

RESTRUCTURING VALUE NETWORKS TO ENABLE SUSTAINABLE INNOVATIONS IN FOOD PACKAGING PLASTIC INDUSTRY

Outi Keränen, Hanna Komulainen & Pauliina Ulkuniemi
Oulu Business School, University of Oulu
outi.keranen@oulu.fi, hanna.komulainen@oulu.fi, pauliina.ulkuniemi@oulu.fi

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INTRODUCTION

Sustainability, including economic, environmental, and social dimensions (Elkington, 1997), presents major challenges for societies and businesses all around the world. From the part of society, different policy instruments, as well as regional and international innovation systems, are in place to advance the development of technologies that enable both more sustainable production and consumption. To advance sustainability transitions and technological change towards sustainability, the role of regulations and efficient policy instruments are important (Rogge & Reichardt, 2016). It has been argued that sustainability policy instruments should aim at both creating niche innovations but also at disestablishing current dominant regimes to create openings that enable the transitioning to sustainable technologies (Kivimaa & Kern, 2016). Therefore, sustainable innovations tend to require the development of new and well-working technology, but also dismantling existing industry regimes that support the use of old technologies and prevent the change towards new more sustainable technologies.

In addition to various measures by public actors, private firms across industries strive to develop technologies that support sustainability in order to look for a competitive advantage. Such market-driven innovations typically combine both business and sustainability values and may thus be efficient in advancing sustainability. In commercialization of innovations, the role of different actors, including customers, users, suppliers, distributors, investors, complementaries, associations, public and non-profit organizations, and policymakers and regulators has been acknowledged (Aarikka-Stenroos et al., 2014). Furthermore, especially in radical innovations, the commercialization process has been identified as very challenging to manage and partly unpredictable (Aarikka-Stenroos & Lehtimäki, 2014). In understanding of how sustainability initiatives can be spread through supply chains and networks, the trust between the counterparts has been argued to be critical (Meqdadi et al., 2017). Diffusion of sustainable innovations and technologies is thus dependent on activities by various actors in a larger network, even in the private sector and in terms of market-driven innovations.

The development of sustainable innovations is on the agenda of research institutes and innovation systems. Commercialization of research-based innovations is often a complex process involving cross-sector collaboration in innovation networks. Existing industry actors may not always find such innovations, although potential, easily adaptable, solutions would exist, due to e.g. established industry structures and market processes. In addition, research-based innovations might be so new and advanced that the regulative framework supporting their adoption may not yet exist nor is it possible to effectively apply such measures before forming a thorough understanding of the implications of such technology on the wider context. Therefore, instead of mere regulative push, it is important to examine the market-driven pull -types of elements of sustainable innovations and its wide-scale use. The creation of understanding of how science-based sustainability innovations are adopted in established industry networks may enable a faster adoption process of sustainable innovations. Thus, our research question is: *What types of changes to existing industry value networks are needed to enable diffusion of science-based sustainability innovations?*

Such a research phenomenon is context dependent and to increase the understanding of the phenomenon, it is useful to focus on a specific industry context to take this embeddedness into account. In the present study, we focus on food packaging industry and the sustainability challenge related to the urge to reduce the use of plastics and substitute them with bioplastics. Plastic is characterized as a versatile, durable, and inexpensive packaging material, and thus it is extremely functional in preserving and protecting the quality and freshness of food during distribution and storage (Mihindukulasuriya & Lim, 2014; Marsh & Bugusu, 2007). The environmental problems related to plastic are however increasingly creating a pressure to develop new packaging films and processes with more user- and environmentally friendly attributes. That is, it has become important to search for more sustainable materials for food packaging. (Siracusa et al., 2008.) To address this, creating new bioplastic solutions (Peelman et al., 2013), derived for example from agricultural and food waste, has been on the agenda for research.

In terms of innovation for new bioplastic solutions for food packaging, in addition to actual technological break-throughs, the dissemination of such new and sustainable materials is heavily dependent on various issues. The regulative framework for pushing firms towards the use of bioplastics is not yet in place. Furthermore, in terms of market-driven motivations, various factors related to the industry, including different actors, technologies, and strategies related to packaging, food, delivery, and retail represent challenges. In fact, the move towards wide-scale use of these new bioplastics will transform the wider industry as well. In this study, we examine the restructuring of value networks required for the uptake of sustainable innovation. Thus, we empirically examine what types of changes to existing industry value networks are needed to enable the large-scale use of biodegradable bio-based bioplastics in the food packaging plastics industry.

