SEA project:
Developing competitive supply chains (3.2)

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Executive Summary

- One critical challenge in developing 'competitive' seaweed supply chains, as part of an economic growth/commercialisation agenda, is that there is no defined pathway to follow;
- To grow investment into nascent and emerging seaweed supply chains, a clearer understanding and engagement with supply chain configuration and strategy is required (emerging product-based opportunities may require different supply chain configurations to support different strategies);
- To make significant gains in terms of resource utilisation and market value, firms could evaluate different supply chain configurations for different strategies, products, and practices - based on LARG (Lean; Agile; Resilient; Green) principles;
- The development of sector-specific 'design rules' can be a key mechanism to enable various specialist stakeholders (with niche specialisms in R&D; process/equipment development, or supply chain designs incorporating digital technologies) to address significant knowledge gaps and knowledge development challenges;
- In line with developments in other process industries (e.g., pharmaceuticals), there is a need to re-define the role of institutional actors beyond that of the traditional governance task, to one of being able to facilitate performance outcomes

1. Introduction

The seaweed sector in the UK and Europe is a nascent fast-growing industry offering seaweed-derived products and processes for commercial use for many downstream industries. The seaweed sector and its demand for seaweed-related products/services are driven heavily by the emergence of environmentally sustainable alternatives for certain industry processes which are otherwise harming the environment (Duarte et al, 2017; Selnes et al, 2021).

With seaweed being increasingly sought after, with many industries realising its commercial and environmental benefits, Taylor (2022) has projected the seaweed industry to rise to $95 Billion by 2027, a rise from $40 Billion in 2020 (Pulidindi and Prakash, 2021).

However, one critical challenge in developing 'competitive' supply chains - as part of the commercialisation process - is that there is no defined pathway to follow. Lack of certainty, in terms of product definition and end-user requirements, forces emerging actors and enterprises to experiment with supply network strategies through a process described as 'effectuation' (Sarasvathy, 2001). This process can be very time-consuming; increasing time-to-market, making it difficult to exploit 'first-mover' competitive advantage and reducing opportunities to grow market share.

Historically, a popular approach has been to consider the industrial 'emergence' process as composed of several distinct phases or 'stages' – albeit from a variety of different perspectives (Harrington and Srai, 2017). In summary, common to most interpretations is the concept of 'process maturity' associated with a product or service. Approaches tend to capture an initial R&D phase, next the demonstration of a viable technology and then production in large scale. However, it is argued these 'stages' for emerging industries are largely conceptual and descriptive, providing limited content and substance on what the supply network features of evolution may be. This can make identification and classification very subjective and does not provide insights on the operational actions that firms need to consider, or those alternative 'options' that may deliver additional supply network benefits. For example, significant progress in the expansion and development of valorisation techniques to utilise biomass has been made in offering environmentally superior end-products (Mahari et al (2022). Bio-acrylic acid produced from seaweed biomass waste is one example of a promising valorisation technique in aquaculture (Karan et al, 2019). However, like many biomass feedstocks for chemical manufacturing, processes often appear conceptual, and despite awareness of internal capabilities, novel biomass technologies are yet to be grounded by economically feasible and scalable supply chain capabilities (Selnes et al, 2021).

1.1. Industry context – supply and demand

There is a consensus across literature and industry data that although the seaweed sector is growing, the market is also inundated with several key supply chain challenges that threaten the growth of the industry. On the supply side, data shows that supply is currently insufficiently meeting the demands of downstream industry customers. It is also interesting to note that the global market for biorefineries is £350Bn rising to £550Bn by 2021 (Research and Markets, 'Biorefinery Products: Global Markets' (2017)). While there are currently 227 biorefineries in the EU, only 9 of these are in the UK – and they are not connected (personal communication, 2022).

