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## Innovation management responses to regulation – SUP-directive and replacing plastic

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**Abstract:** Changes in regulation trigger changes in the innovation environments. They may block specific development trajectories, but they may simultaneously inspire and stimulate completely new openings. In this study, we look into regulation that aims to address environmental problems and facilitate creation and diffusion of sustainable technologies and processes as we examine the responses of innovators to the regulation on plastic use and production – specifically, the so-called SUP-directive. A multiple-case study comprising six companies suggests that companies manage (with) the regulation-induced innovation and needs for change by adopting three distinctive strategies: 1) proactive change orientation, 2) reactive opportunity capturing, or 3) reactive survival mode. Acknowledging that sustainability-oriented regulation may push companies with environmentally friendly innovation activities and solutions towards reactive survival mode highlights the need for managerial agility in adjusting the solutions and the ability to adopt parallel innovation strategies. Observing the strategies adopted by innovators also is informative when evaluating whether the regulation meets its profound goals and intended effects.

**Keywords:** Innovation; Regulation; Sustainability; Strategy; Plastic

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### 1 Introduction

The interaction of regulation and innovation has been acknowledged for decades and has been documented in many studies. At the same time, it has been noted that the relationship between regulation and environmental innovation is still debated and that it involves dynamics that are not yet well known (Zhou et al., 2020). Even if environmental innovation is not merely a response to regulation, regulation does have both push and pull effects on the emergence of such innovation (Constantini & Crespi, 2013; Dijkstra et al., 2020; Porter & Linde, 1995). Sometimes setting clearer rules promotes and supports innovation. A classic example would be the regulation on the intellectual property rights. The patent system, for instance, was designed to afford the innovator with a temporary monopoly and some head start in retrieving the investments placed in the exploration and to enable safe publishing of the innovative creations (Greenhalg & Rogers, 2007); Hurmelinna-Laukkanen et al., 2007). Therefore, regulation supports collaborating for innovation and secures incentives for it in general. New regulation can provide support

structures for innovation also regarding more specific new solutions. An example would be regulatory sandboxes, which allow new financial innovation to be explored and promoted on the outskirts of existing rules and norms (Goo & Heo 2020). Innovation promoting effects emerge when regulation affects market conditions by opening up new opportunities for profiting (Constantini & Crespi, 2013).

On the other hand, regulation can force businesses to create innovation. Recent examples are found in regulation that aims to address environmental challenges such as climate change and air and sea pollution. Some products or materials are being and will be banned as environmental awareness increases (Herbetz et al. 2020). Environmental regulation is known to promote competitiveness under constraints of such regulation (Hu et al. 2020), and it is hence likely to increase R&D at least to a threshold where products or services comply with new regulation (Yang et al. 2020). When the environmental regulation induces new costs of remaining in the existing trajectory for the industry, the innovation process will be accelerated as long as the cost induced is high enough (Masoumi et al., 2021). When products have to change, but user and consumer needs remain unchanged or are only marginally modified, new processes, products, and materials need to be actively developed. This replacement effect and market emergence occurred in the case of mercury, for example, when several new products were rapidly created to replace mercury after the Minamata convention (Born, 2001; Gnybida et al., 2014; Tew & Quelhas, 2018). Furthermore, it is possible that completely new needs, such as the need to reuse materials that have previously treated as waste only, emerge from changes in regulation (see Constantini & Crespi, 2013). On the other hand, there are several cases where regulation has failed to change consumer and business behavior as they have found a way to innovate and shape products for their own needs (Blomkvist & Emmanuel, 2020). Nevertheless, in several fields, regulation is needed to enable disruptive innovation, even in the case where the innovation responds to an existing market need (Sheppard, 2020).

The challenge for innovators is, that it is highly uncertain in which cases innovation related to new regulation increases profits and where it possibly reduces profitability (Rennings & Rammer, 2011). Limited knowledge exists on the effects of different types and forms of environmental regulations, and regional differences of regulation on innovation (Zhou et al., 2020). Hence, there is lack of knowledge on how to benefit from innovation opportunities or to respond to the need to find alternative solutions to replace prohibited ones. It is not clear if abandoning earlier innovation is the only way forward, or if adjustment regarding input, processes, or the output might work.