We will employ the existing literature on value and innovation networks. Innovations tend to be created in complex and collaborative networks of multiple actors. These networks have been identified to develop from research to application focus, and alongside network's goal, structure, actors, resources and governance mechanisms change (Ritala et al., 2012). To provide new products to the market, understanding of these changes and various actors and their activities and roles in the complex value networks is thus needed (Dhanaraj & Parkhe, 2006). Empirically, qualitative methods are applied to investigate the food packaging plastic industry in the transition towards bioplastics and to understand how sustainability innovations are restructuring industry value networks.

PACKAGING IN FOOD INDUSTRY

Product packaging has an important role in creating firms' competitive advantage (Rundh, 2009). For brand owners, packaging is an area of innovation and it tends to form a basis for differentiation and brand building (Niemelä-Nyrhinen & Uusitalo, 2013).

In food packaging, package design and its manufacturing process are critical in defining the shelf life of food products. The primary function of packaging is to *protect* food products from external influences against potential damage, and the environment from the product (Lockhart, 1997; Prendergast & Pitt, 1996). If the packaging fails to protect the product, unnecessary damages and food waste emerge (Grönman et al., 2012). Packaging and package design can also *communicate* the firm's brand message and product benefits to the customer (Hellström & Nilsson, 2011; Rundh, 2009). Indeed, the goal of package design is to attract buyers and provide information and guidelines for using the product safely and economically (Lockhart, 1997). The handling and storing should also be *convenient* for the actors within the supply chain of food product (Niemelä-Nyrhinen & Uusitalo, 2013).

Rundh (2009) argues that the package design is determined in the interface between external driving influences and firms' capability to assess and transform them into attractive

packages. These influences may emerge from changes in technology, logistics, industry, and the degree of internationalization and globalization (Rundh, 2009). For example, the growing environmental demands to transit towards a circular economy and to dispose of waste has challenged the food industry to search and innovate more sustainable packaging materials. Therefore, a feasible substitute for traditional packaging materials has emerged – bioplastics. *Bioplastics* refer to plastics that are bio-based, biodegradable, or they feature both properties (European Bioplastics, 2019).

NETWORK VIEW ON INNOVATION

The emergence of new science- and technology-based business fields such as biotechnology involves high technological complexity and diversity of resources and capabilities required to develop the necessary infrastructure. This means that it is rather impossible for a single firm to create a new technology or business but there is a need to create increasingly complex webs of knowledge and technological bonds between firms with complementary skills and resources (Möller & Svahn, 2009; Möller & Rajala, 2007). In these value-creating networks, each actor has different capabilities and resources, and innovation is created by combining them (Faber & Bouwman, 2003). Therefore, since the creation and commercialization of new business fields are carried out through linked actors in complex interorganizational networks (Möller & Svahn, 2009), a network approach is used as a primary perspective in this study.

Following the extensive literature review conducted by Aarikka-Stenroos et al. (2014), multiple established network approaches can be identified in the extant research, including industrial networks (IMP), strategic nets, social networks, entrepreneurial networks, innovation networks, network theory, and the economics of networks. They differ in terms of the respective focal actors, what determines the network and how the actors are managed (see Araujo & Easton, 1996). In relation to this, Möller and Halinen (2017) identify two research streams in network management research: firstly, there is emergence of new research streams including the strategic networks or value nets perspective and secondly, extension of network management research to new application domains such as commercialization of innovations, business ecosystems, and service systems. Our assumption follows the notions of strategic net approach (Möller & Svahn, 2009; Möller & Rajala, 2007) stating that network relationships with divergent actors can be intentionally developed and orchestrated and it is complemented with the perspective on innovations in networks.

In order to define and clarify the characteristics of the context of the present study and to position it accordingly, a value-system continuum with three types of strategic nets (Möller & Rajala, 2007) is used as a starting point. These nets (or value systems) can be analyzed and classified based on their goals and the determination of their underlying value-creating systems (Parolini, 1999). At one end of the continuum are stable, well-defined value systems; *current business nets* that have achieved relative stability and high level of business process specification in their value creation. They involve well-known actors, technologies, business processes and value activities. In the middle of the continuum are *business renewal nets* that are based on current value-creation systems but are modified through incremental innovation activities, operationalized via multiparty projects and aimed to improve current offerings or specific parts of their businesses. At the other end of the continuum are *emerging business nets* characterized by radical, discontinuous and system-wide changes in old value activities resulting in new technologies, business concepts or even business fields. The emerging value systems involve great uncertainty concerning the actors, activities, and resources, and thus require future-oriented thinking as well as dynamic and complex learning processes that cannot be specified in advance. This is a complex and under-researched domain and comes close to the context of this study since the new bio-based bioplastic solution requires several

actors with diverse skills to form new networks that continuously develop knowledge and technologies and finally create new value for the end customers.

