An extended institutional theory perspective on the adoption of circular economy practices: insights from the seafood industry

Abstract

The management of seafood processing by-products (SPBPs) is an interesting but underexplored topic in the circular economy (CE) research stream. The extant CE literature is mainly devoted to the topic's theoretical aspects and largely neglects the linkages between theory and practice, particularly in developing countries. This paper aims to empirically investigate CE implementation and its associated drivers and barriers in the context of SPBP management in a developing country. A multiple-case design is used on a sample of five firms that engage in SPBP treatment in Vietnam. We find evidence of circular practices in SPBP management that aim at cascading use and higher value creation. We also delineate eight drivers and 14 barriers rooted in four clusters: *regulatory, socio-cognitive, economic and supply chain,* and *technological* factors. In addition to generic factors, we identify three exclusive drivers and five unique barriers specific to our cases. The findings are then interpreted through the lens of extended institutional theory to derive a holistic framework that captures the dynamic influences of various factors on CE diffusion. Our framework includes two add-ons: institutional logic and uncertainty. 'Legitimacy-embedded efficiency' is established as a shared logic of CE, whereby economic growth is achieved in harmony with environmental protection via the optimal use of resources. Uncertainty moderates the relative influences of legitimacy and efficiency-related factors on CE diffusion. Our practical contribution is to offer an actionable guide for key stakeholders of the SPBP supply chain, including local authorities in the transition from low-efficiency practices to novel circular ones.

Keywords – circular economy, institutional theory, seafood by-products, supply chain management, developing countries, case study

Paper type – Research paper

Highlights

- Demonstrate the use of the cascading and higher value creation in managing food by-products
- Highlight distinctive drivers of and barriers to circular seafood by-product management
- Advance the explanatory power of extended institutional theory
- Propose a novel framework for the driver–barrier–practice nexus
- Distinguish between the logics of the circular economy and of the sustainability literature
- Characterise uncertainty as a moderator that affects the roles of various influencers

1. Introduction

Each year, an enormous volume of by-products is generated by the global seafood processing sector. It is estimated that the fish filleting sector discharges 3.17 million tons of by-products, while the figures for the canning and crustacean sectors are 1.5 million tons and 0.5 million tons, respectively (Ferraro *et al.*, 2010). Seafood processing by-products (SPBPs) such as heads, shells, and skins occur in the factory at all stages of processing, from grading, beheading, and trimming to cleaning processes. This huge volume of by-products requires appropriate management to avoid serious environmental repercussions, especially due to SPBPs' high perishability (Arvanitoyannis and Kassaveti, 2008). As seafood consumption continues to grow, it is imperative for businesses in the seafood processing sector to actively seek more sustainable and efficient ways to manage the ever-increasing amount of SPBPs (Pal and Suresh, 2016). One of the emerging approaches to solving this problem is through a circular economy (CE) (Ruiz-Salmón *et al.*, 2020). This solution has been advocated by the superpower economies – notably embodied by China via the CE promotion law (The People's Republic of China, 2008) and Europe with the CE package (European Commission, 2015).

A CE is a regenerative system in which the concept of waste does not exist. Both materials and resources are kept in closed loops for multiple – ideally infinite – cycles to maximise the value retained from resources (Ellen MacArthur Foundation, 2012). In the food sector, establishing a CE involves the utilisation of food waste, including SPBPs, to generate a spectrum of value-added products via recovery and purification technologies. Examples of desirable outputs that can be produced from SPBPs are numerous in the literature. They include nutraceutical products (e.g. collagen and gelatine), foods (e.g. fish sauce, fish oil, and calcium), animal feed (e.g. pet food, fish feed, and bait), chemicals (e.g. lactic acid) and liquid fertiliser (Kim and Mendis, 2006; Denham *et al.*, 2015; Pal and Suresh, 2016). However, these papers neither provide empirical evidence of successful practical applications nor reflect the subtle ideology of the circular economy, such as a cascading use that employs the sequential reuse of the remaining resources from previously used commodities and substances. Particularly, as the concept of the CE is underspecified and difficult to comprehend (de Jesus and Mendonça, 2018), there is a need for empirical evidence of successful pathways to effective by-product management, as well as of the drivers and barriers associated with attaining a CE in the seafood sector. Our paper responds to Govindan and Hasanagic's (2018) call for exploratory research into the nexus of three critical components key practices for implementing CE, drivers for fostering their adoption, and key barriers to be eliminated. We aim to obtain a thorough understanding of state-of-the-art practices and the factors that foster and hinder SPBP management under the transition toward CE in Vietnam.

We choose to focus on the seafood sector of a developing country – Vietnam – for three specific reasons. First, as one of the top five seafood exporters in the world (IMARC, 2019), Vietnam faces an urgent need for effective management of the huge volume of SPBP discharged each year. Second, focusing on a single location allows a deeper analysis and more control of variations in the setting (Eisenhardt, 1989), particularly when food-waste management has regional traits. Lastly, given that research on the CE concept has been scarce for emerging economies, including Vietnam (Ghisellini *et al.*, 2016; Agyemang *et al.*, 2019), setting this study in Vietnam helps to advance the global transition toward CE by adding the contextual nuances of a developing country to the existing literature.

This research aims to answer the following research questions (RQs):

- RQ1: How have CE practices been integrated into the management of seafood processing by-products in a developing country such as Vietnam?
- RQ2: Why are firms being driven to engage in CE practices?
- RQ3: Why is the diffusion of CE practices being derailed or hindered?

Our three RQs are answered through the lens of institutional theory. Although few authors have attempted to analyse CE for theory development and expansion, the institutional theory emerges as a portable theory and has previously been applied in CE studies (Abubakar, 2018; Liu *et al.*, 2018), as will be explained in Section 2.1. We make three distinct contributions by applying the theory's tenets to our analysis. First, we articulate more specifically what the CE concept entails in the seafood sector. Second, we provide a basis for managers and stakeholders in Vietnam to formulate policies and strategies for dealing with the barriers to CE implementation and for successfully implementing the CE system. Third, we demonstrate the fitness of the extended institutional theory and emphasise two important – but often overlooked – elements: uncertainty and institutional logics.

The paper proceeds as follows. Section 2 provides the justification for our theoretical choices and a review of the literature concerning the three RQs. Section 3 elucidates the research methodology. Section 4 presents the findings concerning the nexus of circular practices, drivers, and barriers. Section 5 discusses our insights in the context of the extant literature and the extended institutional framework. Section 6 summarises the conclusions, implications, and limitations of this study.

2. Theoretical background and literature review

2.1. The extended institutional theory in the circular economy

Several theories have been applied in the extant literature to explore the adoption and diffusion of circular practices. Examples include the stakeholder theory (Chiappetta Jabbour *et al.*, 2020), transaction cost economics (TCE) (Dossa *et al.*, 2020), and the resource-based view (Jakhar Suresh *et al.*, 2019). However, institutional theory has become increasingly popular in the CE literature, largely due to its explanatory power in examining and classifying the factors that lead firms to be *isomorphic*, or similar in their actions and inactions (DiMaggio and Powell, 1983; Turkulainen *et al.*, 2017). CE literature uses institutional theory to expla include environmental reporting practices (Dagiliene *et al.*, 2020), lean and green practices (Caldera *et al.*, 2019), outsourcing and internal separation (Stål and Corvellec, 2018), and sustainable packaging (Meherishi *et al.*, 2019). Factors causing mass actions are considered drivers, while factors leading to inaction are viewed as barriers.

There are two variants of institutional theory: sociological and economic (Figure 1) (Kauppi, 2013; Turkulainen *et al.*, 2017). The former is rooted in Meyer and Rowan (1977) and DiMaggio and Powell (1983) and explains what makes firms adopt legitimate practices, such as sustainable practices (see Dubey *et al.*, 2015; Silvestre, 2015; Lucas and Noordewier, 2016; Liu *et al.*, 2018). The latter, grounded in Haunschild and Miner (1997), explains what makes firms adopt similar efficient practices, such as those that reduce costs or increase productivity. Extended institutional theory integrates the sociological and economic variants to consider all external constituents (Figure 1). Since CE facilitates the harmonisation of economic development (efficiency) and environmental protection (legitimacy) (Ghisellini *et al.*, 2016; Murray *et al.*, 2017; Merli *et al.*, 2018), the extended institutional theory is best suited to be our theoretical lens, without the need for any additional qualifier.

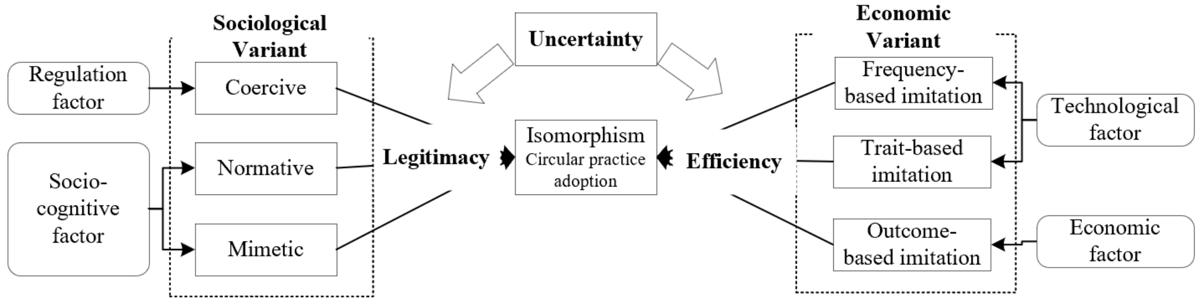

Figure 1: The sociological and economic variants of institutional theory (modified from Kauppi, 2013)

The sociological variant provides three mechanisms for legitimacy-seeking: (i) *coercive pressure*, which derives from law and regulation factors; (ii) *normative pressure*, which stems from social norms and cultural factors; and (iii) *mimetic pressure*, which arises from cognitive factors and leads firms to copy the actions of other firms to reduce uncertainty. The economic variant adds three more mechanisms: (i) *frequency-based imitation*, which refers to the mimicking of actions that reach a critical mass of adopters (Zucker, 1987); (ii) *trait-based imitation*, which involves the adoption of the practices espoused by prestigious firms; and (iii) *outcome-based imitation*, which entails copying actions that provide salient positive outcomes (Haunschild and Miner, 1997). The frequency and trait-based forms of imitation are attributed to technological factors, whereas outcome-based imitation is associated with economic factors. Thus, extended institutional theory gives rise to four distinct influencing factors: (i) *regulatory*, (ii) *socio-cognitive*, (iii) *economic*, and (iv) *technological* (Figure 1). Whereas the first two groups aim at enhancing the legitimacy of the adopted practice, the last two contribute to improving its efficiency.