A recent addition to those areas, where a regulatory push to the search for new applications and solutions emerges, is plastics (Álvarez-Chávez et al., 2012; Zhu & Wang, 2020). Plastic waste (and especially marine debris) is a widely acknowledged environmental problem in international and national forums<sup>i</sup> (Foschi & Bonoli, 2019; Mitrano & Wohlleben, 2020). Therefore, it is not surprising that supranational actors have taken action to address the related problems (Cecere & Corrocher, 2016; Coelho et al., 2020). Among them, the EU has been one major actor in reducing plastics in the sea and using regulation to achieve the pursued results. EU marine strategy from 2008 mentions preventing litter from damaging the sea and coastal environment as one requirement for good environmental status.<sup>ii</sup> In the EU plastic strategy, the pollution of the seas and coastal environments is brought up as the main environmental impact deriving from plastic usage. It also is acknowledged that the problem grows and that one reason behind this is that only 25 % of plastics in the EU are recycled, and 50 % of all

plastics are put on landfills.<sup>iii</sup> Therefore, in the strategy, reducing the use of plastic through regulation is strongly based on environmental impacts, including plastic in landfills and plastic burned to produce energy.<sup>iv</sup>

Many actions have been taken to reduce plastic in the environment. At the end of the 2000-decade, regulation and softer measures began to decrease the emergence of plastic bags in the oceans (Maes et al., 2018). More legislation was implemented in 2015 to advance the reduction of plastic bag litter.<sup>v</sup> Aiming to prevent plastic litter on the coast and to respond to member states' requirements considering the sea environment, new EU regulation came into effect on 5<sup>th</sup> June 2019. Widely extending the regulation on plastics use, *the single-used plastics, i.e., SUP-directive*<sup>vi</sup>, covers a range of different plastic products. The SUP-directive includes several bans and introduces requirements for specific types of plastic products. It also poses some requirements to member states and the companies located in them within a relatively short timeframe, between 2021 and 2029. The directive effectively requires new product development to replace currently widely used plastic products and possibly a change in consuming habits. The task is not easy, as plastic has features that are superior to many other materials making it difficult to replace (Zhu & Wang, 2020; Milios et al., 2018). Adding to the complexity, different countries may follow different trajectories regarding regulation. Although similar regulatory actions are currently taken in several other major market areas as in EU (e.g., with Canada planning to ban several single-used plastic products in following years (Walker & Xanthos, 2018)<sup>vii</sup> and China, the largest plastic producer in the world, having already taken significant actions to reduce plastic waste in the country; Brooks et al., 2018<sup>viii</sup>) the USA, for example, has not implemented any kind of bans on plastic products (Iverson, 2019). Therefore, the market of single-use plastic products and their substitutes is characterized by fragmentation and relatively unknown dynamics. These aspects increase uncertainty regarding the needs for adjustment and change at the firm-level.

This study addresses these issues by focusing on the effects of SUP-directive on innovation and innovation approaches adopted in companies. Some studies have started to examine the effects of the directive (e.g., Foschi and Bonoli, 2019, consider the interactions between European Commission and plastic value chain stakeholders on implementing measures) or have addressed government role for sustainability outcomes (Niesten et al., 2017). Other studies have addressed similar legislation-based activities and their implications (e.g., Veal and Mouzas, 2011, study the compliance of rules and generation of new rules by firms). However, many questions remain open regarding managing innovation and its diffusion under regulatory changes (see Zhou et al., 2020). While the SUP-directive forces – and incentivizes – companies to rapidly develop new solutions replacing plastic in their products, to create new approaches to meeting customer needs, or to create new customer needs, it can be expected based on earlier examples and considering national and regional differences, that the influences on innovation are not straightforward (see, e.g., Veal and Mouzas, 2011; Zhu & Wang 2020; Hoge & Brandão, 2020). Especially firm-specific innovation approaches under regulatory influences call for closer examination.

The goal of this study is to determine how companies generate innovation to become market winners during major regulatory changes and what kind of innovation SUP-directive initiates in companies willing to gain profits from market disruption. The research question that guides our examination is: *How companies approach the needs that regulation (SUP-directive) generates for innovation?* The materials used to reach the goals and answer the research question come from various sources. Analysis of the SUP-

directive and the related regulatory materials show, first, what kind of demands the directive poses on innovation and organizations producing them. This discussion taps into the aspect of variety of regulatory regimes as an influential factor regarding innovation effects, and forms ground for the empirical analysis. We then conduct a multiple case study to examine the strategies and approaches that firms within plastic value chains apply to respond to those demands. Interviews and various documentation provide empirical evidence on what kind of opportunities and threats firms perceive in the regulation and its implications. Within and between case analysis allows us to generate a categorization of different innovation management approaches adopted by varying firms.

In the following sections, we first briefly examine the SUP-directive and its demands on firms, and we then provide information on the data collection and analysis. The results are reflected against existing knowledge on organizations' reactions to regulation in general, and on innovation approaches in particular. Theoretical contributions, practical implications, and limitations, and suggestions for future studies conclude the insights drawn.