Möller and Rajala (2007) further identify three different network categories within the emerging value systems. First, there are *innovation networks* that are science and technology-based research networks involving universities, and research institutions and organizations of major corporations. They are not primarily business networks but rather aimed at scientific discoveries. However, innovation networks involving large companies as research partners can be directed towards achieving specific application-oriented goals. Secondly, in *dominant design nets*, proactive companies try to create dominant technological designs in the pre-market phase of the business field evolution to support their positions in the market. Thirdly, *application nets* are formed to exploit commercially viable business applications as spinoffs from evolving technologies. These networks tend to involve a hub firm, different technology producers and pilot customers. For example, new mobile services are generally created in these types of networks.

The empirical context of this study shares characteristics with innovation networks. In the present study, the network resembles a science network involving a large consortium of different actors – universities, research organizations, food waste suppliers, film producers, packaging firms, technology providers, and other organizations. Thus, the network is not a business network in the traditional sense but a project network emphasizing the achievement of scientific research results. However, it is important to notice that the fundamental aim of the network is the development of bio-based bioplastic solution towards commercialization.

RESEARCH METHODS

Qualitative research methods are used to analyze the food packaging plastic industry and the changes to industry value networks required in the diffusion of science-based sustainability innovations. Qualitative methods aid in describing, understanding and explaining the human interactions, meanings, and processes that create real-life organizational settings (Gephart, 2004), which is in the focus of this study.

The primary data was acquired through 12 thematic interviews for individuals in firms and organizations participating in the food packaging plastic industry (Table 1) to examine their interpretations and perceptions from the research phenomenon (Fontana & Frey, 2000).

Table 1. Qualitative interview data.

Role in the food packaging plastic industry	Informant(s)	Interview details
Retailer	Sustainability Manager & Project Manager	5.11.2018, 70 minutes
Brand owner I	R&D Director & two Product Technicians	4.9.2018, 30 minutes
Brand owner II	Innovation Manager	8.10.2018, 60 minutes
Brand owner III	Technology Development Manager	8.5.2019, 80 minutes
Package designer and manufacturer	R&D Engineer	14.8.2018, 90 minutes
	R&D Engineer	10.4.2019, 50 minutes
Innovation center	R&D Project Manager & Researcher	6.5.2019, 55 minutes
Research and innovation center	Director of Bioprocesses Area,	2.5.2019, 50 minutes
	Researcher & Project Manager	
Research institute	Head of Department of Life Sciences	8.4.2019, 45 minutes
Consulting I	European Project Manager	16.4.2019, 30 minutes
Consulting II	Senior Sustainability Consultant	12.9.2018, 55 minutes
University	Research Funding Specialist	8.8.2018, 40 minutes

The interview data was supplemented by data gathered from industry reports, and web pages of the industry-related firms and organizations. The data was gathered to understand the food packaging plastic industry and the role of bioplastics in the market, and reaffirm the findings of the interviews. The empirical data was analyzed thematically to identify similarities and

differences within the data (Miles & Huberman, 1994). The data was examined from different actors' perspective to understand thoroughly the required changes in industry value networks.

FOOD PACKAGING PLASTIC INDUSTRY

The food packaging plastic industry includes many SMEs and larger firms producing plastic for food packaging purposes. The industry is characterized by the maturity of technology and differentiated service offerings. The food packaging industry is regulated by strict regulations that aid in protecting food products.

The manufacturer of packaging materials is important in the packaging industry (Figure 1). Brand owners pack their food to protect them in distribution to wholesalers and retailers, and thus they are the customers of this industry. Packaging and package design rest on the development work between brand owners and material or packaging suppliers (Rundh 2005.)