The two variants share the common element of uncertainty, which can arise from supply, demand, technology, or process (Kauppi, 2013). The greater the uncertainty between means and ends, the more firms model themselves on counterparts they perceive to be rational, legitimate, or successful (DiMaggio and Powell, 1983). This imitation is rooted in anxiety, which is exacerbated by uncertainty and linked to the desire to avoid having to reinvent the wheel or to face first-mover risk (Miemczyk, 2008). Kauppi (2013) argued that when experiencing deep uncertainty, firms are more likely to adopt a practice due to legitimacy pressure rather than efficiency pressure. In other words, regulatory and socio-cognitive factors (legitimacy) have a stronger influence than economic and technological factors (efficiency) in the presence of uncertainty.

To our knowledge, no empirical investigation has hitherto been conducted on the extended institutional theory in the CE literature. This study, therefore, increases the theory's explanatory power by integrating its two variants in order to explore the factors driving and hindering the adoption of CE in SPBP management.

2.2. Seafood processing by-product management practices under the circular economy paradigm

A circular economy is defined as 'an industrial system that is restorative or regenerative by intention and design' (Ellen MacArthur Foundation, 2012, p. 7). Such a system is self-sustained via the continuous use of waste resources. Thus, the effective management of biowastes, including SPBPs, plays a pivotal role in the transition toward CE in the food supply chain (Jurgilevich *et al.*, 2016; Vilariño *et al.*, 2017). Two core CE principles are highlighted in biowaste management: (i) cascading use and (ii) higher value creation. Cascading use refers to 'optimising resource utilisation through a sequential reuse of the remaining resource's quality from previously used commodities and substances' (Sirkin and Houten, 1994, p. 217). In the context of biowaste, cascading use involves the effective separation and extraction of multiple materials and compounds from biowaste in a sequential process. This both eliminates resource leakage and discourages the use of toxic chemicals that hinder material reuse, which reduces environmental harm.

Higher value creation prioritises the generation of higher added-value products from by-products. The biomass value pyramid developed by BioBased Economy Netherlands (Davis *et al.*, 2017) is a useful reference for prioritising the value ranking. In descending order of value, the desirable output products are ranked as (i) nutraceutical and fine chemicals, (ii) food, (iii) feed, (iv) bulk chemicals, and (iv) energy (Berbel and Posadillo, 2018). Accordingly, biowaste should be prioritised to produce nutraceutical and pharmaceutical products before generating less valuable products, including food, feed bulk chemicals (e.g. solvents, biofuels, and fertilisers), and energy (e.g. biofuels, heat, and electricity).

Due to its compositional biodiversity, SPBP provides an ideal example of how these two core CE principles are applied. SPBP is an excellent source of high-added-value compounds, including collagen, gelatine, protein and peptides, oil and lipids, chitin, enzymes, glycosaminoglycans, polyunsaturated fatty acids (PUFAs), minerals, vitamins, pigments, and flavours (Ferraro *et al.*, 2010; Al Khawli *et al.*, 2019). These compounds have large-scale industrial and scientific applications. However, feed production is the most popular recycling method for this valuable bio-stream, followed by bulk low-value chemicals such as fertilisers and chitin (FAO, 2016; Al Khawli *et al.*, 2019). Although these methods retain some value from SPBPs, they aim only at single-output products with low added value, which violates the two principles of CE. The recent literature has paid increasing attention to the potential use of biotechnologies to produce valuable compounds and maximise value creation from SPBPs. Examples can be found in the review papers of Ferraro *et al.* (2010), Rustad *et al.* (2011), and Nawaz *et al.* (2020). Frequently discussed biotechnologies include supercritical fluid extraction (SCF), ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), pulsed electric field (PEF), and enzymatic hydrolysis (Ivanovs and Blumberga, 2017; Al Khawli *et al.*, 2019). These technologies follow the biological route, which addressing the challenges associated with the chemical route of using corrosive and hazardous solvents (e.g. HCl and NaOH). Such challenges include high pollution, high energy consumption, high cost, and resource wastage.

The dry weight of the shrimp sector's by-products contains 18% chitin, 43% protein, 29% minerals/ash and 10% lipid fat (Mao *et al.*, 2017). Chitin production has achieved industrial-scale success by removing protein (deproteinisation stage; DP) and minerals (demineralisation stage; DM) via the chemical route. However, the presence of strong alkalis and acids in DP and DM damages the structure of biomolecules, including protein, minerals (calcium carbonate), and lipid oil, which contains astaxanthin pigments. As a result, only chitin is recovered with this method. Biotechnologies such as enzymatic hydrolysis and microbial fermentation offer an ecologically safe alternative and enable the recovery of protein, minerals, and oil in the chitin production process (Mao *et al.*, 2017). The UAE, SCF, and PEF technologies for high-value lipid extraction from shrimp by-products are also discussed in the literature (see Gulzar *et al.*, 2020).

In the fish sector, fish heads, viscera, skin, tails, offal, and blood are all valuable resources that can be valorised for high-value retention. The literature has thoroughly explored various options in an effort to find the best use for these by-products. For instance, Vázquez *et al.* (2020) conducted a lab- and pilot-scale biorefinery experiment based on enzymatic hydrolysis to convert fish waste materials into multiple outputs, including fish protein hydrolysates (FPHs), oils, bioactive peptides, and fish peptones. As regards fish oil (PUFA) extraction, Ivanovs and Blumberga (2017) compared the pros and cons of four green extraction options (SCF, UAE, MAE, and enzymatic hydrolysis), while Al Khawli *et al.* (2019) and Melgosa *et al.* (2021) advocated SCF as the most suitable method. Finally, biological methods of collagen and gelatine extraction (enzymatic hydrolysis and microorganism fermentation) have the potential for industrial-scale deployment and avoid the problems of the chemical solvent method (Pal and Suresh, 2016).

In summary, the literature approaches the application of CE to SPBP management primarily from a technological perspective, focusing on experimental studies and reviews. However, to our knowledge, no empirical evidence exists for commercial-scale projects. The present study aims to fill this gap in the literature.

2.3. Drivers of and barriers to the implementation of the circular economy in food processing by-product management

The exploration of drivers and barriers for the CE transition is an emergent topic in the CE literature (Leder *et al.*, 2020). Several systematic literature reviews have been carried out (see de Jesus and Mendonça, 2018; Govindan and Hasanagic, 2018), and several methods of classification have been proposed. For instance, Kirchherr *et al.* (2018) categorised 15 CE barriers into four groups, whereas Tura *et al.* (2019) and Russell *et al.* (2020) recommended seven and five groups, respectively. Because drivers and barriers are highly context-specific (Tura *et al.*, 2019), increasing attention has been paid to different business environments. These include the automotive industry (Agyemang *et al.*, 2019; Urbinati *et al.*, 2021), mining (Upadhyay *et al.*, 2021), and construction (Kanters, 2020). Other authors have explored waste management – reduce, reuse, and recycle (3Rs) (Ranta *et al.*, 2018) – as well as the food industry (coffee in van Keulen and Kirchherr, 2021; meat and dairy in Gregg *et al.*, 2020). In particular, there are important differences between managing technical materials (e.g. steel, plastics) and biological materials (e.g. food); some factors such as enablers of repairs or product recall in the former are not applicable to the latter. Therefore, it is imperative to conduct an empirical investigation of the factors that promote and hinder the circularity of by-products in the seafood sector. As far as we know, despite some attempts to describe the challenges of fish valorisation (see Pal and Suresh, 2016; de la Caba *et al.*, 2019; Nawaz *et al.*, 2020), no such study has been performed in the seafood sector. Therefore, we expanded the scope of this review to include by-product management in the food sector in general.

The literature on food by-product valorisation has identified a number of facilitators and hindrances in various processing contexts, such as the dairy, slaughterhouse, beer brewing (Gregg *et al.*, 2020), and apricot sectors (Boumali *et al.*, 2020). Donner *et al.* (2021) provided the most exhaustive list of influencers in agri-residue valorisation. The authors grouped these factors into five sources: (1) technical and logistic; (2) economic, financial, and marketing; (3) organisational and spatial; (4) institutional and legal; and (5) environmental, social, and cultural factors. In the Asian context, Joshi and Visvanathan (2019) highlighted a list of policy and technological barriers to four methods of food-waste management: (1) animal feeds, (2) anaerobic digestion (AD), (3) AD composting, and (4) incineration. Similarly, Ong *et al.* (2018) identified drivers and challenges for converting food waste into animal feed, energy, and platform chemicals in five Asian countries. In general, no consistent method has been offered to classify these drivers and barriers.

To overcome this issue, we borrow the extended institutional theory's classification approach (Section 2.1) to group the drivers and barriers found in the extant literature into four groups. We make one slight modification to this approach, renaming the *economic factor* the *economic and supply chain factor* because the element of the supply chain emerges from the literature review.

