprint compared to the existing product [Information on website of BF3]

Source: Authors own work