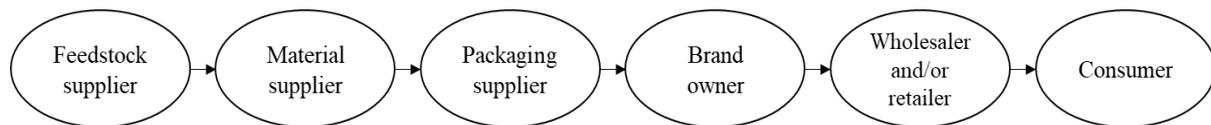


Figure 1. The supply chain of the food packaging plastic industry.

The number of bioplastic materials, applications and products are nevertheless persistently growing and steadily attracting new material and packaging suppliers, and brand owners to enter the market. The industry includes SMEs and few larger firms producing and providing packages from first-generation biomass materials, for example, PLA (European Bioplastics Association). These bioplastics are made from carbohydrate-rich plants; that is, food crops. Nevertheless, the development work related to mechanical and barrier properties are required, and to further moderate the impact of bioplastic production to the environment, researchers and firms are trying to develop new ways of producing biomaterials that would derive from food waste, for example, potato peels. The diffusion of such innovation is assumed to create changes to the existing network structures of food packaging.

EMPIRICAL ANALYSIS

The food packaging plastic industry is examined from the perspective of the different actors in the supply chain of food packaging to understand the changes to industry value networks required in the diffusion of bioplastic innovation.

The role of *material suppliers* of first-generation biomaterials is critical in the diffusion of bioplastics, derived from food waste, for example, potato peels. These manufacturers are skillful to turn into later generation bioplastic actors. Technologies and machinery to produce different biomaterials are the same, although their production tends to require adjusting the process. Nevertheless, although bioplastics are technologically mature materials, developing formulas to produce bioplastic from food waste require basic research, and thus universities and different research institutions are too important actors in the diffusion of such innovation. Commercializing the innovation requires support from existing material suppliers who would be willing to invest and change their production processes to facilitate the emergence of later generation bioplastics, or alternatively new actors entering the market.

The manufacturers of the plastics for the packaging manufacturers... This kind of companies are really the companies that can drive innovation plastics to the value chains, industrial chain because they are producing the materials for the packaging producer. (Innovation Manager, Brand Owner II)

The availability of feedstocks for bioplastic production is stabilized and reasonable good in food packaging. For example, large material manufacturers grow their own feedstocks, which safeguards the availability of feedstocks for them. Thus, from this perspective, the need for material suppliers to change their production processes to produce later generation bioplastics is not imperative. To indemnify feedstocks for later generation bioplastics, new actors with new value activities must thus enter the market. The diffusion of such bioplastic innovation would require new *feedstock suppliers*, for example, food processing firms and *distributors* to enter the market to detect feasible logistic opportunities to circulate food waste efficiently for material suppliers. If required food waste is utilised for other purposes, for example, feeding farm animals, changes to food packaging networks would create changes to other networks, too.

For *brand owners*, the external regulations and incentives, including market pressure from *consumers* and *retailers* towards sustainable packaging, are critical in the transitioning towards both first and later generation bioplastics.

We are always the final user but we are pretty affected by the opinions of the consumers, and you know that the opinion of the consumers is -- the popularity of plastic is decreasing, a lot. So the alternative is bioplastics. (Innovation Manager, Brand Owner II)

It is a requirement of our clients, for example, big brands. We think that these kinds of clients require us to work with more sustainable packaging. (R&D Director, Brand Owner I)

Nevertheless, although consumers are increasingly interested in sustainable packaging and requiring environmentally friendly solutions, they do not entirely understand what bioplastics are and how they contribute to sustainability. Therefore, sustainable packages compete with traditional packages in terms of their functionality and attractiveness, and price.

People really do not get the difference, do not know that -- polymer can be bio-based or biodegradable so people are not informed of this so they just say, oh yeah, this looks better and buy that. -- If brands are able to put this label and it is not more expensive, they will do that, [and] if not, they will just keep buying conventional packaging. (R&D Engineer, Package Designer)

The market pull that would demand brand owners to change their packaging solutions is thus just emerging and developing. To hasten this development, consumers need more instructions and education on bioplastics. For example, together with environmental organizations, large retailers could act as influencing actors in society regarding sustainability.