Drivers

Below is an analysis of the driving factors (Table 1):

(i) Regulatory drivers: These come from a mix of laws and regulations, incentives and funding, prizes and awards, and awareness campaigns. Stricter environmental laws (such as the whey disposal law; Gregg *et al.*, 2020) and the relaxation of regulations (such as allowing the use of slaughterhouse by-products in the AD plants) drive valorisation efforts (Donner *et al.*, 2021). Regulatory drivers also derive from the availability of fiscal incentives (Donner *et al.*, 2021) and public funding for research and development (R&D) projects in food-waste valorisation (Ong *et al.*, 2018; Boumali *et al.*, 2020). Prizes and awards for circular innovation efforts are another important driving force for valorisation projects (Donner *et al.*, 2021). Finally, government initiatives to increase citizens' awareness are also a driver in this group (Joshi and Visvanathan, 2019).

(ii) Socio-cognitive drivers: These drivers arise from the awareness and commitment of CE stakeholders, including by-product processors, by-product producers (seafood processors), and customers. They include the recognition of the potential to recover valuable nutrients and energy from by-products (Joshi and Visvanathan, 2019), an awareness of the environmental issues associated with food waste – which, in turn, drives the commitment to engage in clean production to tackle the problem (Joshi and Visvanathan, 2019; Leder *et al.*, 2020) – as well as ecological awareness to reduce human dependencies on virgin resource depletion (Joshi and Visvanathan, 2019; Santagata *et al.*, 2021). Collaboration and information sharing among stakeholders also facilitate the adoption of CE in the context of unconventional non-food production (Boumali *et al.*, 2020; Leder *et al.*, 2020). The last driver lies in customers' interest in buying 'green' products generated by transparent and traceable bio-based production processes, and particularly products that are locally produced from nature-based functionalities (Gregg *et al.*, 2020; Donner *et al.*, 2021). Notably, customers include both consumers and business-to-business (B2B) customers (Leder *et al.*, 2020). An example of consumer interest in biowaste-based processes is the higher acceptance of the decentralised AD compared to centralised AD plants, which allows the former to secure financial capital more easily (Joshi and Visvanathan, 2019).

(iii) Economic and supply chain drivers: These stem from the cost benefits of acquiring input materials cheaply at negligible logistics costs thanks to high volume discharged at several locations (Sheppard *et al.*, 2020). Sourcing advantage is another crucial driver because processing residues are often found in large quantities given consistent quality and traceability assurance (Donner *et al.*, 2021).

(iv) Technological drivers: These drivers derive from a range of technological options for food-waste treatment, including biotechnology and non-solvent treatments (Sheppard *et al.*, 2020). AD is an especially good example of such a driver, as it is a marketable technology (Donner *et al.*, 2021). Moreover, advances in biochemistry have played a key role in enabling a successful biorefinery model in the dairy industry (Gregg *et al.*, 2020).

Table 1: List of drivers and barriers from the literature

Category	Drivers	Barriers
Regulatory	1. Laws and regulations 2. Incentives and R&D funding 3. Prizes and awards 4. Awareness campaigns	1. Insufficient laws and regulations 2. Ineffective law enforcement capacity 3. Lack of incentives and funding for industrial upscaling
Socio-cognitive	5. Awareness of the potential to recover materials and energy from food by-products 6. Awareness of environmental issues in by-product management 7. Awareness of virgin resource depletion 8. Collaborations and information sharing in the industry 9. High consumer interest in product and process	4. Low interest in biowaste valorisation 5. Cultural and regional constraints limit conversion options 6. Low consumer trust in new products such as biofuels
Economic and supply chain	10. Financial incentive from low-cost input materials and low logistics costs 11. Sourcing advantages from abundant, high-quality, traceable input materials	7. Unstable market demand 8. Price competitiveness with cheap fossil-based alternatives and high barriers to entry into the existing market 9. Competition between multiple routes for by-product resources 10. Sourcing challenges with respect to quantity and quality 11. Logistical and space requirements of efficient processing
Technological	12. A spectrum of technological options with several marketable technologies	12. Technological upscaling challenges 13. Low technical competence and resource constraints (capital, labour, time) 14. High capital investment with a long payback period 15. Concerns about output products (safety, sensorial, and nutritional)

Barriers

Similarly, barriers found in the literature are also grouped into four clusters (Table 1):

(i) Regulatory barriers: These arise from insufficient laws and regulations, ineffective enforcement capacity, and a lack of government incentives. First, legal barriers include ineffective recycling policies, ambiguity in waste disposal policy (Sadhukhan *et al.*, 2020), changes in agricultural waste management legislation, complex and region-specific regulations (Leder *et al.*, 2020; Donner *et al.*, 2021), and restrictions on the reuse of by-products due to food safety and quality concerns (Santagata *et al.*, 2021). Regulatory barriers also include the absence of a legislative framework to govern trading in the by-product market (Boumali *et al.*, 2020; Leder *et al.*, 2020) and bureaucratic processes for the safety approval of novel end products (Donner *et al.*, 2021). Second, insufficient law enforcement capability consists of inadequate monitoring and even insufficient budget allocations (Joshi and Visvanathan, 2019). Third, a lack of incentives may exist due to insufficient public funding in the scale-up phase and an absence of subsidies (Donner *et al.*, 2021). Moreover, misaligned incentives may prioritise valorisation routes at the bottom of the waste hierarchy, such as energy conversion (Sadhukhan *et al.*, 2020).

(ii) Socio-cognitive barriers: These barriers stem from the attitude and awareness of CE stakeholders. They include low interest among processors in bio-based production using agricultural by-products as feedstocks (Boumali *et al.*, 2020; Leder *et al.*, 2020); constraints on the choice of valorisation pathways due to traditional, cultural, and religious factors (such as the use of meat by-products for human consumption; Gregg *et al.*, 2020); and low consumer trust in novel biowaste-derived products like biofuels (Donner *et al.*, 2021).

(iv) Economic and supply chain barriers: These encompass the lack of stable demand for end products (such as those made of slaughterhouse by-products in Gregg *et al.*, 2020 or apricot pits in Boumali *et al.*, 2020), the uncompetitive prices of new bio-based products compared to the cheap and highly volatile fossil-based products and energy that dominate existing markets (Donner *et al.*, 2021; Santagata *et al.*, 2021), and high market entry barriers for new products (Donner *et al.*, 2021). Non-price competitiveness is attributable to immature and pilot-scale processes and the complex bio-composition of by-products (Donner *et al.*, 2021). There is also concern about the competition between multiple valorisation pathways for the same waste feedstocks (Donner *et al.*, 2021). Finally, supply chain barriers comprise sourcing variations due to the seasonal, local, and compositional attributes of by-products, which could pose risks for continuous manufacturing (Pal and Suresh, 2016; Joshi and Visvanathan, 2019; Donner *et al.*, 2021). The necessity of efficient, flexible inbound and outbound logistics and of large storage capacity for both materials and end products also create supply chain barriers (Leder *et al.*, 2020; Nawaz *et al.*, 2020; Donner *et al.*, 2021). These logistical challenges arise from the special traits of by-products, which are often bulky, heterogeneous, and highly perishable.

(iv) Technological barriers: These barriers have been emphasised in most of the extant literature. First, current technologies for treating food waste (except anaerobic digestion) have a low technology readiness level (TRL) and are subject to numerous upscaling challenges (Boumali *et al.*, 2020; Nawaz *et al.*, 2020; Donner *et al.*, 2021). Furthermore, technological adoption requires high technical competence and skilled labourers (Boumali *et al.*, 2020) to integrate new technology into the existing business model (Leder *et al.*, 2020). The financial hurdle due to a long payback period associated with novel technological development is the third barrier in this group. For example, it is estimated that an AD plant for meat by-products has a payback period of 4.3 years despite having a relatively high TRL (Gregg *et al.*, 2020). Lastly, in the case of food and nutraceutical end-products, there are concerns associated with safety, sensorial, and nutritional aspects, as well as interactions with other ingredients (Pal and Suresh, 2016; de la Caba *et al.*, 2019; Nawaz *et al.*, 2020). There is thus a pressing need to evaluate the safety and bioavailability of nutrients, particularly for nutraceutical products.

In summary, we identify 12 drivers and 15 barriers for generic food-waste management under CE in the extant literature and group them into four clusters based on the extended institutional theory. This theory-based classification is also applied in our data analysis. Since the extant literature has neglected the drivers of and barriers to circular SPBP adoption, this paper fills an important research gap.

3. Methodology

We employed a multiple-case study method in this paper for several reasons. First, the literature review revealed the lack of prior knowledge in this specific research stream, which made an exploratory case method ideal for our study (Eisenhardt and Graebner, 2007; Yin, 2013). Second, case studies are well suited for the study of emergent and multifaceted phenomena – such as CE – because they provide an interpretative informational richness that quantitative methods such as surveys may not achieve (Baxter and Jack, 2008; Barratt *et al.*, 2011). Third, case studies are suitable for constructing new operational management theories from concrete and context-dependent knowledge (Voss *et al.*, 2002). We chose a multi-case approach over a single-case approach because it is likely to deliver more compelling stories by facilitating comparisons (Yin, 2013). Such comparisons can elucidate whether emergent findings are merely idiosyncratic to a single case or consistently replicated in several cases (Eisenhardt, 1989). Our research process consists of three steps in which case sampling, data collection, and data analysis are performed iteratively (Corbin and Strauss, 2014).