Despite growing demand for seaweed-related products in Europe and the UK, downstream users often have to supplement their supply with imports from far cheaper Asia supply. In addition, Asia's supply dominates much of the global supply of seaweed, with over 35.8 million tonnes to the amount of 97% of global supply coming from Asia, with more than half from Chinese waters (Taylor, 2022). Therefore, when supply is insufficient to meet upstream demands, a given seaweed processor can comfortably use Asia imports which has implications for sustainable and competitive supply chains in

East Anglia and the UK. See more information from the 'Best Practice Report and Current State Analysis of the Norfolk and UK Seaweed Sector 2023' in **Appendix I**.

2. Towards sustainable and competitive supply chains

At various levels of maturity, supply chains in their respective industries implement certain strategies for best commercialising their industries. In achieving a sustainable and competitive supply chain, numerous factors that govern performance, resources, partners, suppliers and customers will be required to be coordinated (Harrington and Srai 2017) – linking to deliverable 3.1.

Such an imperative is more easily understood for mature supply chains, such as the automotive industry wherein the requirements of key stakeholders are more easily interpreted and actioned on. However, for nascent and emerging supply chains, characterised by fragmented supply and uncertainty over end-consumer requirements, the distinction over the appropriateness of a particular supply chain configuration is not so easily discerned. For example, carrageenan-based film - derived from seaweed - exhibits excellent physical and mechanical properties that are desirable for use as bioplastic film, especially in non-food and food packaging. However, further studies are needed to evaluate its commercial potential and economic feasibility (Sudhakar et al, 2020). As well as product and process architecture (and associated business model) considerations, a limiting factor of nascent supply chains and as congruent with a report on biomass feedstocks for chemical manufacturing (Mort, 2022), upstream, bio-mass availability supply is fragmented and downstream, a consensus over customer demands in terms of volume requirements and product/product variety is lacking.

To grow investment into nascent and emergent seaweed supply chains, a clearer understanding and engagement with supply chain configuration and strategy is required. In short, an emerging firm may have require different supply chain configurations in supporting different strategies.

2.1. Supply chain configurations and strategies

The seaweed industry in the UK and Europe is one such industry composed of nascent and emerging supply chains (Mort, 2022). Seaweed biomass offers many superior environmental benefits to various industries which are otherwise harming ecological efforts. However, despite the conception of various novel technologies, commercialisation is limited for many nascent supply chains within the seaweed sector, as they lack a sufficient understanding of external, supply chain-wide capabilities and strategies (Stedt et al, 2022).

Traditionally, supply chain configurations and strategies in the field of supply chain management (SCM) have been focused on achieving sustainable competitive advantages efficiently and effectively at the most optimal cost level through the management philosophies of lean and/or agile (Azevedo et al, 2016). For highly competitive markets, supply chains must adopt strategies that provide the ability to respond rapidly and cost-effectively to unpredictable changes in demand and market requirements (Carvalho et al, 2011). In addition to agiity, supply chains must aim to reduce costs and improve efficiency by eliminating or reducing non-value-added activities (Cabral et al, 2012). However, the highly dynamic nature of supply chains today suggests its various stages can become inefficient, vulnerable and unpredictable (Lotfi and Saghiri, 2018). This, therefore, necessitates that traditional management philosophies of lean and agile are not solely sufficient for satisfying the demands of contemporary supply chains (Azevedo et al, 2016).

Mitigating against unexpected supply chain disruptions and the ability to return to normal business levels has popularised the concept of Resilient SCM wherein literature suggests that quantifying supply chain risk and incorporating a dedicated plan for business continuity is critical for ensuring a sustainable and competitive supply chain. Contemporary research is also topical on Green SCM and that supply chains should strive to minimise the ecological and environmental impact of their activities in order to ensure environmental sustainability (Laosirihongthong et al, 2013). Hence, novel circular bioeconomy approaches have emerged (Stedt et al, 2022), in a post-harvesting seaweed process using a novel nutrient loop of reinstated process water from food production.