Then we want customers into this, and guide and tell them more about this plastic work [we have done] and help customers in that as well. -- Then there are some associations guiding and advising consumers. (Responsibility Leader, Retailer)

The limitations in functionality regarding the mechanical and barrier properties of bioplastics influence negatively the intentions of brand owners to use bioplastics. Furthermore, the experts in the food packaging plastic industry describe that price is too high for firms to pack their food products in bioplastics, although they are interested in their potential.

The bioplastics have not really reached the market, but companies are trying to invest a little bit in that -- but until the price does not go lower, they will not start buying these products. (R&D Engineer, Package Designer)

Similarly, *packaging suppliers* experience challenges: packaging suppliers may not possess necessary materials for bioplastic packaging or they may not be able to produce reasonably priced bioplastic packages. The processing and transforming bioplastics into packages is thus problematic and packaging suppliers may not be willing to invest in basic research, which

would permit the development of bioplastic packages. Universities and research institutes are thus needed to facilitate the diffusion of bioplastic innovations.

Packaging companies, are not interested really right now, in, launching bioplastic packaging, because, they are, they see that the customer will not pay so much more for that packaging, and also because it doesn't meet the performance, especially for, the permeability performance. They will not do it themselves. It requires more basic research. I don't think they would invest so much in, first developing the basic research to meet the barrier properties and then, developing the whole packaging concept. (R&D Engineer, Package Designer)

Nevertheless, if regulations regarding the use of plastic in food packaging are changed, brand owners and packaging suppliers are ready to move towards bio- and biodegradable plastics. This illustrates the role of *policymakers* and regulations in diffusing bioplastic innovations in the food packaging plastic industry.

Companies are trying to get in the market to be aware of what is going on. Just in case, [if] they need to go that way. -- The bioplastics have not really reached the market, but companies are trying to invest a little bit in that, just in case legislation changes or consumers demand that. (R&D Engineer, Package Designer)

The food packaging plastic industry rests on long-term collaborations and contracts between the actors in the food packaging networks. This creates partnerships, in which switching the partner is not possible or even wanted. Specifically, the collaboration between brand owners and packaging suppliers is characterized as tight. Food packages tend to require customizing, and thus the ability of a buying organization to switch their food-packaging supplier might be limited and require changing the package. The excerpts illustrate that relationships in the food industry are influenced by the degree of standardization and customization of food packages:

If you are producing a specific packaging, and that is your product, you have to stay loyal as otherwise, your product will change. You cannot really change the product that easily. (R&D Engineer, Package Designer)

When you are using standard packages, it is very easy to change [partners]. It is a question of costs. In case that you have a personalized, customized project... -- In this case, the relationship is closer with the packager. So, in this case, it will be more difficult to change, because you are under a contract, which regulates the exclusivity of the packaging, so in case that you change, you have to supply all the technology to the new provider. So, it's not impossible but it's more difficult. (Innovation Manager, Brand Owner II)

The interest of brand owner to change their package material might require a new packaging supplier and changes in packaging machinery. Nevertheless, long-term relationships between brand owners and packaging suppliers might create barriers for new firms entering the market by making it difficult to find customers and developing effective channels for distribution.

Interestingly, brand owners do not collaborate directly with material suppliers, although material suppliers are critical in the diffusion of bioplastic innovations. To communicate the market demands further within the supply chain, it would thus be critical to adjust existing value activities and create new ones in collaboration between brand owners and packaging and material suppliers.

The market demands bioplastics. -- The food industry demands new packaging for this market. The plastic manufacturers, I suppose, demand bioplastics to produce packages. I suppose, but I do not know. I am not very sure if they realize that bioplastics are so important for the business. (Innovation Manager, Brand Owner II)

Similarly, retailers are merely connected with brand owners, through which they mediate the demands of consumers and try to influence the environmental actions of the food-packaging supply chains. Nevertheless, the excerpts illustrate that the implementation of sustainability issues require strong collaboration with multiple actors, and thus changes are important in the food packaging supply chain and more networked type of collaboration is required:

Many things, sustainability issues are not handled in a way that we think them alone and work with them alone. Instead, collaboration in the value chain is extremely important. (Responsibility Leader, Retailer)

The diffusion of bioplastic innovation into the food-packaging network requires further new actors with new roles and activities. Specifically, to minimize environmental impacts, it is important to identify the end-of-life processes of the bioplastic packages. This might require new actors to enter the market as, for example, existing industrial facilities do not recycle or compost bioplastics.

