ENOUGH

EUROPEAN FOOD CHAIN SUPPLY TO REDUCE GHG EMISSIONS BY 2050

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EXECUTIVE SUMMARY

The European Green Deal and the Farm to Fork strategy undertake a set of policies and financial mechanisms to promote a sustainable transformation of the European Union (EU) economy. The success of which depends on how successful governments will be to adopt and implement the necessary actions to regulate markets and the use of natural resources, as well as to monitor emissions, support innovation and development, and spur consumption of goods and services produced under sustainable standards. In particular, decarbonizing the food sector, given its relevance, requires that the green agenda remains the main political priority in the long run. Moreover, already existing policies shall be synergic to new proposals and financial mechanisms shall be allocated in priority areas to support policy implementation. This report provides comprehensive information about current policies and finance related to the green transition, as well as elements that potentially support feasible policy design in relation to the food supply chain (FSC).

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1 INTRODUCTION

The European Union (EU) is the frontrunner to push new political, economic, and behavior paradigms into an emissions net-zero economy (EC, 2023c). Since 2019, when the European Green Deal (EGD) was launched, the European Commission (EC) has been engaged in designing policies and guaranteeing financial mechanisms to support the green transition (European Commission, 2021). Policies and finance have been developed within nine forefront domains: *climate, energy, environment and oceans, agriculture, transport, industry, research and innovation, finance and regional development, and new European Bauhaus* (European Commission, 2021). The food sector is central to the green transition for several reasons. Firstly, the food and beverages sector is amongst the main manufacturing sectors in terms of output share in Europe[1]. The share of food, drinks and tobacco exported to Extra-EU countries has steadily increased over the years[2]. The European FSC encompasses highly integrated numerous small and medium sized enterprises (SMEs) as well as multinational companies that have production facilities acting locally, regionally, nationally and internationally (Kühne et al., 2010). The aforementioned facts describe the food sector's strong performance in the EU. Given its economic relevance, the growth in food production and exports have significant environmental implications. According to EDGAR[3] estimations, the food sector is responsible for about one third of global anthropogenic greenhouse gas (GHG) emissions. Crippa et al. (2021) found that such emissions are mainly driven by energy use, industrial operations and waste management. While much political and economic emphasis is placed on land-use and land use change (LULUC) activities to reduce GHG emissions, less attention has been given to other stages of the FSC. Establishing sustainability standards achieving carbon neutrality in the food sector will only be possible with efforts to reshape all FSC stages, within and beyond the farm gate. Such efforts lie in decarbonizing current industrial activities while continuously incorporating new zero-carbon technologies (Bataille, 2020). This should be translated into to political and economic engagement, with initiatives by both industries and citizens should be aligned with regional priorities, capacities, and conditions (Bataille, 2020).

In the political sphere, the EGD and the Farm to Fork strategy (F2F) have gradually put forward a set of policy proposals to push for a green net-zero food system (EC, 2019, 2022). Future policies shall be

[1] www.ec.europa.eu/eurostat/web/main/data/database
[2] www.ec.europa.eu/eurostat/web/main/data/database
[3] Estimation data from EDGAR: https://edgar.jrc.ec.europa.eu/.

synergically integrated with existing ones so there is a mutual enforcement towards sustainability (Bazzan et al., 2023). In this context, designing feasible policies is a process that accounts what is desirable, but mainly what is possible to be achieved in the timeframe proposed (Meltsner, 1972). Thus, coupling regulatory and financial contributions might be an optimal way to enable an effective and timely transition to a net-zero and equitable food sector (Schebesta & Candel, 2020). Achieving the F2F premises requires the reallocation of financial resources along the entire FSC (Wesseler, 2022). According to Barreiro-Hurle et al. (2021) current technological improvements in the food industry will not be able to offset the current and future costs envisioned by the F2F.

Following from that, this report lays out comprehensive information about policies guidelines, priorities in relation to the food sector. Additionally, we underscore the importance of financial mechanisms to promote a sustainable food sector in Europe. Moreover, we shed the light on how current financial ventures are allocate their funds, as well as which areas shall be targeted along the FSC. Such information can potentially assist policymakers on the process of designing feasible policies in food-related priority areas.