Recent research (Tsolakis, Harrington and Srai 2023) has examined different supply chain configurations and strategies in a seaweed sector context. Specifically, to inform *new operating principles for co-operative agility* in the design, analysis and management of circular bioeconomy-focused operations. For example, the circular exploitation of algae biomass in synthesising value-added intermediates or end-products, e.g. by extending our current models of biofertilizers and omega-3 oils, in order to efficiently utilise renewable feedstocks for promoting sustainable value-adding manufacturing networks.

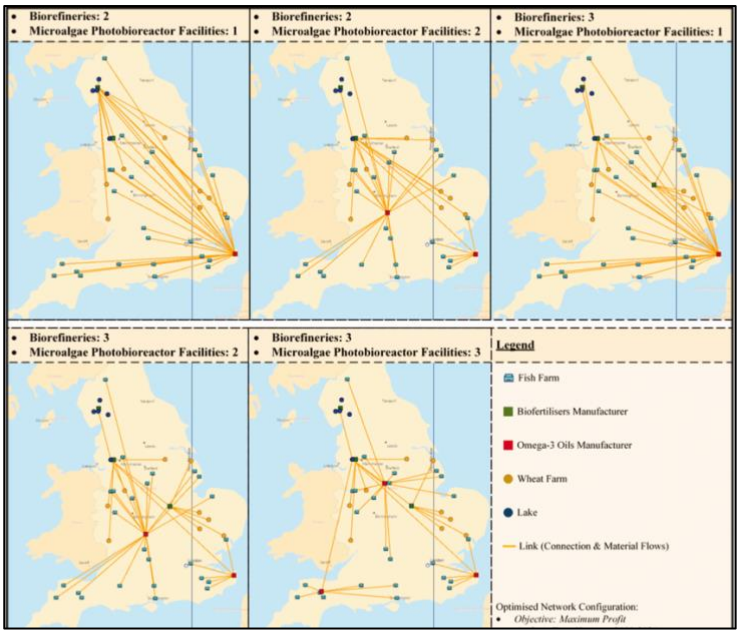

Figure 1. Optimised circular supply network configurations – 5 scenarios developed using LARG-type practices for emerging supply chain design rules (adapted from Tsolakis, Harrington and Srai, 2023)

A sensors-enabled continuous manufacturing process employed in a network of distributed 'micro-factories' enables enhanced agility. Given the dispersed geography of resource availability (selected UK lakes) along with their recursive nature, variant duration and intensity of the algal bloom phenomenon, digital applications can allow real-time monitoring to inform effective planning and scheduling of harvesting operations at co-located biofertilizer manufacturing plants. Results demonstrate significant gains in terms of resources utilisation and market value obtained, and you may have different supply chain configurations for different strategies and practices (i.e,. **LARG - Lean; Agile; Resilient;** or **Green**).

2.2. Exploring seaweed supply chain configurations and "LARG" practices

A recent pilot study examined LARG (**Lean; Agile; Resilient; Green**) practices in a seaweed context (Saward and Harrington, 2022). The pilot focused on LARG SCM, and performance measures for the seaweed sector in the UK and Europe. To do so, a comprehensive literature review was first conducted to explore synergies and divergencies in the academic literature to identify key themes and research gaps. The search process was inclusive of the following steps. Firstly, to narrow down the topic, some keywords relevant to the concepts explored were identified, namely "Lean," "Agile," "Resilient" "Green" "Seaweed" and "Supply Chain."