3.1. Case selection

Case selection is the critical first step of the case study research design (Dubois and Araujo, 2007). Following a replication logic, cases were selected based on the likelihood that they would offer theoretical insights that would illuminate the underexplored phenomenon under study and elaborate on the emergent theory (Yin, 2013). As this study aimed to develop rather than to test a theory, we chose purposive sampling as opposed to random or stratified sampling (Eisenhardt and Graebner, 2007). Case selection was based not so much on the uniqueness of the cases but on their contribution to theoretical development. The two criteria for case selection were as follows: (i) *Major operations*: The cases had to be *(a)* registered entities on the list of seafood establishments in Vietnam (the database is available at the National Agro-Forestry-Fisheries Quality Assurance Department – NAFIQAD, 2019) with *(b)* major operations in managing SPBPs in the Mekong Delta that *(c)* satisfy at least one of the two CE principles; (ii) *Reputation*: the cases were filtered based on their reputations in SPBP valorisation. As specified, we relied on industry databases and other publications and reports to operationalise these two criteria. These documents include publications and reports from the Vietnam Association of Seafood Exporters and Producers (VASEP), relevant government agencies (the previously mentioned NAFIQAD and the Department of Natural Resources and Environment; DONRE), a university that specialises in seafood studies (Nong Lam University; NLU), and from independent research bodies (e.g. the World Bank). We selected reputable cases because their structured and well-established processes permit a fine-grained analysis, as befits an exploratory study. Furthermore, we targeted case companies that process shrimp and pangasius because these two products are essential exports in Vietnam's seafood portfolio. The selection was completed with the aid of two experienced researchers from NLU and the general manager of a top-ten Vietnamese seafood exporter.

Five cases that satisfy the selection criteria were sampled. This was deemed a sufficient number to give a fairly accurate exploratory account in a natural setting (Eisenhardt, 1989), to provide the required depth of observation, and to highlight any contrasting patterns in the data (Yin, 2013). These five cases can be split into two types based on size: small firms (i.e. S1 and S2) and large firms (i.e. L1, L2, and L3). Detailed information about each case is thoroughly examined in Section 4.1 and summarised in Table 2.

3.2. Data collection

The data was triangulated from four sources: (i) semi-structured interviews, (ii) site visits and field notes, (iii) physical artefacts (i.e. technology and business models), and (iv) internal reports and website information. We used interviews as our main tool to gather data due to their ability to provide a range of perspectives on the topic (Kvale, 1994). Prior to each interview, we used each firm's website to collect background information in order to adapt the interview questions. Site visits, field notes, internal reports, and particularly physical artefacts (technology and business models) provided further insights into the overall operations and technological processes, allowing a deeper exploration of the first RQ. Data triangulation was beneficial because it provided diverse perspectives on circular practices and enhance the data's validity and reliability (Voss *et al.*, 2002; Yin, 2013)

In each case, interviews were conducted with at least one member of high-level management and one member of the purchasing and sales staff. At least two researchers participated in all the interviews, which were conducted with the help of an experienced local lecturer at NLU. Whenever possible, stakeholders from the supply chains of the sample cases were included in the interviews. These included seafood processors (suppliers of by-products), buyers of output products, and academics acting as technical consultants. We also recruited two government officials – one who was responsible for environmental affairs (DONRE) and another who worked for the food safety certification department (NAFIQUAD). In total, we conducted 22 interviews that varied from 30 to 90 minutes in duration (mean: 52 minutes). Appendix 1 provides the interviewee profiles.

Interviews followed the semi-structured style with open-ended questions. This format allowed rich discourse and gave the informants the flexibility to express their opinions in unpredictable ways (Yin, 2013; Charmaz, 2014; Corbin and Strauss, 2014). The interview questions are presented in the interview protocol (see Appendix 2). We were careful to follow the interviewees' leads and adapted our questions to the progression of each interview and the characteristics of each case (Corbin and Strauss, 2014). The interviews took place on the companies' premises, and interviewee anonymity and confidentiality were assured. The transcripts and summaries of the key deliverables were e-mailed to the interviewees so that they could validate facts and check for any misinterpretation of content. We also contacted the respondents via e-mail when clarifications or supplementary data were needed.

3.3. Data analysis

We conducted both within-case analysis and cross-case analysis (Miles and Huberman, 1994; Yin, 2013). In within-case analysis, all the gathered materials (including interviews, field notes, business models, company reports, and website information) were organised separately for each case. We began the case analysis by adopting open coding and axial coding techniques to qualitatively build a data structure containing first and second-order codes. In open coding, we analysed each paragraph of the case materials to create coding labels that represent the data. The coding process was independently conducted by two researchers to minimise misinterpretation between the labels and raw data. These tentative labels were then jointly compared and discussed among the researchers until a harmonious agreement was reached to assure inter-rater reliability; this process produced a list of first-order codes. Next, we conducted axial coding by aggregating the first-order concepts into higher-order themes (also known as second-order codes): regulatory, socio-cognitive, economic and supply chain, and technological factors. The first-order data reflected informant transcripts, while the second-order codes reflected theory-centric interpretations. Examples of first- and second-order codes are demonstrated in Table 3 and Table 4 (Section 4.2).

Cross-case analysis was carried out after within-case analysis. In this analysis, we used a pattern-matching technique to detect any commonalities or differences between the cases, thus allowing the theory to emerge (Eisenhardt, 1989). In the case study design, pattern matching is one of the techniques most frequently used to '*compare an empirically based pattern – that is, one based on the findings from your case study – with a predicted one made before you collected your data*' (Yin, 2013, p. 143). This made it possible to identify similar practices, drivers, and barriers among the cases, the contrasting patterns between small and large cases, and each case's idiosyncrasies.

4. Findings

4.1. Within-case analysis

This section presents the circular practices evident in each case as well as their associated drivers and barriers. Tables 3 and 4 provide the list of drivers and factors along with relevant excerpts from the interviews.

S1

Established in 1997, S1 had many years of experience in producing chitin/chitosan from shrimp by-products following a chemical route. In 2017, after two years of collaboration with a technology university in Vietnam, S1 successfully developed a physiochemical process to separate and recover proteins from shrimp by-products before the residues are used for chitin production. The new process requires a significantly lower volume of solvents compared to the conventional method, and it produces higher-quality chitin products. Additionally, the retrieved protein that was not obtainable in the old process is now utilised to produce shrimp soluble extract (SSE) – an attractant that is used as a feed nutrient to increase feed's palatability. S1 sells SSE to a large feed production organisation, which generates an additional revenue stream for S1.

S1's endeavours are driven by four factors: (i) increasingly strict environmental laws, (ii) the financial benefits of lowering wastewater treatment costs and gaining additional income from a new product line (SSE), (iii) awareness of environmental issues caused by heavy chemical use in the conventional process, and (iv) recognition of the potential to extract proteins from shrimp by-products.

To extend the success of S1 to other shrimp by-product processors, S1 mentioned four barriers that must be overcome: (i) uneven environmental law enforcement in different areas, resulting in regionally distinct innovation efforts, (ii) low public funds allocated for R&D in SPBP valorisation, (iii) prevailing norms to convert shrimp waste into low-quality chitin or low-value feed with minimal technological effort, and (iv) low market demand for new feed nutrition. S1 believed that adequate public funds for R&D are crucial to foster collaborative environments in this nascent field, particularly for small processors with capital constraints and limited technical competence.

S2

Founded in 1995, S2 had supplied fish skins to produce animal feeds for many years. In 2017, S2 decided to invest in the processing machinery to produce snacks from fish skins, and now its monthly export volume is 60 tons. Although S2's processing technology is not sophisticated, its raw materials must meet stringent requirements in terms of freshness and traceability. Additionally, the entire production process must meet strict safety requirements for savoury food. The use of fish skin to produce food instead of feed has increased the added value of this raw material fourfold from $0.25 to $1 per kilogram of fish skin. This satisfies the second CE principle of higher value creation.

S2 is driven directly by a combination of three factors: (i) financial gains when receiving a large order for fish skin snacks from an international firm, (ii) the consumer trend towards marine-derived products due to their nutritional value, and (iii) the recognition of the potential to transform fish skins into highly nutritional snacks for human consumption.

To extend the success of S2, three challenges should be considered: (i) the sourcing challenges of ensuring that materials maintain high quality and full traceability in the food market, (ii) complicated technical requirements related to food safety and quality that must be met to obtain export permits, and (iii) prevailing norms of using fish skins in animal feed production, which prevent access to food-grade materials.

L1

Established in 2013, L1 aims to become a pioneer in the research and application of technology to produce high-value products from shrimp by-products. Its vision is to solve shrimp by-product management – the last remaining sustainability puzzle in the shrimp sector – via a comprehensive eco-friendly solution based on enzymatic hydrolysis with a biotechnological zero-waste mindset. L1 has two factories located in the heart of two shrimp processing zones in the Mekong Delta. One factory is located next to the largest shrimp processing factory in Vietnam and to which the by-products are transported using conveyor belts. L1 has designed an efficient inbound transport system that reduces collection times to less than half an hour in order to maintain the highest quality of input materials. A novel biotechnology process allows L1 to commercialise a range of food ingredients (e.g. shrimp powder, extracts, oil, and seasoning), feed nutrition (e.g. SSE), and chemicals (low-molecule chitosan and biofertilisers). L1 continuously invests in R&D and has achieved success at a pilot scale, widening its product portfolio to include higher-added-value nutraceutical and pharmaceutical products (functional peptides and astaxanthin). With a recovery rate of 80%, the current added-value ratio of L1 is six to eight times, compared to the two to three times achieved by its competitors. The company's production capacity is 200 tons of raw material per day, which lowers the environmental impacts of shrimp by-products discharged in the region.

L1 is driven to develop and use biotechnology by a combination of six driving forces: (i) a strong vision of making the best use of waste by using biotechnology, (ii) awareness of the pressing need to replace unsustainable treatment practices, (iii) awareness of the potential to recover a range of valuable compounds from shrimp by-products, (iv) rising demand and costs for human food and feed nutrition, (v) the sourcing advantages of large-scale production and full traceability, and (vi) the economic incentives of reducing waste treatment costs and generating additional revenue streams by diversifying output ranges.

The diffusion of L1's zero-waste philosophy faces seven barriers: (i) a weak legal system governing the operations of recyclers, (ii) no legislative framework supporting the commercialisation of end products, (iii) the widespread use of outdated technologies in the market, (iv) low interest among shrimp processors and exporters in shrimp by-product management due to their entrenched views of this stream as waste, (v) a lack of clear market mechanisms for the new products, (vi) obtaining technology and equipment on a scale that can generate high-quality products at a competitive price, and (vii) the demands of cold-chain logistics. Since seafood deteriorates quickly (in less than four hours), the efficient design of cold-chain logistics from collection to storage represents both a key factor for success and a real challenge in Vietnam.