CONCLUSIONS

This study increases the understanding of innovation networks by detecting the changes to existing value networks that may enable the large-scale production and commercialization of science-based sustainability innovations and relationship dynamics regarding such diffusion. Specifically, changes to existing value activities and relationship structures and new actors with new value activities and relationship connections entering the market are required. This would facilitate the development of innovative technologies that permit the transformation towards later generation biomaterials and products and the distribution of food waste for their production (Figure 2).

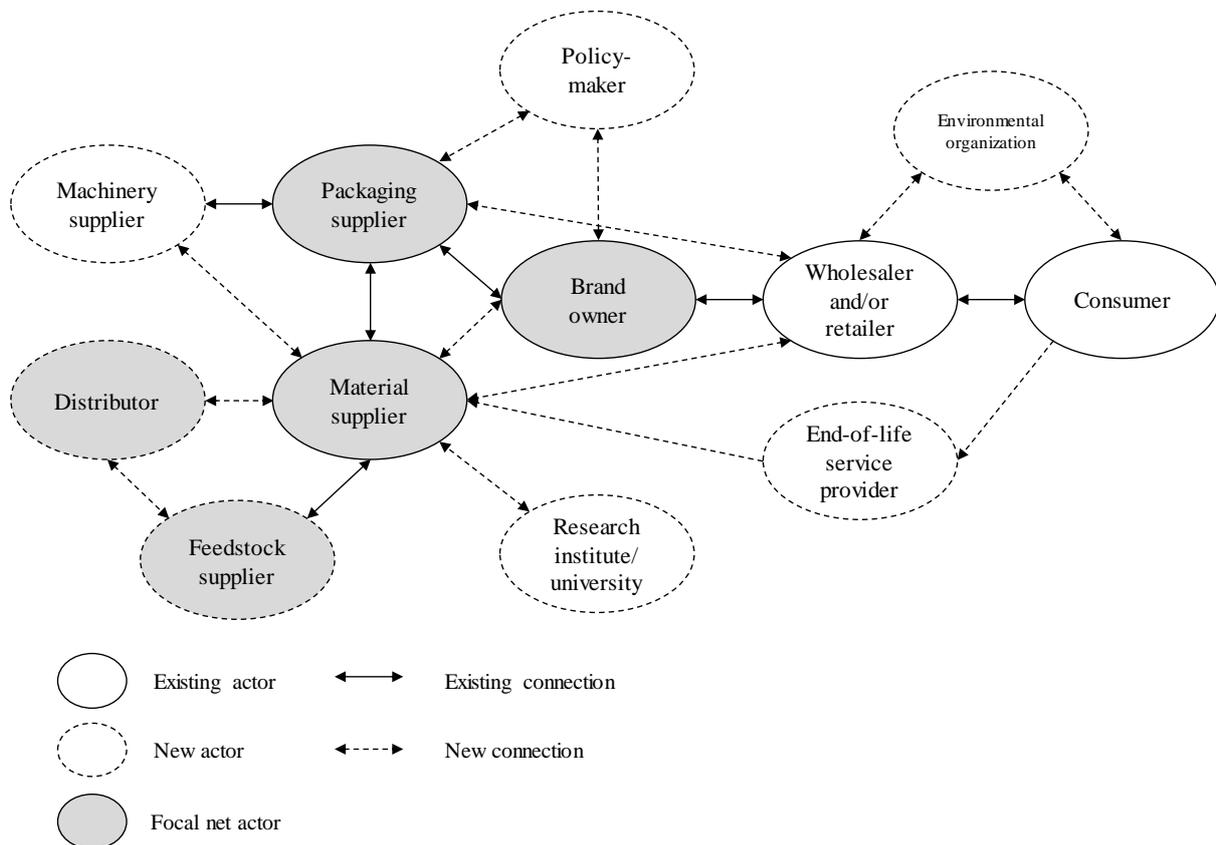


Figure 2. Diffusion of science-based sustainability innovation in food packaging plastic industry.

The diffusion of sustainability innovations is based on a networked type of collaboration, in which individual actors are holistically connected and influenced by each other. Furthermore, it is identified that focal nets and key actors in them may play a critical role in enabling the diffusion of sustainability innovation within industry value networks.

This study provides a contribution in terms of describing the anticipated value network changes that may have implications for policy development. Successful policy implications

towards sustainability transition in the area of bioplastics in food packaging need to address the industry actors across the supply network and promote the collaboration and joint efforts in the industry.

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