- **Lean SCM:** Lean SCM is focused on reducing or eliminating non-value-added activities across the supply chain, reducing variability and implementing continuous improvement (Vonderembse et al 2006; Shah and Ward, 2007; Singh and Pandey, 2015. Many literature proponents posit the importance of reducing waste to lower costs, as the downstream end customer will not be willing to pay for it (Agus and Hajinoor, 2012). Waste permeates throughout the supply chain, most notably as prescribed by Jasti and Kodali (2015) in the form of overproduction, unnecessary motion, inventory, defects, waiting, transportation and overprocessing;
- **Agile SCM:** Gligor et al (2015) define the agility context as the ability of a supply chain to rapidly respond to changes in demand and the flexibility to accommodate high variety. Agility research is generally unified in that the agile dimension is contextualised by supply chain needs of responsiveness, flexibility, visibility, integration and collaboration (Carvalho et al, 2012; Gligor, 2016; Gligor and Holcomb, 2012).
- **Resilient SCM:** Recently, the increased regularity with which supply chain disruptions and unexpected events have occurred, disturbing the regular flow of products, components, materials and information along the supply chain and ultimately supply chain performance has sparked an marked increase in resilience-related literature (Ruiz-Benitez et al, 2018). Literature posits the importance of understanding risk and mitigating it (Scholten and Schilder, 2015; Pettit et al, 2013). Such risk has come under observation by supply chain scholars not only due to unexpected events such as natural disasters, war-conflict and the Covid-19 pandemic but also importantly, due to changing business and market conditions surrounding

supply chains today (Remko, 2020). Conditions like high variability of demand, an increase in competition, and customer expectation demanding reduced lead times - enabled by advancements in (digital) technologies - are making supply chains more unpredictable and vulnerable (Pereira et al, 2014).

- **Green SCM:** Green SCM has gained increasing notoriety in contemporary supply chain literature due to greater environmental awareness and mounting pressure to comply with environmental regulations (Rao and Holt, 2005). Green SCM as a concept is seen as the proactive efforts of supply chains to make their practices and processes more ecologically and environmentally friendly (Zhu et al, 2005). It specifically encompasses initiatives to enhance environmental performance, reduce waste and implement closed-loop circular supply chain activities (Lee et al, 2012).

2.3. Synergies and divergencies across LARG phenomena

The aforementioned concepts, although distinct in their purposes and objective motivations, are not entirely mutually exclusive. In fact, much of the LARG literature and the propensity for exploring the concepts is founded on the existence of mutual connections between the paradigms (Cabral et al, 2012). Scholars have sought to understand the relationships between LARG paradigms in regard to how they can be integrated simultaneously to improve supply chain performance (Carvalho et al, 2011). Azevedo et al (2016) propose that LARG practices should not be approached in isolation and that instead, LARG practices should be aggregated due to their complimentary capabilities.

Mutual relationships between paradigms can also be found in the work of Ruiz-Benitez et al (2018) who adopted the IPA and ISM methodology to study the relationship between lean and resilient practices in an aerospace manufacturing context. Their work found synergies in the involvement of similar practices despite their distinct purposes. In particular, collaboration, information sharing, and electronically-enabled supply chains are shared practices which enable both the lean and resilient paradigms. Lean, in terms of ensuring waste reduction throughout the chain, and from a resilient perspective, are simultaneously needed to identify and manage sources of risk throughout the chain.

This sentiment is further supported by Sezen et al (2012) and Costantino et al (2014) who note that despite the noticeable conflict concerning inventory strategy, in so far as lean focuses on minimising inventory to reduce unnecessary holding costs, this may lead the chain to being susceptible to increased vulnerability. They both propose an inventory replenishment strategy which relies on collaboration and information sharing to improve resilience in the presence of a lean strategy.

This evidence of complimentary relationships between LARG elements (despite their distinct purpose) supports a view in the academic literature that supply chains should seek to implement practices in a coalesced fashion due to the leveraging abilities of any one paradigm with another, rather than seeing practices as direct trade-offs, serving only to compromise performance (Maleki and Machado, 2013).

Table 1 summarises key principles and some of the overlapping synergies that exist between distinct lean, agile, resilient and green SCM focuses. Despite a singular focus on a paradigm, synergies do exist as evidenced by overlaps. The data directly supports the findings of multidisciplinary works such as Govindan et al, (2015) and Ruiz-Benitez et al (2017) whereby one or more paradigms are explored in combination, and where synergies exist despite their distinct and often conflicting objective motivations.