## **2 SUP-directive**

The SUP -directive was given on 5<sup>th</sup> June 2019, and it entered into force twenty days later.<sup>ix</sup> Most parts of the directive have to be implemented in national legislation latest at 3<sup>rd</sup> July 2021; other parts have to be implemented between 2021-2024. The directive was based on article TFEU<sup>x</sup> 192, which refers to goals stated in article TFEU 191 on the EU's environmental policy goals. The SUP-directive aims to promote the circular economy and reduce waste produced as it is the first goal of the waste hierarchy.<sup>xi</sup> The main arguments for and against plastic regulation were based on environmental and economic impacts; health impacts were not considered as significant (Mederake & Knoblauch, 2019), even if transition periods exist, for food packing, for example, due to the need to consider food safety and hygiene issues.<sup>xii</sup> An important practical goal is to reduce marine litter in line with several international treaties, like the law of the sea convention and marine pollution treaty, as well as with resolutions of several international organisations like UN, G7, and G20.<sup>xiii</sup> While previous directives related to the state of the oceans and waters have failed to do reduce marine litter, expectations are now high for SUP-directive (Black & Kopke, 2019). Plastic products covered by the directive are chosen based on how much of them are found on the shores of the EU.<sup>xiv</sup> Other goals relate to promoting a circular economy in the EU and balancing environmental goals with some economic goals. The directive was partly based on arguments that it would create new business opportunities for products replacing plastics (Mederake & Knoblauch, 2019). The SUP-directive recognizes that there are currently not enough suitable replacements for several single-used plastic products, and that markets need to develop these.

The heaviest instrument in SUP is found in article 5. According to article 5, member states must prohibit placing of several plastic products on the market. According to SUP article 3, "placing on the market" means the "first making available of a product on the market of a Member State" and "making available on the market" means any supply of a product for distribution, consumption, or use on the market of a Member State in the course of commercial activity, whether in return for payment or free of charge. These regulations cover practically all commercial uses of plastic products, where consumers or businesses can obtain these products. While "making available on the market" does not

include importing plastic products and owning them, they cannot be used in the EU for commercial activities.<sup>xv</sup> Therefore, SUP-directive effectively ends the usage of these products in the EU. Article 5 covers, for example, plastic cutlery, plates, straws, beverage stirrers, and convenience food packages.<sup>xvi</sup>

Banning these quite common products forces industries to create products from other materials, like paper, or discard them (Herberz, 2020; Hoge & Brandão, 2020; Zhu & Wang, 2020). European Commission sees that when these plastic products are banned, the consumption will shift to two different alternatives: more environmentally-friendly single used products, that is, “more suitable alternatives,” and “more sustainable alternatives” that can be used several times. This indicates that article 5 is expected to create markets for several different products. Some of them will be alternatives for plastics and others for single-usable products. These products are most likely to compete with each other as they are designed to fulfil the same needs that single-used plastic products meet now.

Other changes are introduced also. Caps and lids of containers are among the most common plastic litter found the most on beaches in the Union.<sup>xvii</sup> Therefore, article 6 expects that beverage containers capacity less than 3 litres, that are not made of metal or glass, and that have caps and lids made of plastic, may be placed on the market only if the caps and lids remain attached to the containers during the products’ intended use stage. This means that there will be no separate bottle caps in the bottles in the future. Article 6 requires that all plastic bottles under three litres manufactured from PET (Polyethylene terephthalate as the major component) must contain at least 25 % recycled plastic by 2025, and all plastic bottles must contain at least 30 % recycled plastic by 2030. This article is designed to force current manufacturers to develop their products to meet new design requirements and adapt their production chains in relation to the implementation of the product design. Therefore, this article forces companies to innovate on how their products can meet design requirements set by legislators. To ease use of recycled plastics, the commission prepares to make a standard about the quality of secondary raw materials.<sup>xviii</sup>

Article 7 includes marking requirements that do not affect product development and innovation as such. However, these too may initiate additional costs, which may affect attractiveness of developing certain products or materials.

Article 8 introduces rules about extended producer responsibility that may initiate varying changes. The extended responsibility means that producers of certain single-use plastic products are responsible for (1) the costs of the awareness-raising measures; (2) the costs of waste collection (for those products that are discarded in public collection systems), including the infrastructure and its operation, and the subsequent transport and treatment of the waste; and (3) the costs of cleaning up, transport, and treatment of litter resulting from the products. Products covered by this article include convenience food packages, fast food packages, and beverage containers with a capacity of up to three litres, cups for beverages, and lightweight plastic carrier bags. It is unclear whether Article 8 will force producers to change their products to reduce their costs from their liabilities.

Articles 4, 9, and 10 set requirements only to member states, and they are therefore not likely to initiate immediate changes for existing products. The following Table 1 summarises the requirements that SUP-directive sets for market actors.

**Table 1** Changes from SUP-directive for market actors

<i>Article</i>	<i>Requirements</i>	<i>Implementation</i>
5	Creating new products to replace those that are banned, i.e., straws, plates, cutlery, and certain food containers	3rd Jul 2021
6	Change certain beverage containers so that caps and lids remain attached to the containers during the products' intended use stage	3rd Jul 2024
7	Have product marking about the presence of plastic in product and waste management options	3rd Jul 2021
8	Pay costs that arise from awareness rising, waste collection, and cleaning	3rd Jul 2024, (5th Jan 2023)

A notable challenge considering the effects of regulation in general, and the SUP-directive in particular, is that improvements introduced based on it may not be genuine, or that an improvement in one area does not necessarily mean that problems are solved in a sustainable manner (Gibson, 2019). For example, innovative companies may become guilty of greenwashing (Zhu & Wang, 2020), or the change from one material to another may move the burden from water areas to air pollution, for example (Hoge & Brandão, 2020). Making it difficult to evaluate the actual implications, the means (such as Life cycle assessment; LCA) used by practicing managers and policymakers to evaluate the sustainability impacts of packaging, for instance, has its limitations (Lewis et al., 2010).