2 POLICY INTERVENTIONS

Political and investment plans to spur a healthy and sustainable European food sector set a new paradigm in the EU. Although such ambitions have already been discussed in political agendas in the past, they fell short in terms of policy integration and lack of attention paid to post farm-gate stages (Rayner et al., 2008). Advancing decarbonization strategies in the European food sector needs a well-designed political framework, built in accordance with socio-economic, cultural and environmental conditions across countries, while accounting all FSC stages. This framework should consider pathways to facilitate investments in human capital, technological innovation and sustainable consumption, as well as guaranteeing that production patterns are aligned to political objectives. Related to this, the EGD and F2F set the directions to attain a sustainable food sector, encompassing a series of strategies, regulations, and investment plans supporting the green production paradigm. For this aim, structural changes shall be integrated across societal groups, with strong command and control of public and financial authorities (Pettifor, 2019). Moreover, technology and governance should function jointly to transform the economy in the long run (Pianta & Lucchese, 2020). In practice, given the green transition's urgent nature, this represents a key challenge in consolidating a carbon-neutral EU. Important aspects to be analyzed are (i) the changes in the energy mix, (ii)the role of product standards, (iii) the ongoing consumer and (iv) industry initiatives, and (v) the policy interventions and evaluations. We evaluate each aspect in what follows.

First, the shift from dirty to clean energy sources and the implementation of energy efficient systems should be accompanied by technical knowledge integrated as a governmental capacity. This means that political institutions shall develop information tools to progressively monitor production systems, processes, their demands, and impacts. Second, informing consumers about a product's origins and processes can potentially influence market behavior and the solidification of food produced under environmental standards. When consumers choose what food to buy, they indirectly determine preferences for production means and food standards. This behavior influences market forces and it is directly related to companies motion of rethinking social responsibility impacts from production to waste management (Grunert, 2011; De Carvalho et al., 2016). In this context, food-related voluntary certification and eco-labelling initiatives have increased in recent years. Non-governmental organizations (NGOs) together with industry associations have led a series of ecolabels in response to environmental concerns of consumers and activists' groups (Gulbrandsen, 2006). Ecolabels support sustainable consumption, and its adoption encourages producers to increase their environmental

standards (Horne, 2009). Nevertheless, ecolabels are voluntary instruments to enhance awareness about food quality, origin, nutrition, carbon footprint, fair trade, among others. Policies have the role to establish appropriate conditions, so market demand for green technologies steadily increases and replaces fossil-fuel based means of production. Necessary political mechanisms that regulate markets for low-carbon products and processes have to be in place and simultaneously account for consumer awareness to help shaping markets. Likewise, offering quality food for fair prices is key when planning a large-scale transition.

Third, consumer initiatives are an important part of civil engagement to enhance sustainability awareness and to promote sustainable food consumption (Moreira-Dantas et al., 2022). The EU highlights the importance of civil efforts to raise awareness about food sustainability and the implementation of appropriate sustainable practices according to local contexts (European Commission, 2017). Meanwhile, private and public engagement is related to the profitability of R&D from mature and new technologies (Mathews et al., 2010; McCollum et al., 2018). In any case, policy and investments shall envision and support strategies to foster consumers' awareness across all FSC stages. Thus, there is a need to increase the level of engagement in FSC stages, especially those after the farm-gate. Moreover, continuously integrating private and public actions is essential, so that stakeholders can communicate their current needs, identify limiting factors for technological transition, design interventions, and improve emissions reporting.

Four, in the industrial arena, technology roadmaps support policy design (Saritas & Aylen, 2010) by providing guidance on technical issues (when shifting to cleaner technologies) and addressing steps to progressively decarbonize operations (Caritte et al., 2015). Designing roadmaps is challenging, because food and drink industries are not clustered in one location, but spread across geographical areas. On the one hand, this fuels the economic activity in a wider geographical outreach, but, on the other, it limits the technological access to centralized natural gas and hydrogen facilities. Additionally, the food sector is composed of several processes and products, highlighting the need for food-specific decarbonization processes, rather than a "one size fits all" framework applicable to other sectors[4].