Table 1. Summary comparison of LARG elements

Reference	Focus				Principles								
	Lean	Agile	Resilient	Green	JIT	WR7	IT	CLB+INFO	SC Surplus	FLEX	RESPN	RISKPLN	CE
(Vonderembse et al, 2006)	•				•	•							
(Naylor et al, 1999)	•	•			•	•				•	•		
(Shah and ward, 2007)	•				•	•							
(Agus and Hajinoor, 2012)	•				•	•							
(Garza-Reyez et al, 2018)	•			•	•	•							•
(Ruiz-Benitez, et al, 2017)	•		•	•	•	•	•	•	•		•	•	•
(Govindan et al, 2015)	•		•	•	•	•		•	•		•	•	•
(Christopher et al, 2006)	•	•	•		•	•		•	•	•	•	•	
(Swafford et al, 2008)		•			•		•	•	•	•	•		
(Petit et al, 2013)			•				•	•	•	•	•	•	
(Lotfi and Saghiri, 2018)	•	•	•		•	•		•	•	•	•	•	
(Dües et al, 2013)	•			•	•	•	•	•					•
(Cankaya and Sezen, 2018)				•	•	•							•
(Rao and Holt, 2005)				•	•	•							•
(Agarwal et al, 2007)		•							•	•	•		
(Carvalho et al, 2011)	•	•	•	•	•	•	•	•	•	•	•	•	•
(Azevedo et al, 2016)	•	•	•	•	•	•	•	•	•	•	•	•	•
(Campos and Vasquez-Brust, 2016)	•			•	•	•							•

***JIT**; Just-in-Time, **WR7**: Waste reduction of 7 wastes, **IT**; Information Technology, **CLB+INFO**, Collaboration and information sharing, **SC Surplus**: Surplus across supply chain (processes, resources), **FLEX**; supply chain flexibility (ability to produce in large/small batches, **RESPN**; supply chain responsiveness to changes in demand and supply chain environment, **RISK PLN**; risk detection and mitigation methods, **CE**; Circular economy initiatives in the supply chain.*

An Importance-Performance-Analysis (IPA) methodology (Martilla and James,1977) was then adopted to refine LARG practices more accurately into quadrants wherein specific propositions for supply chain configuration could be afforded. In this manner, the complexity and disparate nature of LARG phenomena in the seaweed sector could be broken down and becomes more manageable. The IPA framework works by graphically dividing a set of practices against the attributes of *importance* (ability of a given practice to satisfy key performance measures) and performance substituted with *implementation* (to what extent is the given practice implemented) into a two-dimensional grid matrix.

On the basis of given scores through a simple 5-point Likert scale, the practices, as taken from the literature review were then grouped into a corresponding quadrant wherein each section required a specific managerial direction, namely "concentrate here" "keep up the good work" "low priority" and "possible overkill" (Bacon, 2003). From a purely managerial perspective, the tool is useful in its simplicity for guiding rational decisions reflective of the demands of an industry (Oh, 2001).

In a similar fashion, with a few modifications to ensure contextual appropriateness to SCM and the seaweed sector, for the purpose of the pilot, the IPA model asked participants to rank LARG practices based on importance to satisfying key performance measures at the firm level and/or the whole supply network and also the grade of implementation of the respective LARG practice at the firm and/or supply network (Ruiz-Benitez et al, 2017).

As a pilot, to gather a snapshot of the seaweed sector and its derived supply chains, the IPA survey was distributed to two academics involved in supply chain development for nascent and emergent seaweed supply chains and two industrialists. The resultant matrix as shown in figure 2 is divided into four quadrants: A-Concentrate here, B-Keep up the good work, C-Low priority and finally D-Possible overkill. Each quadrant is classified distinctly, and can offer tailored strategic guidance for supply chain managers.