The effects of new regulation may also generate surprising outcomes in other ways. Compliance is not automatic by any means, but as Veal and Mouzas (2011) indicate, the introduction of regulation may give a start to new kinds of rules emerging in the markets as companies start to act in ways that may circumvent or distort the original intent. Variety in the norms across the world also generates fragmentation. Companies may move to different geographical markets, where the regulation allows them to continue their activities (Zhou et al., 2020). The direct and indirect effects of requirements set in terms of the input, process, and output or outcomes remain to be seen only later.

Considering that this kind of implications may emerge, but limited scholarly knowledge is available on what they mean for individual firms' innovation management approaches, we will next examine empirical materials to gain a better view of how companies operating with plastic or its (potential) replacements have approached the requirements of the regulation (SUP-directive) in their innovation activities.

### **3 Empirical evidence – Innovation under the influence of regulation**

A qualitative study has the potential to reveal relevant insight on issues with relatively limited prior information (Eisenhardt & Graebner, 2007). Therefore, we adopted this kind of approach for the empirical examination.

#### *3.1 Case-companies and data collection*

We used purposive sampling (Sharma, 2017) to identify six companies that are likely to be influenced by the introduction and implementation of the SUP-directive. A natural limitation was to search for European firms that develop plastic-free solutions and/or

substitutes in the areas of the production of plastics materials, the conversion of plastics materials, and the production of plastics products (Bauer et al., 2018). The plastic manufactures are typically large, international corporations affiliated with global petrochemistry companies, such as Dow Chemical, BASF, Braskem, Sinopec, or SABIC (Tullo, 2017). They host significant RDI resources. Plastic is turned into blended plastic materials and final products by converting and compounding companies. Recycling companies account for the smallest group in the plastics value chain. Converters and compounders are commonly smaller actors with fewer opportunities to influence plastic manufacturing. According to Bauer et al. (2018), current actors in this sector typically employ processes and technologies which link to petrochemical raw materials and may thus be reluctant to turn to any new technologies which require significant investments. Instead, drop-in solutions are preferred.

We wanted to allow for variety in the size and age and the degree of internationalization of the firms, as these aspects might bear relevance in adopting different kinds of approaches to innovation management based on the changes brought by the SUP-directive. Eventually, we studied six firms described in Table 2.

**Table 2** Case companies

<i>Firm</i>	<i>Revenue M€</i>	<i>Est.</i>	<i>Role in the value chain</i>	<i>Offering</i>
Firm A	15,1	1979	Product manufacturer	Single-used plastic-free hygiene products
Firm B	N/A	2019	Product manufacturer	Plastic-free straws
Firm C	0,335	2015	Material producer and product manufacturer	Plastic-free materials
Firm D	2,1	2016	Material producer and product manufacturer	Biodegradable single-used products
Firm E	0,032	2011	Material producer and product manufacturer	Recyclable bio-based packaging material
Firm F	3 000	1921	Product manufacturer	Single-used packaging products

Source: Publicly available data and interviews

The data on the companies, their responses to the SUP-directive, and the adopted innovation approaches was collected in two phases. First, data was collected from public sources, such as company web pages, news announcements, sustainability reports, and annual reports. This comprised both general descriptive information on the organizations and, where available, information on the innovation activities (e.g., announcements of acquisitions or collaboration activities related to innovation for replacing plastics, or announcements on sustainable innovation, for example). The documentary materials account for about 300 pages of text. Second, the firms were contacted by email and phone to interview the firm representatives. The interviews lasted about 30 minutes on average. In firm F, the data is based on materials received on the firm rather than interview.

### 3.2 Data analysis and findings

The data analysis comprised within and between case analyses (see Eisenhardt, 1989). We first coded the data for each firm looking for approaches to the directive, including the attitudes, perceptions, and actions taken based on the awareness of the directive and its implications, aggregating the insights from the analyses and categorizing them (Gioia et al., 2013; Lo et al., 2020).