L2

L2, an affiliate of a large regional seafood producer, was founded in 2010 to produce cooking oil from fish fat. Before L2's establishment, its parent firm had a long history of converting fish fat into biodiesels for export. After three years of actively searching, learning, and testing, L2 found a leading supplier of oil refining equipment and technology in Europe. This supplier provided technology that follows a physical refinery route to deodorise and refine premium oil that is 100% sourced from fish fat. The deodorising process involves heating, filtering using fine fibre layers, and bleaching. The process takes 48 hours and is tightly controlled and monitored in accordance with international standards, including Food Safety System Certification (FSSC) 22000, Hazard Analysis Critical Control Point (HACCAP), and halal. The final products are olein (thin oil) and stearin (thick oil); the former is sold as home cooking oil while the latter is used as an ingredient in the food processing sector. These products have successfully entered the domestic and international markets The two markets make up approximately equal shares of L2's business. L2's current production capacity is 400 tons of raw material per day, which makes up 3% of the market share of domestic cooking oil demand.

L2 is motivated by six factors: (i) a strong desire to intensify the fish value chain via biotechnology, (ii) an awareness of the potential to convert fish oils into cooking oil for human consumption in a cost-effective manner, (iii) ever-increasing costs of vegetable-based cooking oils in the domestic market combined with rising demand, (iv) customers' preference for fish-derived products, (v) an exclusive sourcing advantage with vertical integration, and (vi) financial incentives as a result of the success in eliminating fish odours. Vertical integration with the by-product supplier, which is also a major seafood processor, reduces material costs and helps to ensure that the materials along L2's supply chain are fully traceable.

In discussing the diffusion of biotechnology as an SPBP management tool, L2 identified three key obstacles: (i) the deployment of technology at a suitable scale to achieve cost-effectiveness and quality, (ii) prevailing practices of converting fat to biodiesel and feed without technological investment, and (iii) the difficulties of integrating into the distribution network. Overcoming the third barrier is crucial to the success of the business-to-customer (B2C) model due to the uniqueness of the distribution network in Vietnam; the network includes numerous small grocery stores, which incurs high last-mile transportation costs.

L3

L3 was founded in 2011 following a successful lab-scale experiment on the extraction of collagen and gelatine from fish skin. A commercial-scale factory began operation in 2014 and supplies premium freshwater collagen and gelatine products that meet the most stringent requirements of the pharmaceutical and food industry. The factory is certified by ISO and GMP WHO and obtained halal certification in 2015. L3 possesses a modern and sophisticated state-of-the-art facility that uses biological methods (enzymatic hydrolysis) to extract and purify collagen and gelatine. The proximity of the fish factory and L3's processing facility enables the production of collagen and gelatine from a living fish within 24 hours of being harvested, which guarantees the freshness of material inputs. The annual capacity of the factory is 2,000 tons of gelatine powder and collagen peptide output.

L3 is driven by five factors: (i) a strong desire to improve the fish value chain using biotechnology, (ii) consumer preferences for fish-derived products due to cultural and nutraceutical considerations, (iii) awareness of the potential of recovering pharmaceutical- and nutraceutical-grade products from fish skins, (iv) an exclusive sourcing advantage with vertical integration, and (v) financial incentives created by adding higher value to the product. Similar to L2, vertical integration is present in L3, with the self-sufficiency ratio of 65% in 2020. Given the fish industry's high fluctuations in demand and market price over the last few years, intensifying the fish value chain enables L3's parent corporation to achieve more sustainable growth.

L3 identified seven barriers to expanding its success in this area: (i) the low price competitiveness of fish-based gelatine and collagen compared to cow-based alternatives, (ii) low consumer trust in local nutraceutical brands, which prevents its growth in the B2C segment, (iii) prevailing norms in the market that focus on animal feed production from skins, (iv) the necessity of cold-chain logistics, (v) the challenge of scaling-up technology to obtain high-purity products in a cost-effective manner, (vi) high capital investment and a long payback period, and (vii) a long exporting and testing procedure. The first barrier reflects the fact that cow skins require a simpler technology to extract and purify collagen, making it cheaper than fish-based products. As such, L3 currently targets Islamic-majority countries as its main market; these countries prefer fish-based products for cultural acceptance reasons. Regarding the fourth barrier, L3 emphasises the importance of a cold-chain facility because the storage conditions affect the production yield. The last barrier relates to the bureaucratic obstacles associated with obtaining export permits and with importers' lengthy quality-check processes. In several instances, it took three years for the importers to check and test the materials, which directly worsened the sixth barrier: a long payback period in the early stages of operation.

4.2. Cross-case analysis

This section synthesises the findings from individual cases and identifies the common and contrasting patterns across the five cases with respect to our three RQs.

The circular practices

Five cases have successfully achieved commercial-scale closed-loop production to offer products in the domestic and/or global market that comply with international standards. The circular practices that these firms adopted aim at cascading use and/or higher value creation to generate end products for the pharmaceutical, nutraceutical, food, and feed nutrient markets (Table 2). All cases except for S2 apply advanced technology in their production. This reflects the nature of S2, which produces human foods in the form of snacks without the need for isolation, extraction, and purification as in the remaining cases.

Table 2: Summaries of case information and circular practices adopted

Case ID	Size	Year founded	SPBP types	Technology routes	Production capacity	CE principle	Targeted outputs
S1	Small	1997	Shrimp heads	Physiochemical (extraction and chemical)	2 tons of input materials per day	Cascading use	Feed (attractants) Bulk chemical (chitin/chitosan)
S2	Small	1995	Fish skins	Thermal process	60 tons of input materials per month	Higher value creation	Food (fish skin snacks)
L1	Large	2013	Shrimp heads	Biochemical (enzymatic hydrolysis)	200 tons of input materials per day	Cascading use & higher value creation	Nutraceutical (functional peptides and astaxanthin) Food ingredients (shrimp powder, extracts, oil, seasoning) Feed ingredient (SSE) Bulk chemicals (chitin/chitosan, biofertilisers)

L2	Large	2010	Fish fats	Physical refinery	400 tons of materials per day	Higher value creation	Food (home cooking oil, food ingredients)
L3	Large	2011	Fish skins	Biochemical (Enzymatic hydrolysis)	2,000 tons of outputs per year	Higher value creation	Nutraceutical /pharmaceutical (gelatine powder and collagen peptides)

Notwithstanding these commonalities, there are important differences between the practices adopted by small and large firms. The small firms appear to have converted their conventional recycling model to a greener and more efficient process. They selected simpler technologies with low capital investments and short development times. Moreover, they sought affordable options that build on their existing processes and resources. Their new products (feed nutrients – S1, fish snacks – S2) are sold to a single customer in a B2B model, which reduces downstream complexity. This approach is reasonable given small firms' capability and resource constraints, which prevent them from implementing methods involving advanced biotechnology.

In contrast, the large firms were all established on the foundation of the CE, which aims at applying biotechnology to maximise resource utilisation while minimising environmental impacts. These firms adopted green technologies, including enzymatic hydrolysis (L1, L3) and physical refining (L2), to produce novel and high-quality products that can be sold at lower prices while reducing environmental harm. Their state-of-the-art technologies and equipment are the result of a lengthy R&D process with a high capital tie-up. Interestingly, the large cases are all roughly a decade old.

Table 3: Drivers of our case firms' engagement

Sources (Second-order code)	No.	Drivers (First-order code)	Cases	Quotations	References/New factors
Regulatory	1	Stricter environmental laws	S1	'The government has now tightened the measures to control wastewater discharge. We recognised the need for change and decided to adopt a cleaner closed-loop production […]' (Factory Manager, S1)	Gregg *et al.* (2020)
Socio-cognitive	2	Strong visions of intensifying the value chain via biotechnology	L1, L2, L3	'We look at the success in other countries […] Iceland has successfully created a value chain for fish by-products, adding 28 times the value to the by-products […] We have vision and confidence in maximising the value of wastes' (General Manager, L1). 'Our ambition is to make a difference for made-in-Vietnam products. With the application of cutting-edge biorefinery, we can transform fish by-products into a range of high-end nutraceutical products, such as collagen and gelatine, that meet international standards […] The frozen fillet industry was hit hard by low prices in 2019, so diversification of the product portfolio is our strategic development' (General Manager, L3)	Exclusive factor found in this study
	3	Awareness of the potential to recover valuable materials from SPBP	All cases	'At a proportion of 35–45% of raw materials, the volume of this by-product is more than 300,000 tons per year and continues to increase. We need to tap into this huge resource and turn it into high-value products' (Sales Manager, L1) 'Mekong Delta each year supplies 140,000 tons of fish fat […] they are mainly converted into biodiesels, which, according to me, is a waste' (Operational Manager, L2)	Joshi and Visvanathan (2019)
	4	Awareness of environmental issues in SPBP management	S1, L1	'At present, shrimp by-products were ground and dried as feed ingredients or raw materials for chitin production in the chemical route or dumped in the river, causing huge environmental issues, and wasting proteins and lipids […] We've shown that it's possible to go carbon-neutral in extracting protein from aquatic products' (General Manager, L1)	Joshi and Visvanathan (2019); Leder *et al.* (2020)
	5	High customer interest in marine-derived products from nutritional and cultural viewpoints	S2, L2, L3	'Our only issue is to get rid of fish smells, we are confident about the nutritional value embedded in our product overtaking vegetable oils' (Operational Manager, S2). 'Our single-source pharmaceutical-grade products are widely accepted across cultures and religions […] we want to address consumers' desire for freshwater collagen and gelatine with safety, purity, and consistency' (General Manager, L2)	Exclusive factor found in this study
Economic – supply chain	6	Rising demand and cost of raw materials	L1, L2	'The driving force for our food nutrition is to tackle nutrition, malnourishment, and environmental issues by considering aquatic by-products as an alternative source of protein for the growing population with a rising protein shortage […] The driving force behind our feed ingredients alleviates the reliance on imported materials like fish meal from Peru […] Our SSE product helps to save feeding costs by 2% for fish farmers and 11% for pig farmers' (Sales Manager, L1) '[…] when Vietnam has to splash out millions of dollars each year to import cooking oils for the food processing industry […] we offer a local and healthy alternative at a competitive price to alleviate the reliance on imported vegetable oil' (Operational Manager, L2)	Exclusive factor found in this study