Figure 2. Combined graphical plotting of Academic and Commercial LARG insights (pilot study). See Appendix I for descriptions of the labels (e.g., AP1; AP3; RP3; RP5; GP2; GP3: GP4).

The discrepancy between implementation and importance for practices in quadrant A ('concentrate here'), representing over 35% of practices in the IPA chart is consistent with literature findings. As per Capuzzo (2022), the seaweed sector remains inundated with several technical supply challenges which reflect the conditions of practices within quadrant A. For example, several green practices lack proper implementation and the seaweed sector faces a knowledge gap in terms of understanding the environmental impact of supply chain activities (suggesting green supply chain practices are not fully incorporated).

3. Towards sector-specific 'design rules'?

Linking to the sector maps from deliverable 3.1, we observed firms operating at various stages of the UK seaweed value chain. As with other process industries, (i) distinct stakeholders appear to be heavily involved in R&D only; (ii) others have fundamentally different competencies and goals, in designing and manufacturing products; (iii) some are concentrating on equipment and process development and (iv) there appears to be a large network of 'service' providers. Then, there are regulatory bodies and agencies that may mandate the performance and the conformance quality of final products. In short, the seaweed sector can be regarded as being made up of different 'knowledge communities' (Upham 2022), each carrying different domains of specialized knowledge.

In considering how these communities exchange knowledge to help create innovation, Postrel (2002) noted that entities (SMEs; individuals) that have specialized knowledge, need trans-specialist understanding (i.e., knowledge of adjacent domains of work) to undertake problem solving and consequent innovation. Recent studies suggest that the 'speed' in which such trans-specialist understanding can be developed, and shared, is a critical component of building competitive supply chains (Srai et al, 2024, in review). A recent study from the Norwegian seaweed sector (Solvang et al., 2021) outlines a series of design criteria (in equipment/process development) which could be considered as high-level design rules for trans-specialist understanding.

Pre-competitive supply chain consortia have been set up for this purpose in UK Pharma, supported by institutional actors (regional government and regulators). In sum, a "network of design rules" has the potential to serve as a key mechanism to enable specialist stakeholders exchange knowledge and create novel processes through trans-specialist understanding (Srai et al., 2024, in review). The same can be true for the UK seaweed sector.