The analysis showed that the companies had quite distinctive responses to the regulation, and that these responses did not depend strongly on their structural features; size or age of the firm did not emerge as a critical factors (see Table 2). Table 3 below summarizes firm-specific features that illustrate the adopted approaches as indicated by the data. Some firms had adopted a *proactive approach*, having started to innovate along such lines that fit the SUP-directive already before the directive was introduced. For example, a manager from Firm A noted that “*we already had a model for replacing those plastic products in our portfolio*”. Proactive firms showed that they had acknowledged the SUP-directive but did not find it particularly challenging to meet its requirements. A manager for Firm C stated “*Our products are already plastic-free and the SUP-directive might open up new business opportunities*”. A common factor for these firms was that they had anticipated quite correctly where the developments and regulation would be going. However, the companies still were concerned about the challenges with the strictness and uncertainty related to the directive. Firm C noted “*[the directive] may open business opportunities [...] but the related confusion may hurt them.*”

Other companies exhibited a *reactive approach*. The data indicates that they had not actively prepared for the changes in regulation, but when they learned about it, they found it necessary or reasonable to respond to it. Reactions among the companies were two-fold. Some companies had found the directive as an *opportunity* (see firms B and E in Table 3). Firm B represents a case where the whole firm was established based on the new regulation. They built on an idea that certain plastic products will be banned, and replacements will be needed: “*[the founder] got an idea that they could develop a product without [the feature made of plastic], but then the idea went further, and we figured out a way to use new material.*” The Firm E representative notes that “*the SUP came like a bomb [...] It looked like a threat and opportunity. [When studying the directive we saw] we already had made some right choices earlier [...] We realized that [the directive] does not mean as much to us, it actually strengthens our business.*” However, even if these firms embraced the emerging opportunities, they acknowledged the challenges with ambiguity related to the directive “*So now we just are on the lookout and wait what happens next.*” (Firm E).

The data also revealed firms for which the directive was a *threat* and that had notably a hard time accepting the directive and adjusting their operations. In most extreme cases, this meant turning to “survival mode.” These firms found it difficult to adjust their business to the directive and saw no new business opportunities. Manager in firm D reflected: “*The same day we heard about the directive, we started to think whether we could produce a single product that would pass the new regulation.*” Firm F appreciated very much the environmental goals, but raised questions if the directive will actually produce adverse effects: “*Even smallest amount of plastic in an otherwise biodegradable and recyclable product makes the whole product a plastic product that is banned or requires product marking [...] Markings require adjusting production for each market, which increases costs and decreases incentives to invest in development.*” Similarly, Firm



D notes that the problem is “*the far-reaching definition of plastic [...] which covers also such materials that are meant to replace plastic [...] which hinders recycling and causes challenges for developing sustainable material alternatives.*” Table 3 below illustrates the firms in these categories and shows their position to the SUP directive.

**Table 3** Case companies’ approaches to SUP-directive and innovation management practices

<i>Firm</i>	<i>Approach to directive</i>	<i>Innovation approaches</i>
Firm A	<p><i>Proactive</i> – Started to introduce and design plastic-free products early</p> <p>Faced ban of individual elements, but replacement existed</p> <p>Challenges related to existing inventory (product marking requirements)</p> <p>Challenges related to uncertainty (uncertain boundaries of regulation)</p>	<p>Innovation on alternatives for plastics</p> <p>Innovation continued as before, focusing on environmental issues.</p> <p>Inhouse development</p> <p>Replacing those individual elements that would be banned</p> <p>Active work with stakeholders to introduce plastic-free products to the market as soon as possible</p>
Firm B	<p><i>Reactive opportunity</i> – Started their business based on the opportunity they saw in the SUP-directive.</p> <p>Ban of existing products was considered as an opening for new alternatives.</p>	<p>Innovation on alternatives for plastics</p> <p>Launched innovation processes after hearing about SUP-directive and upcoming regulation.</p> <p>Secured the needed IPR (multiple patents in different countries)</p> <p>Focus on internal development; some selected collaborators that could provide support</p>
Firm C	<p><i>Proactive</i> – Saw weak signals and considered the directive when it was only a draft</p> <p>Started innovation based on the signals</p> <p>Observed business opportunities, but high uncertainty</p>	<p>Innovation on alternatives for plastics</p> <p>Renewable, recyclable, reusable (Innovation on alternatives for single-usable products)</p> <p>Innovation generation based on the directive and other environmental goals and possible requirements</p> <p>No notable needs for changing or enhancing innovation activity</p>
Firm D	<p><i>Reactive survival</i> – Faced ban of existing products. Directive introduced a need to reinvent products to fulfil requirements</p> <p>Cautious approach due to uncertainty about the future</p> <p>Opposing excessive restrictions of the directive (those that interpret inherently biodegradable materials as SUP)</p>	<p>Innovation on alternatives for plastics (Innovation on alternatives for single-usable products)</p> <p>Renewable, biodegradable materials</p> <p>Kept current practices but explored new areas based on upcoming requirements.</p> <p>Patents on biodegradable and microplastic-free substitute for plastics</p> <p>Inhouse development</p> <p>Same partners in production; same equipment</p> <p>Pursuing lead-time</p> <p>Validation established for biodegradability</p>
Firm E	<p><i>Reactive opportunity</i> – The directive led to initial chaos, but</p>	<p>Innovation on alternatives for plastics</p> <p>Innovation on alternatives for single-usable</p>