	7	Financial incentives from higher-value-added end products and/or cost-saving	All cases	'The key was a combination of the two things as a financial driver. Firstly, you might make some money directly out of this waste stream. And secondly, that you might save some money from wastewater treatment' (Director, S1) 'Because clearly there was a lot of nutrients left in shrimp heads and shells, there was potentially a commercial benefit in recovering it' (Factory Manager, L1)	Sheppard *et al.* (2020); Donner *et al.* (2021)
	8	Sourcing advantages with the presence of vertical integration or long-term contracts	L1, L2, L3	'Last year we raised our self-supply ratio from 55% to 65% […] The vertical integration strategy contributes to lowering the material costs and ensuring full traceability down to the pond, batch, date of harvest, rearing conditions, and feeding source' (General Manager, L3) 'We already signed a fifteen-year contract with one large shrimp processor in the area to secure the supply' (L1)	Donner *et al.* (2021)

Table 4: Barriers to diffuse our case firms' circular practices

Sources (Second-order code)	No	Barriers to diffuse the practice (First-order code)	Cases	Quotations	References/New factors
Regulatory	1	No legislative framework supporting novel end products	L1	'Policy to support by-product valorisation is slow and less adaptive [….] It took nearly two years for our feed products to obtain legal permission. There is a need to improve the policy framework to facilitate the commercialisation phase' (R&D staff, L1)	Boumali *et al.* (2020); Leder *et al.* (2020); Donner *et al.* (2021)
	2	Uneven law enforcement and weak monitoring of recycling activities	S1, L1	'It might not be the case for other companies, particularly in remote areas. Illegal wastewater discharge is commonplace […] with environmental laws, certainty is more important than severity' (Factory Manager, S1) 'Our weak legal system allows whoever wants to, to be a waste recycler. The waste-based industry needs to be properly recognised and reshaped. It should begin with the role of the government in tightening the waste management policy; say, granting licences to legitimate businesses involved in by-product treatment […]' (General Manager, L1)	Joshi and Visvanathan (2019)
	3	Lack of fiscal incentives, low public funding in R&D	S1	'Public funds have encouraged research institutes, universities, and investment in making products from shrimp by-products, but the impacts are still modest. Outputs are mostly raw materials. I think more support should be given to boost this further' (Director, S1)	Donner *et al.* (2021); Santagata *et al.* (2021)
Socio-cognitive	4	Prevailing practice involving outdated technology and low value-added outputs	All cases	'Many processors in the area are quite conservative, so there was a lack of regular interest in pursuing innovation […] I do not think the current production of grinding and drying applies any technology at all' (General Manager, L1)	Exclusive factor found in this study
	5	Low interest in advanced SPBP management due to the view of by-products as waste	L1	'When the focus is mostly on the shrimp meat, almost half of the shrimp's weight is overlooked […] We must no longer consider shrimp by-products as a waste, but instead a co-product at the processing plant. Values are not only in the meat, but this is easier said than done […] Still processors show little interest in managing this waste stream' (General Manager, L1)	Boumali *et al.* (2020); Leder *et al.* (2020)
	6	Low customer trust in local nutraceutical brands	L3	'Local consumers are hesitant about local nutraceutical products, so the company exports mainly now […] B2B is our current strategy' (General Manager, L3)	Exclusive factor found in this study
Economic – supply	7	Lack of stable market demand	S1,	'The next question is how to find the market in this nascent industry. This is a barrier	Boumali *et al.* (2020); Gregg

chain		for new products	L1	when the market demand and value of the end product were not clear until we had developed the process from which we can extract it' (Sales Manager, L1)	*et al.* (2020)
	8	Low price competitiveness compared to cow-based collagen	L3	'Cow-based collagen is cheaper due to a simpler production process (General Manager, L3)	Donner *et al.* (2021); Santagata *et al.* (2021)
	9	Sourcing challenges of securing quality and traceability requirements	S2	'To export fish skins as snacks, not only our process has to meet stringent health and safety standards, but the quality of input materials has to be secured… I guess upstream procurement is our pressing concern right now' (Operational Manager, S2)	Pal and Suresh (2016); Donner *et al.* (2021)
	10	Cold-chain logistics requirement	L1, L3	'A key issue in this playfield is that seafood is also highly susceptible to microbial spoilage. Within 4 hours without a cold chain, it will deteriorate […] Our collection time is 30 minutes and each day we collect 100 tons on average' (Sales Manager, L1) 'A barrier that I must mention is with cold-chain infrastructure because the storage conditions of the skins influence the extraction yield' (General Manager, L3)	Exclusive factor found in this study
	11	Challenges of integration into the local distribution network	L2	'We have our own sales team, and the issue here is integration in both supermarkets and small-scale retailers, incurring high transport costs […] We are still negotiating to expand further in the national distribution network' (Operational Manager, L2)	Exclusive factor found in this study
Technological	12	Technological upscaling challenges to achieve cost-effective and high-quality outputs	L1, L2, L3	'A key issue lies in the technology scaling-up to extract the materials at the quality that we want, and then how to produce at a competitive price. If the price is not competitive or quality does not meet the requirement, we cannot survive […] It is a long process with big decisions and commitment […] Last year, we paid a billion dongs to import a compressing machine and could not use it' (R&D staff, L1) 'Technology is the main barrier in this segment. We need technology to extract high-grade collagen and gelatine without the risk of contamination from heavy metals […] We are proud to say that after a long research and development process, we are able to offer products with a unique purity and medical profile. We now supply directly to the health and wellness producers' (Operational Manager, L3)	Boumali *et al.* (2020); Nawaz *et al.* (2020); Donner *et al.* (2021)
	13	High capital investment with a long payback period	L3	'An issue that should be borne in mind is a long payback period. Unlike frozen fillet, nutraceutical production takes a much longer time to make a return on investment, and partially because of a huge capital tie-up at the beginning' (General Manager, L3)	Gregg *et al.* (2020)
	14	Complicated and time-consuming exporting and testing process	S2, L3	'When we started, we had to wait one year to obtain necessary exporting permits and three years for our partners to conduct quality evaluations' (General Manager, L3)	Exclusive factor found in this study

The drivers

Table 3 condenses eight drivers behind our cases' engagement. Following the classification scheme of extended institutional theory, the drivers are grouped into three sources: regulatory, socio-cognitive, and economic and supply chain factors. Several interesting patterns emerge in the list of drivers.

First, financial incentives and awareness of the potential to recover added-value materials from SPBP are common drivers across our five cases. The financial benefit comes not only from adding higher value to the end products but also from cost savings (such as wastewater treatment costs in S1 and L1) thanks to less downstream waste.

Second, small and large firms have different drivers. The small firms tended to participate in CE reactively. Their actions emanated from either stricter environmental laws or strong market pull when receiving a large order from an international firm. Therefore, it appears that the drivers for small firms are more related to the external environment than internal vision or commitment. In contrast, large firms are driven by a combination of exclusive sourcing advantages and a strong vision to add more value to the fish chain via biotechnology. All large firms have their own R&D departments and are actively engaged in R&D projects in collaboration with the world's leading biotechnology firms. Large firms also possess a secure supply of high-quality input materials with full traceability. They are either strategic partners with a large processor under a 15-year contract (L1) or affiliates of large-scale seafood producers with a high self-supply ratio (L2 and L3). For these large firms, vertical integration eliminates any potential sourcing risks that could jeopardise long-term success. This exclusive advantage also acts as a barrier for competitors to enter this niche market; competing firms may possess technology but struggle to secure the supply of input materials.

Third, one of the exclusive drivers associated with shrimp by-products is the awareness of environmental issues. Current shrimp by-product management is the source of huge environmental concerns in the community surrounding fish processing plants due to the use of heavy chemical solvents and the generation of hazardous downstream waste. The cascading principle helps to solve this issue and generate additional income from multiple end products, as in the case of S1 and L1. This sets the two firms apart from the common chemical-intensive chitin treatment of shrimp by-products in the market.

Finally, the technology-related factor is not listed as a driver for all the cases' engagement. We find that firms actively seek the technological options best suited to their needs as determined by the other drivers.

The barriers

Table 4 synthesises 14 barriers that prevent CE models from achieving nationwide diffusion. Following the extended institutional theory classification, the barriers are grouped into four sources: (i) regulatory, (ii) socio-cognitive, (iii) economic and supply chain, and (iv) technological. Both small and large firms identified a range of obstacles from these sources. The firms exhibited no common pattern except for a shared barrier of acknowledging the prevailing outdated SPBP treatment processes for feed, bulk chemical, and fuel production in Vietnam.

The regulatory barriers include weak and region-specific enforcement and monitoring mechanisms (S1, L1), no fiscal incentives and low public funding for R&D, and the absence of a legislative framework supporting the commercialisation of new end products (L1). While S1 pointed out the issue of region-specific compliance, L2 recommended that policymakers should monitor the operations of the by-product process via licensing, thereby avoiding illegitimate businesses. In the case of novel end products such as SSE, the lack of a legislative framework might cause a lengthy approval process, thereby escalating the cost and risks for processors (L1).

The socio-cognitive barriers include several factors shared across cases: the prevailing outdated technology, the 'wrong' mindset of seeing by-products as waste, and low consumer trust in local nutraceutical brands. The second barrier in this group reflects many seafood processors' reluctance to diverge from their core business, which is frozen seafood production. For these processors, their by-products are treated as the third waste stream coming out from their operations, along with wastewater and packaging wastes, to be sold to external parties. The last barrier is only applicable to nutraceutical applications such as collagen, which hinders its entry into the B2C model; thus, L3 currently follows a B2B business model.