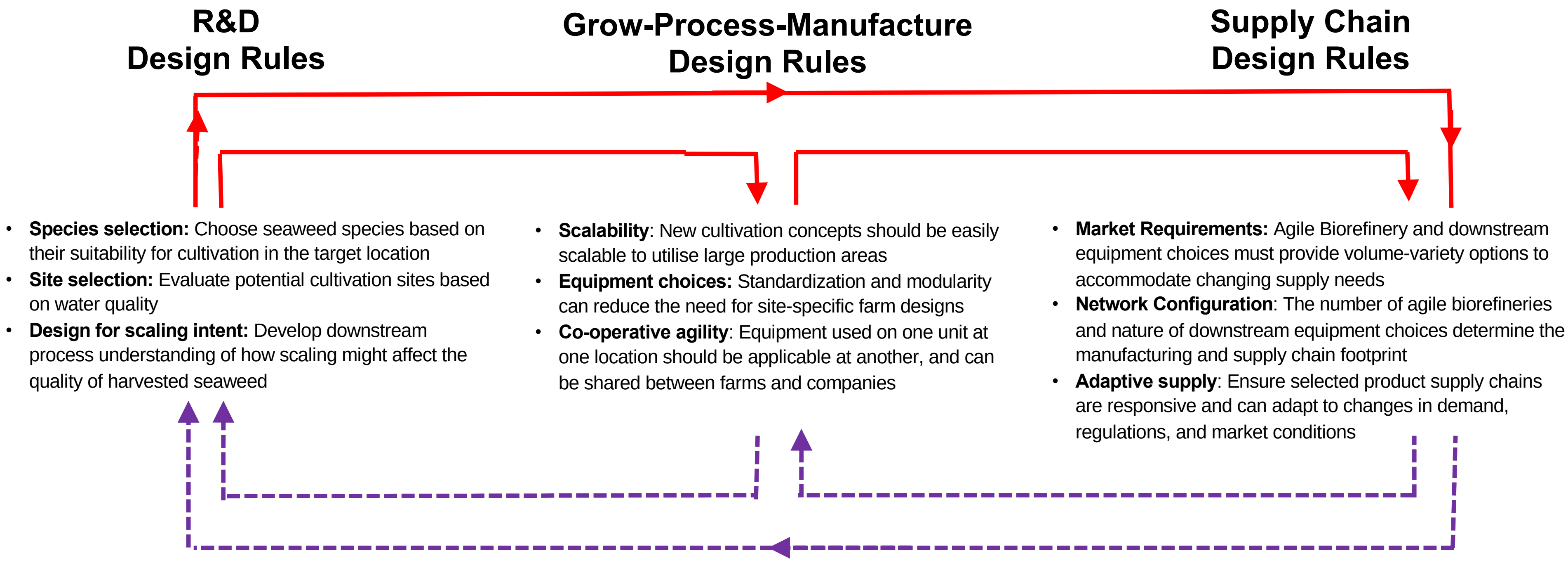

Figure X. An example of a 'network of design rules' with conceptual knowledge flows/interdependencies (adapted from Srai et al., 2024, under review)

Conclusion

One critical challenge in developing 'competitive' seaweed supply chains, as part of an economic growth/commercialisation agenda, is that there is no defined pathway to follow.

To grow investment into nascent and emerging seaweed supply chains, a clearer understanding and engagement with supply chain configuration and strategy is required (emerging product-based opportunities may require different supply chain configurations to support different strategies).

To make significant gains in terms of resources utilisation and market value firms could evaluate different supply chain configurations for different strategies, products, and practices - based on LARG (Lean; Agile; Resilient; Green) principles (one approach).

The development of sector-specific 'design rules' may be a key mechanism to enable various specialist stakeholders (with niche specialisms in R&D; or process/equipment development; or supply chain designs) address significant knowledge gaps and knowledge development challenges.

In line with other process industries (e.g., pharmaceuticals), there is a need to re-define the role of institutional actors beyond that of the traditional governance task, to one of being able to facilitate performance outcomes

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Appendix I. The challenge for UK companies producing seaweed products

From 'Best Practice Report and Current State Analysis of the Norfolk and UK Seaweed Sector 2023' – A challenge for UK companies producing seaweed products is competition with similar products currently available from overseas companies at a considerably lower price and a higher volume. For this to be resolved, the end user needs to see the value in paying more for a local product supporting local businesses. This is especially because the price point for UK-grown seaweed is unlikely to drop below seaweed prices from the Asian market because of lower labour and operation costs. More research into UK seaweed product development is therefore needed to add value to the components extracted and thereby increase the value of UK-produced products.

There are also UK product manufacturing companies that use seaweed that cannot be farmed in UK waters and that are not found native to the UK coast, such as many red seaweed species. These companies therefore have to get their seaweed from elsewhere as most seaweed cultivators in the UK grow native brown seaweed species. Attaining raw material supply sustainably is consequently a challenge for the product-producing companies to grow.

A way to overcome this is to grow the seaweed species in demand that cannot be farmed in UK waters in cultivation tanks on land. However, the companies interviewed for this study that currently use seaweed that cannot naturally be sourced in the UK were all interested in opportunities to access and investigate using locally farmed seaweed. To enable this, collaborations and partnerships to create the infrastructure within the sector will be needed. Additionally, establishing solid and strategic partnerships with local seaweed farmers will be vital to sustainably sourcing the biomass and extracts and ensuring availability, as product demand could exceed the seaweed supply. Relying on a single supply of seaweed to obtain their raw material is also a risk factor for the business, so securing multiple suppliers is vital to ensure that the biomass needed is available.