	then directive seen as an opportunity	products (recyclable materials; circular economy approach)  Kept current practices. No pressures for new innovation, but opportunities for business expansion.  Earlier biodegradability was important, now also recyclability demands for innovation – these were already established in the firm  Selected collaboration partners to support innovation
Firm F	<i>Reactive survival</i> – Faced ban of existing products; Product marking requirements; Awareness requirements  New product innovation introduced that meet the directive requirements.  Opposing excessive restrictions of the directive and lobbying for own environmentally friendly products.	Innovation on alternatives for plastics Active collaboration with stakeholders. Platform-based approach to innovate. Cooperation for validation of product life cycles.  Trying to promote innovation in recycling and other such areas but acknowledged losing incentives with increasing demands.

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Source: Publicly available data and interviews

Based on the initial findings and categorization of the firms according to their responses to the directive, we continued the analysis to gain better insight into the innovation management approaches of the firms and trying to find relevant patterns (see Eisenhardt & Graebner, 2007). These are summarized in the right column of Table 3.

In the first group, firms have previously developed approaches that mostly align with the demands and other contents of the directive, in which case they are quite indifferent to the regulatory requirements or can even promote those and leverage them in their innovation activity. Considering their innovation approaches, they can be considered to have “**proactive change orientation**” to innovation as a response to regulation. They have established internal R&D and IPR promoting their leading positions, and the collaborators are aligned to match their innovation. However, those firms that have already started to proactively move away from plastics also bring up possible challenges in the directive and therefore voice their concern that the strictest bans may also have adverse effects considering the directive’s purpose, especially regarding recycling. “*We believe that we are on the right track, but the unclear definitions cause uncertainty*” (representative of Firm A). These firms are worried about the short timeframe within which new regulation is introduced and the ways in which it is done, and the resulting uncertainties.

On the other hand, for some companies, regulation means restructuring and changes of business models, especially due to the ban of those products that they have been developing. These firms can be considered to be in “**reactive survival mode**.” These firms had already developed environmentally sustainable solutions in response to the changing markets, but as the directive is very restricting and shows little tolerance, their innovation is in jeopardy. Firm F notes, “*a safe and technically viable solution [that would allow removing plastic completely] does not exist yet*” and that “*Our recent product innovations demonstrate commitment to developing solutions that take us closer*

to circular economy.” For these firms, the adopted approaches to innovation include steps such as trying to modify their product to meet the requirements, and opposing the regulation that they feel threatens sustainable solutions: “A concern is that unclear and too broad definition of plastic [prevents the directive] from effectively meeting its objectives to reduce the impact of plastic products [...] and promote new sustainable material innovations.” (Firm D). They seek collaboration partners for these purposes, and they pursue to validate their offerings (e.g., through peer-reviewed life cycle assessments) to demonstrate the value of their innovation trajectories: “[Instead of bans], we propose increasing use of renewable materials, better collection and recycling.” (Firm F).

In between, there are companies who make completely new openings or need to make changes induced by the regulation, but instead of approaching regulation as a threat, find opportunities for diversification, for example: “Biodegradability reduces performance, so we decided to move to a different direction [that is, recyclability].” (Firm E). Overall, they believe that while their innovation management practices are not affected much, the value appropriation from innovation may be promoted: “SUP strengthens our story”; “We use SUP to show that we are front-runners” (Firm E). These actors belonging to the category of “**reactive opportunity capturing**” needed to consider their collaborators in innovation, however: “We examined SUP carefully and organized online discussions, if we should form an alliance.” (Firm B). Reactive opportunity capturing does not mean that the situation would be clear for the innovators, but there is concern about the shifts in the innovation environment.

## 4 Discussion

Overall, the effects of regulation may have quite varying effects on innovation and innovation management of sustainable solutions (Ashford & Hall, 2011; Jaffe et al., 2003). Our findings indicate that companies manage (with) the needs for change by adopting three distinctive strategies: 1) *proactive change orientation*, 2) *reactive opportunity capturing*, or 3) *reactive survival mode*. Each of these types of companies has specific managerial approaches to innovation management.

Some companies started innovating completely new products and solutions to benefit from SUP and change in markets – even before they were sure that such regulation was in force (firms A and C). They generally could meet the requirements in the Directive articles rather than saw them as a challenge. Most of them also avoided additional investment in increasing awareness (see article 8) as they already were engaged in activities that were aligned with the directive. Product marking requirement was not a notable issue for them either. They had found it relevant to secure their lead with IPR and inhouse development, assisted by selective partnering. For these firms, the new regulation did not necessarily involve radical changes in existing innovation approaches, as the companies saw that they were already doing what they should and that they would benefit from directive with their current innovation management policies, having a head-start. This finding is in line with Rexhäuser and Rammer (2014), who note that voluntary innovation and over-compliance regarding the environmental regulation can generate higher returns compared to pure regulation-induced innovation; it pays off to innovate ahead of regulation and secure relevant assets and network partners that enable identifying next valuable trajectories of innovation. However, the proactive firms acknowledged that a look at the directive was an important checkpoint, and that

benefitting from the regulation required action to be taken. Passive role would not be rewarded.