Economic and supply chain barriers consist of five factors: lack of stable market demand for novel products, lack of price competitiveness, sourcing challenges, the need for cold-chain logistics, and the challenges of integration into the downstream distribution network. As these factors are case-specific, they have been discussed as part of within-case analysis (see Table 4 for relevant quotations).

Lastly, technological challenges are cited as key barriers to the dissemination of large firms' circular practices. These include the challenges of upscaling to achieve cost-effective and high-quality outputs, high capital tie-up with a long payback period, and time-consuming and complex export and quality testing processes.

5. Discussions

In this section, the key findings based on the case analysis (Section 4) are compared with those in the extant literature and the theoretical lens of institutional theory to derive further insights.

5.1. Comparison of circular practices with extant literature

RQ1 sets out to identify the circular practices adopted in SPBP management. The evidence from the five cases (Table 2) shows how two intrinsic principles – cascading use and higher value creation – are operationalised. These principles are complementary to the conventional 3Rs, thereby contributing to the CE transition. While the common norms of SPBP recycling involve feed, bulk chemicals, and bioenergy conversion, our five Vietnamese cases exemplify practices that seek to maximise the efficiency of biomass use, lowering environmental impact while increasing revenue. This is also consistent with the findings of the literature.

First, there is broad support for the cascading principle via integrated biorefineries – analogous to a petroleum refinery – to produce a spectrum of marketable products and energy in the form of both intermediates and final products, which is an essential tool to fuel the CE transition (Romero-García *et al.*, 2014; Venkata Mohan *et al.*, 2016; Dahiya *et al.*, 2018; Zabaniotou and Kamaterou, 2019). This is clearly illustrated by our cases, and especially case L1, which offers chitin/chitosan and derivatives, astaxanthin, food ingredients, feed nutrients, and biofertilisers from shrimp by-products.

Second, the literature emphasises higher value creation by encouraging the selection of multiple alternatives to retain the highest possible value and maximise that value over the products' life cycle (Stone *et al.*, 2019; Venkata Mohan *et al.*, 2019). In our cases, the alternatives include converting fish skins to either food, collagen and gelatine, or animal feed, and converting fish fat to either biodiesel or cooking oil. Furthermore, RQ1 draws our attention to the innovation patterns of small and large firms. While small firms look for simpler technologies that build on their existing infrastructure to improve production processes, large firms leverage their capability for technological development to be the real game-changers in the sector. We argue that as long as the CE principles are articulated, SPBP processors should be flexible and entrepreneurial in the choice of conversion pathways that suit their internal resources and capabilities.

Food-waste-based projects at an industrial scale are rare in the literature (Santagata *et al.*, 2021), and our empirical evidence fills this gap. Two technologies used in these cases include enzymatic hydrolysis to extract protein and minerals (L1) and gelatine and collagen (L3) and physical refining to deodorise cooking oil (L2). As discussed in Section 2.1, enzymatic hydrolysis is a popular technology that follows the biological route to valorise shrimp by-products (Mao *et al.*, 2017) and fish by-products (Pal and Suresh, 2016). This biological pathway can also be used to create fish oil supplements (see Ivanovs and Blumberga, 2017). However, because L2 aims to produce cooking oil, a physical refinery is the most suitable approach for this firm. Notably, although several practical cases are found in the literature, they tend to focus on energy-based biorefining (e.g. AD) to co-produce biogas and platform chemicals, as in some Asian countries (Sadhukhan *et al.*, 2020), or the pyrolysis-based system to produce food and energy (Zabaniotou *et al.*, 2018). This can be explained by the high TRL of energy conversion compared to the TRL of other conversion pathways due to the challenges of cost-effectiveness and technological scale-up (Cristóbal *et al.*, 2018).

Finally, there is sufficient evidence that circular practices allow our cases to achieve the dual objectives of economic value and environmental goals. Economic value is retained by lowering operational costs and preventing the degradation of compounds in the waste (Morone *et al.*, 2019), while environmental goals are achieved by using greener technologies – thus eliminating the use of toxic chemicals – and by generating less downstream waste through higher resource utilisation. Further, utilisation of food by-products rather than tapping in virgin resources helps to tackle resource scarcity and increasing demand in the market while promoting diet sustainability. These benefits have been discussed both in the CE literature in general (Venkata Mohan *et al.*, 2019) and for fish waste valorisation in particular (Lucarini *et al.*, 2020). Thus, our findings validate the claim that CE is a workable techno-social regime that decouples resource growth from resource depletion and environmental harm (Ghisellini *et al.*, 2016; Murray *et al.*, 2017; Merli *et al.*, 2018).

5.2. Comparison of drivers and barriers with extant literature

RQ2 and RQ3 enable the identification of eight drivers and 14 barriers in comparison with the extant literature (Table 3 and Table 4). Although this list is not as exhaustive as the drivers and barriers found in the literature (Table 1), three drivers and five barriers are exclusive to our cases.

We identify five drivers that are similar to those identified in the literature: (i) stricter environmental laws, (ii) awareness of the potential to recover valuable materials from by-products, (iii) awareness of environmental harms caused by prevailing SPBP recycling activities, (iv) financial incentives, and (v) sourcing advantages. Interestingly, we identified vertical integration as a sourcing advantage, where seafood processors set up affiliates to process by-products discharged from their factories and convert them into marketable end products. The three novel drivers are as follows: (i) a strong vision to intensify the value chain of the marine sector via the use of biotechnology in treating by-products, (ii) high customer interest in marine-derived products from nutritional and cultural perspectives, and (iii) rising demand and prices for materials and products, driving a search for cost-effective alternatives such as low-cost by-products.

With respect to the diffusion barriers, all the legitimacy- and efficiency-related factors play a part. *In the regulatory group*, except for stricter environmental laws, the current legislative framework in

Vietnam does not support cascading use or higher value retention. SPBP recycling activities grow spontaneously with little control by state agencies, and these activities receive no direct financial support from the government. Meanwhile, the commercialisation of new SPBP-based products encounters legislative difficulties. This is consistent with the findings in the extant literature and holds true in the context of developed countries. In such countries, fiscal incentives (e.g. the Feed-in-Tariff, Renewable Heat Incentive, and Renewable Transport Fuel Obligation) are available but are designed to support only energy conversion, which is located at the bottom of the biomass hierarchy pyramid (Sadhukhan *et al.*, 2020). *Among the three barriers found in the socio-cultural group*, two novel barriers arise from our cases: the prevailing practice of using simple technology to produce low added value and low customer trust in local nutraceutical brands. While processors' low interest in investing in SPBP valorisation is also identified in the literature (Boumali *et al.*, 2020; Leder *et al.*, 2020), our cases attribute this barrier to the 'wrong' mindset of considering by-products as waste. To stimulate interest in SPBP valorisation, it is crucial to alter this mindset and treat by-products as co-products in the processing factories. *Among the five barriers of the economic and supply chain group*, three are consistent with the literature: a lack of price competitiveness, a lack of stable market demand for new products, and sourcing concerns. The two unique barriers in this cluster include the requirement of cold-chain logistics due to a high deterioration rate and the challenges of integrating into the Vietnamese distribution network for the B2C model. *Among the three barriers in the technological group*, one emergent barrier lies in long approval procedures. These include both obtaining export permits and passing buyers' quality testing. This barrier can be generalised in the context of the overall techno-social environment, which does not support biotechnology development; new products are required to undergo a lengthy process to enter the global market. We also identified technological upscaling challenges and high capital investment with a longer payback period as barriers that reflect the findings of the extant literature. Successful scaling-up requires not only technological feasibility but also the achievement of cost-effectiveness and product quality.

5.3. An integrated framework for the driver–barrier–practice nexus

To highlight the dual objectives of CE, we recognised a need to incorporate the concept of the institutional logic, which refers to 'the belief systems and related practices that predominate in an organisational field' (Scott, 2014, p. 139). Institutional logics represent a shared understanding and bonding among firms in the field (Zucker, 1987). Therefore, a change in dominant logics shifts the attention of firms towards actions that conform with the new paradigm, which ultimately induces change (Thornton and Ocasio, 1999; 2008). In supply chain management (SCM) studies, the discussion of institutional logic focuses on the dichotomy between efficiency (cost minimisation, profit maximisation) and legitimacy (sustainability) (Liu *et al.*, 2012; Glover *et al.*, 2014). Because CE facilitates the attainment of both economic and environmental value, we labelled the CE logic as legitimacy-embedded efficiency. The introduction of institutional logics also underlines the fundamental differences between CE and green SCM adoption. Whereas the latter aims to enhance firm legitimacy – potentially at the expense of efficiency – CE offers a good balance between the two. This also explains why the purely sociological stream of research has become popular in green SCM studies (Liu *et al.*, 2018).

Because our cases establish that the prevailing norm in SPBP management in Vietnam is associated with simple technology and low-value-added outputs, we ascribe this norm to a low-efficiency institutional logic. We posit that SPBP management practices in Vietnam are in the infant stage of transitioning from low-efficiency to legitimacy-embedded efficiency. According to the institutional theory, such a transition (i.e. a shift in the institutional logic) encounters drivers and barriers that derive from both legitimacy (regulatory and socio-cognitive) and efficiency groups (economic–supply chain and technology). The co-existence of drivers and barriers from the legitimacy and efficiency groups in the transition period is validated by the findings of our cases (Tables 3 and 4). Notably, although these four groups have been mentioned in the literature (see Donner *et al.*, 2021), the legitimacy–efficiency dichotomy is an original contribution.