Appendix II. LARG descriptions for pilot study

Attribute code	Description	Sources
LP1	*Low inventory strategy*- Efficient low inventory strategy to reduce unnecessary business waste	(Vonderembse et al, 2006; Shah and Ward, 2007; Agus and Hajinoor, 2012)
LP2	*Just-in-time (JIT) philosophy*- products are only made based on actual customer orders, supply is based on actual demand, this helps to reduce business waste	(Kannan and Tan, 2005, Agus and Hajinoor, 2012)
LP3	*Collaboration with stakeholders in the supply chain*- frequent information exchange in order to reduce business waste	(Bhasin, 2008; Tortorella et al, 2017; Adamides et al, 2006; Vonderembse et al, 2006)
LP4	*Elimination/reduction of 7 Lean wastes* - reduction of waste which arises from overproduction, waiting, transportation, processing, defects, inventory and motion. reducing these helps to lower costs, improve quality and efficiency	(Garza-reyez et al, 2018; Naylor et al, 1999; Vonderembse et al, 2006)
AP1	*Reducing lead times*- reducing the time between processes in the supply chain in order to more quickly respond to demand	(Christopher and Towill, 2001; Naylor et al, 1999; Gligor et al, 2015)
AP2	*Inventory surplus*- having additional inventory on standby in order to respond quickly to any changes in demand.	(Mason-Jones et al, 2000; Carvalho et al 2012; Fayezi et al, 2017; Govindan et al, 2015)
AP3	*Production flexibility*- be able to produce in large or small batches in accordance with varying customer requirements	(Govindan et al, 2015; Agarwal et al, 2007)
AP4	*Use of Information technology (IT)* - to coordinate/integrate activities in the supply chain in order to ensure flexibility and speed	(Swafford et al, 2008; Degroote and Max, 2013; Christopher et al, 2006)
RP1	*Strategic inventory*- surplus of inventory in order to mitigate against any unexpected supply disturbances	(Christopher and Peck, 2004; Ruiz-Benitez et al, 2018; Govindan et al, 2015; Sezen et al, 2012)
RP2	*Risk planning*-dedicated system for continuously identifying sources of supply chain risks.	(Petit et al, 2013; Scholten and Schilder, 2015; Lotfi and Saghiri, 2018, Faisal et al, 2006: Cabrita et al, 2016; Scholten et al, 2014)
RP3	*Alternative supply*- diversified supply base in order to mitigate against potential supply disruptions	(Jüttner and Maklan, 2011; Christopher and Peck, 2004; Chowdhury and Quaddus, 2015, Sonar et al, 2022)
RP4	*Alternative logistics*- multiple sourcing for aspects of logistics in case of disturbances- across packaging, handling, storage/warehousing and transportation	(Govindan et al, 2015, Petit et al, 2013; Mensah and Merkuryev, 2014)
RP5	*Collaboration with stakeholders*- information sharing across the supply chain in order to share risk information and disruptions	(Scholten and Schilder, 2015; Faisal et al, 2006; Chowdhury and Quaddus, 2015)
GP1	*Waste reduction*- Eliminate/reduce certain business activities (such as inventory, transportation, packaging and lead time) in order to improve environmental performance and reduce unnecessary resource consumption	(Dües et al, 2013; Lee et al, 2012)
GP2	*Collaboration and information sharing*- communicate to share environmental sustainability knowledge and environmental initiatives	(Dües et al, 2013; Cankaya and Sezen, 2018; Zhu et al, 2013)
GP3	*Supplier selection and evaluation*- ensure that partners in the supply chain across supply, logistics, manufacturing etc. meet strict environmental requirements	(Zhu et al, 2013; Zhu et al, 2005; Lee et al, 2012)
GP4	*Circular economy*- initiative for the involvement of reduce, re-use, recycle, refurbish, repair, rethink and refuse	(Cankaya and Sezen, 2018; Beamon, 1999; Rao and Holt, 2005)