Those firms that faced bans and the need for product markings experienced, naturally, more profound needs to revisit their innovation strategies. More specifically, the changes comprised adjustment in innovation targets, in modes of operation, and in terms of connecting to stakeholders. These companies were caught by surprise of the strictness of the regulation and tried to survive by adjusting their current product portfolio to fulfil directive requirements (firms D and F)<sup>xix</sup> – often in collaboration with other actors. In parallel to these actions, they aimed to secure existing lines of innovation, that they considered to already address environmental needs, through validation and by publishing materials to voice the problems of the regulation. These findings resonate with the studies by researchers such as Coelho et al. (2020) reminding that switching to reusable materials is not without problems and Veal and Mouzas (2011) suggesting that firms do not simply comply with rules. It also illustrates how innovators can adopt multiple approaches simultaneously, that may even be somewhat opposing; while opposing strictest regulation to secure their current innovation trajectories, the firms also started to search for reasonable ways to meet the regulatory requirements.

Our data further indicates that especially the relatively rapid introduction of the regulation gave start to notable uncertainties for all types of firms. This connects to how they manage innovation. Importantly, uncertainties exist regarding the interpretation of the regulation. All case companies were unsure which products and materials would be considered as single-use plastics, which made innovation management challenging. Especially those firms that already had invested in development of biodegradable plastics, or products that were meant to reduce plastic in the products, faced both the need to start moving their R&D to new areas, and to maintain and validate their contemporary innovation and try to affect the interpretations (to be able to stay competitive in case their existing offerings would remain viable). In particular, the risk that the regulation will have unintended consequences was used as argument (see, also Gibson, 2019; and Niesten et al., 2017, warning about adverse effects) to turn attention to benefits of their own, earlier adopted approaches. In this way, the firms prepared for possible regulatory changes in the future.

Finding the right place to conduct innovation along the value chain emerges as an important decision point. While regulation covers the whole plastic value chain, changes in regulation affect different parts differently. SUP directive was seen to emphasize one aspect over others; reducing plastic in the environment (especially oceans). On one hand, reduction of harmful waste, like plastic debris, is necessary at the source of the problem, which stimulates innovation of products (and services), that would replace, first, plastic in the products or, second, plastic-based offerings as the response to the customer needs completely. An example is replacing plastic packaging by reusable systems (Coelho et al., 2020). In our data, the companies that had targeted innovation to the areas where lower levels of uncertainty emerged – that is, in plastic-free development trajectories – were in the best position to react to the emerging opportunities, yet active leveraging of the opportunities was also needed. On the other hand, regulation may be targeted to stimulate innovation based on reducing the waste at the later stages of the product life cycle (Dijkstra et al. 2020). More efficient ways of retrieving used plastics back into the production processes and new uses of recycled plastics (plastic waste innovation) have already now provided some companies new business opportunities (Oyake-Ombis et al., 2015). However, firms in our case study focusing on this aspect experienced challenges

and certain disincentivising of innovation. This illustrates varied effects of regulation on the innovation approaches for individual firms (see Zhou et al., 2020).

## **5 Conclusions**

### *5.1 Theoretical contributions*

Our study contributes to the existing knowledge by looking at the implications of new regulation at the firm level. As innovative firms are at the core of implementing changes, focus on their reactions to regulation shows the consequences of regulatory changes at the industry-level (e.g., in terms of the technological developments) in a new light. We expand the work by researchers like Veal and Mouzas (2011) on compliance and pursuing to change the rules, and Zhou et al. (2020) and Foschi and Bonoli (2019) looking at the effects on the regulation on industry developments by showing what kind of managerial approaches are present in innovating organizations when a new regulation is introduced. The proactive change orientation and reactive opportunity capturing reflect cases where a company has been able to create solutions that align with the new regulation, or where the requirements are met by following the guidance of the regulation when initiating innovation activities. We further find that a company may fall into reactive survival mode even if it were positioned in line with the principles of the new regulation. By categorizing the approaches to regulation in the light of the related innovation management approaches in this way, we provide bases for future studies that can evaluate, to what extent forcing innovation to a specific trajectory comprises the risk of suboptimal results: Sometimes regulation may erode the foundation for businesses that promote sustainability with recycling logic, and/or lead to pursuing such offerings that are perhaps sustainable as such but are produced in less than sustainable processes (Miller, 2020; Hoge & Brandão, 2020).