The list of barriers (Table 4) reveals deep uncertainty connected to the economic–supply chain and technological sources in current circular SPBP management in Vietnam. The theory argues that, under such conditions, the driving force behind CE engagement is more likely to derive from legitimacy forces. This is substantiated by our findings. Except for S2, which enjoys low uncertainty thanks to an advance order, the overarching messages in the remaining cases indicate strong legitimacy forces. These include the vision of transforming the supply chain via biotechnology, an awareness of environmental and resource underutilisation issues, and stricter environmental laws.

We propose a coherent framework that brings together all the discussed elements: CE practices and associated drivers and barriers, institutional logics, and uncertainty (Figure 2). Although the framework is grounded in our case findings, it is also relevant to generic CE implementations. Consider, for instance, the study of Gregg *et al.* (2020) on the success of the dairy biorefinery in the CE. The authors observed that in the early stages, the adoption of the dairy biorefinery model was driven by regulatory pressure on whey disposal. Over time, as market and technological hurdles lessened due to advanced biorefinery capabilities and rising demand for products based on dairy residuals, the sector developed a well-developed value chain for bio-residuals with a myriad of products.

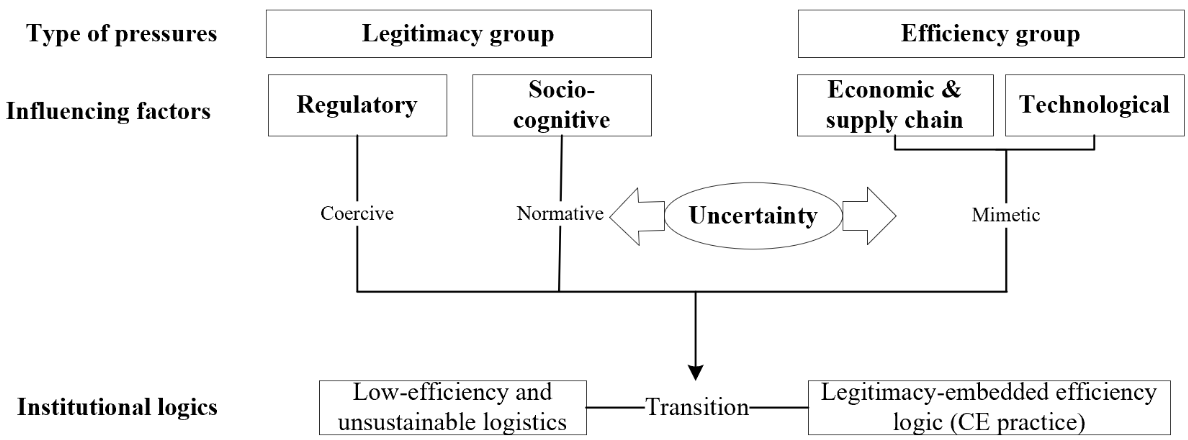

Figure 2: The CE paradigm in the seafood sector from extended institutional theory

6. Conclusions

This exploratory paper is among the very few studies that have attempted to capture the holistic milieu of the CE paradigm using empirical evidence. We identify five circular practices with eight drivers and 14 barriers in five case studies adopting CE principles in SPBP management. The circular practices we describe focus on cascading use and higher value creation principles to achieve both economic and environmental value. We also analyse the patterns of CE adoption in small and large firms, demonstrating how CE choices vary in accordance with firms' capabilities and resources. The associated drivers and barriers are classified into four groups based on institutional theory: (i) regulatory, (ii) socio-cognitive, (iii) economic and supply chain, and (iv) technological factors. In addition to common factors found in the literature, we add three exclusive drivers and five unique barriers specific to our case context, thus advancing the understanding of the drivers–barriers–practice nexus. The novel drivers include a strong vision to intensify the value chain via biotechnology, high customer interest in marine-derived products from nutritional and cultural viewpoints, and the rising demand for, and cost of, raw materials. The five unique barriers consist of (i) the prevailing practice of using outdated technology and low-value-added outputs, (ii) low customer trust in local nutraceutical brands, (iii) the requirement of cold-chain logistics, (iv) the challenges of integrating into the local distribution network, and (v) complicated and time-consuming export-licence and quality testing processes for innovative products.

6.1. Theoretical implications

Our central theoretical contribution lies in the establishment of a coherent framework that synthesises the practices, drivers, and barriers to support future CE research (Figure 2). We make three specific theoretical contributions. First, we describe the institutional logics of circular practices as legitimacy-embedded efficiency, which underlines the fundamental difference between CE and the sustainability paradigm. Second, we extend the framework beyond purely institutional accounts of isomorphism by classifying the factors into four types and arguing that CE engagement is dynamically influenced by their interactions; the types include (i) regulatory, (ii) socio-cognitive (belonging to the legitimacy group), (iii) economic and supply chain, and (iv) technological factors (belonging to the efficiency group). Any factors among these types that facilitate the CE transition are identified as *drivers*, whereas any factors that impede it are *barriers*. This classification helps to determine the relative power of the legitimacy and efficiency groups in the CE transition. When the barriers – particularly those in the efficiency group – are still plentiful, the uncertainty level in the market is high. In such conditions, CE diffusion is likely to be influenced by legitimacy factors, such as regulatory actions or the cognitive behaviours of several individual firms. When efficiency-related barriers weaken, CE dissemination is automatically generated by the motive of improving efficiency. This leads to our third theoretical contribution: introducing the moderating role of uncertainty in determining the relative influence of the two groups in the CE transition.

6.2. Managerial and policy implications

Various managerial and policy implications can be drawn from the insights of the cases and the associated critical elements. First, managers should be flexible and entrepreneurial in their choice of pathways in order to reflect two principles: cascading use and the creation of higher added value. This choice depends on firms' internal capabilities and resources, and should not be interpreted as an option available only to large firms with technological and capital advantages. Given that higher utilisation of food residues and higher value retention have been shown to be feasible, the traditional focus on feed and low-added-value product creation should be altered.

Second, companies that consider integrating the two CE principles should be wary of potential difficulties in their journey and should find the drivers necessary to overcome them. These factors (Table 3 and Table 4) will provide managers and scholars with a richer and more holistic view of the multiple factors that influence circular SPBP management in the seafood sector. Gaining dynamic insight into the factors in the four groups, as well as their interactions, also enables managers to customise their practices to suit their companies' requirements instead of copying the circular practices applied in other firms.

Finally, our study also offers policy implications. The need for government intervention is underlined in the early stages of food-waste valorisation due to high uncertainty (Joshi and Visvanathan, 2019; Gregg *et al.*, 2020). State agencies should tighten control on by-product valorisation activities in their areas to ensure compliance with environmental laws and eliminate unsustainable activities. Policymakers can also play a role through several tools, including laws and regulations, fiscal incentives, public funding, and a flexible legislative regime supporting the launch of end products. Such measures are crucial to lowering uncertainty for players who wish to invest in circular practices. Additionally, policymakers should carefully acknowledge and thoroughly coordinate the guidelines suggested by different categories of stakeholders, including local communities and scientific experts.

6.3. Limitations and future research

This study comes with limitations that offer opportunities for future research. First, we employed a multi-case study method using a limited sample. We attempted to refine and elaborate a theory rather than test it. As such, this study serves as a pilot, opening various research avenues for future deductive studies. We call for future research that uses our findings to build a testable hypothesis about the factors in the framework and then verifies the hypothesis via a quantitative enquiry (i.e., a survey administered to a larger sample for statistical testing). Specifically, the role played by uncertainty and shared logics should be underscored in the CE context. We also propose research that seeks a broader understanding of the impacts of the factors on a wider range of stakeholders. Finally, another interesting avenue would be an investigation of the most influential drivers of, and barriers to, the CE transition by building on the list provided in this article.

Second, our sample was confined to successful CE cases in the SPBP management of a developing country. Although we trust that our proposed framework will hold true for the agriculture sector in other countries, any nuances in various sectors in other countries will surely make a difference. Cross-country or cross-sector studies that shed more light on the context of developed countries may thus inform the academic discourse. Finally, we invite fellow researchers to explore the perspectives of firms that have not engaged in CE practices to gain additional insights into their lack of momentum.

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Appendix 1: Interviewee profiles

Case	SC actors	Functional role (years with firm)	Data collection
S1	By-product processors	Director (13) Factory Manager (10)	30–90 minutes each from September 2019
S2	By-product processors	General Manager (7) Operational Manager (5)	30–50 minutes each in December 2019
L1	By-product processors	Sales Manager (5) R&D staff (6) General Manager (7)	30–90 minutes each in October 2019
	Shrimp processor (L1's supplier)	General Manager (15) Production Manager (7)	45–60 minutes each in October 2019
	Animal feed firm (L1's buyer)	Product development manager (15) Purchasing manager (8) Sales Manager (10)	45–60 minutes each in November 2019
L2	By-product processors	General Manager (3) Operational Manager (3)	45–60 minutes each in December 2019
	Food processors (L2's buyer)	Purchasing Manager (20) Product quality staff (5)	45–60 minutes each in January 2020
L3	By-product processors	General Manager (10) Operational Manager (5)	30–90 minutes each in January 2020
Researcher	Academic	Consultant (20)	30 minutes in Sept 19
Researcher	Academic	Consultant (17)	60 minutes in Sept 19
Government authority	Environmental legal management	Legal enforcement (15)	50 minutes in Dec 2019
Government authority	Safety certification	Safety certification (10)	30 minutes in Dec 2019

Appendix 2. Interview protocol

Section	**Interview questions**
Introduction	Can you please introduce yourself and provide the background of your firm? (including historical development, production capacity and market share)?
Circular practices	How do you interpret the circular economy and adopt it in your operations? Which type of technologies do you use to convert the seafood processing by-products into desirable outputs? What is the TRL level of the technology? What are your targeted output products? Which department is responsible for the development of these processes in your firm?
Drivers	What drives your firm to engage in these innovative circular economy practices? To what extent do these factors influence your decisions to engage in circular practices?
Barriers	What types of barriers prevent the diffusion of your practices in seafood processing by-product management in Vietnam? To what extent do these barriers influence diffusion? What are the most pressing barriers which require industrial attention?