### *5.2 Practical implications*

Our study shows that managerial alertness and responsiveness to regulation is essential. Alertness and agility is needed, whether it comprises adjusting the innovation endeavors, changing the business, or starting new collaborations to respond to the changes in the regulatory environment. Having an analytical understanding of the approaches that companies adopt in response to the changes in regulation ease managers to avoid over- or under-reaction and -investments in the regulatory change situations and informs them about the ways in which it is possible to manage (in) the changing environment. It seems that only when reactive survival mode emerges, companies need to consider adopting parallel strategies; defending the existing innovation trajectories and starting to make adjustments to meet the regulatory demands. For policy makers, having a view on the reactions and subsequent development paths of innovators helps identifying the feasible level of regulation to meet the intended goals, as well as finding the appropriate means to address the whole value chain in a manner that does not suffocate viable solutions. For example, if products that build on recycling of plastic waste (e.g., the microplastics gathered from the environment) (see Dijkstra et al., 2020) face strict regulation, innovation in this direction might become unattractive, which could, in the end, lead to an increase in net waste. Another question is whether the development and production of

replacements of plastic cause more environmental problems – or other problems. For example, it already has been questioned if replacing plastic straws with paper ones is actually a sound solution regarding environmental effects (Hoge & Brandão, 2020), or considering health issues (which were not included in the preparation work of the regulation). Innovators experience problems emerge if they are not heard in decision making or if the regulation is introduced too fast. There is a need for wide-ranging views and close collaboration between stakeholders, in which ecosystemic approaches can provide direction.

### *5.3 Limitations and future research directions*

Qualitative studies are naturally limited in terms of generalizability, which is the case for our study also. We call for other qualitative work and quantitative, cross-sectional and longitudinal, studies that address the interaction of regulation and innovation aiming for sustainable output and outcomes. In particular, as sustainability has different forms (e.g. those emerging at the origins of the value chains, some at later stages), some of which may function under somewhat contradictory logics and forces, there is plenty of room for further examination. Similar considerations may emerge, for example, in relation to e-cars vs. biogas where there is a huge difference in measuring the pollution from the exhaust pipes and at the location of production of the electricity or biogas, or the manufacturing of the needed infrastructure and machinery. Likewise, while we acknowledged that regulation is different in different countries, we could not get deeper into what this means for adopted innovation approaches, if, for example, varying solutions may be tried in markets with different regulations. Examining the effects that the differences have in individual firms and for environmental developments more widely, as well as the obstacles and incentives for relocating businesses and R&D facilities specifically with environmental regulation in mind warrants further examination. We hope that the insights in this paper can be used in such research work.

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Notes:

<sup>i</sup> About international recognition, see UNEA Resolution 1/6 Marine plastic debris and microplastics.

<sup>ii</sup> Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) OJ L 164, 25.6.2008, p. 19-40, annex 1.

<sup>iii</sup> Communication from the Commission to the European parliament, the Council, the European economic and social committee and the Committee of the regions. Brussels, 2.12.2015 COM(2015) 614 final. Closing the loop - An EU action plan for the Circular Economy p. 14

<sup>iv</sup> Communication from the commission to the European parliament, the Council, the European economic and social committee and the committee of the regions. European Strategy for Plastics in a Circular Economy COM/2018/028 final.



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- <sup>v</sup> European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste OJ L 365, 31.12.1994, p. 10–23 (ES, DA, DE, EL, EN, FR, IT, NL, PT) and later changes.
- <sup>vi</sup> Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment PE/11/2019/REV/1 OJ L 155, 12.6.2019, p. 1–19. Also known as “Single-used plastics directive”, shorter as “SUP-directive”.
- <sup>vii</sup> "Canada to Ban Single-use Plastics, Hold Companies Responsible." Waste360 (Online) 2019.
- <sup>viii</sup> BBC News 20.1.2020. Single-use plastic: China to ban bags and other items. Available on: <https://www.bbc.com/news/world-asia-china-51171491>.
- <sup>ix</sup> SUP directive article 18.
- <sup>x</sup> Consolidated version of the Treaty on the Functioning of the European Union OJ C 326, 26.10.2012, p. 47–390.
- <sup>xi</sup> SUP directive, reasoning paragraph 2.
- <sup>xii</sup> SUP directive, reasoning paragraph 14.
- <sup>xiii</sup> SUP directive, reasoning paragraphs 3-6.
- <sup>xiv</sup> SUP directive, reasoning paragraph 12.
- <sup>xv</sup> See directive Regulation (EC) No 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products (Text with EEA relevance) OJ L 286, 31.10.2009, p. 36–39, where relation between placing on the market and importing are stated more clearly.
- <sup>xvi</sup> See SUP-directive annex part B for coverage.
- <sup>xvii</sup> SUP directive, reasoning paragraphs 17.
- <sup>xviii</sup> Communication from the Commission to the European parliament, the Council, the European economic and social committee and the Committee of the regions. Brussels, 2.12.2015 COM(2015) 614 final. Closing the loop - An EU action plan for the Circular Economy p. 11.
- <sup>xix</sup> These firms were also acknowledged in the preparatory documents for the national laws.