Finally, when targeting feasible policy interventions, policies and regulations should be complemented by evaluating policy efficiency and designing low-carbon interventions. This can be supported by industrial sustainability reports, which provide information of industrial emissions periodically and transparently. Nevertheless, corporate emissions data is limited, and available data do not broadly cover all stages of the supply chains and SMEs (Busch et al., 2022). In the EU, there is no harmonized mechanism for energy data reporting and to consolidate clean energy sources (e.g., wind and solar power) (Aszódi et al., 2021). Compulsory energy reporting mechanisms are, therefore, essential to evaluate where incentives are needed, to spot difficulties to shift to clean energy sources, and to guarantee that emissions do not exceed carbon removal (net-zero).

To achieve the EGD's political objectives, the EC presented the "*Fit for 55*" plan, which revised climate and energy legislation and industrial objectives. According to the European Council (2023), the proposed measures demand fundamental reductions in national specific GHG emissions from sectors not covered by the European Trade System (ETS), including agriculture and waste management. EU members, with their own individual quotas, shall increase the share of renewable energy sources by at least 1,1% in the heating and cooling sector. Another measure is the Carbon Border Adjustment

[4] Source: https://www.fooddrinkeurope.eu/wp-content/uploads/2021/09/Decarbonising-the-European-food-and-drink-manufacturing-sector_v2.pdf.

Mechanism (CBAM)[5], a tariff that will increase the price of imported goods in emissions-intensive sectors that are not produced under low-emission standards. These legal instruments are generally applied to specific productive sectors and do not include some stages of the FSC. Regulatory proposals involving specific FSC stages are likewise applied to productive sectors other than the food sector. Food production (agriculture), however, receives attention with proposals designed specifically for land use activities. As an example of production-specific legislation, the "*Amending Regulations (EU) 2018/841*" aims to increase carbon removals in the combined land use, forestry and agricultural sector at EU level by 2035. Its feasibility, however, depends on clear guidelines, incentives, and a detailed action plan to guarantee carbon removal in all production processes.

As a second example, the "*F-gas regulation*[6]" illustrates a political enforcement applied to all sectors utilizing F-gases within the FSC and beyond. This regulation has a mechanism to reduce F-gases by two thirds of the 2010 level by 2030. It consists on progressively phasing down production and import of high global warming potential (GWP) refrigerants, banning high GWP refrigerants in new equipment (e.g. fridges in households or supermarkets, air conditioning, foams and aerosols), and also in the servicing of such equipment. Additionally, F-gases emissions from existing equipment shall be monitored. The feasibility of overall policies will depend on factors related to company size, market integration, available investments, and national sector-specific political directionality.

3 FINANCIAL MECHANISMS

In the supply side, governments play a fundamental role in understanding investment conditions while prioritizing low risks, which is seen as the main barrier to a faster, cheaper, and lasting transition (Polzin & Sanders, 2020). Climate-friendly investments are crucial when seeking to achieve energy efficiency, adopting low-carbon technologies, and reducing overall GHG emissions (Hrovatin et al., 2016). Replacing fossil-based energy sources by clean technologies requires investments in both technology development and diffusion (Polzin, 2017). Unfortunatelly, major energy financing remains for fossil-fuel based technologies, and overall funds for clean-energy have decreased in the past decade (Andrijevic et al., 2020; UNEP, 2014). By analyzing current ventures supporting clean energy in Europe, Polzin & Sanders (2020) suggest that the European financing portfolio is large enough to incentive green-energy, however, there is considerable qualitative divergence regarding where the current investments are placed and where they are most needed. There are very few private small-scale equity funds for clean-technology research, development, and demonstrations (Polzin & Sanders, 2020). As a result, revamping financial strategies to solve the current financial gap and to foster green energy sources is timely (Pianta & Lucchese, 2020). In this context, private players tend to modestly invest in research and development (R&D), thus additional public funds should be allocated to technology development that contribute to decarbonization (Hannon & Skea, 2014).

Coherence is therefore essential to ensure that applicable tools are available to enable different regions to achieve international commitments to decarbonize their food sector. The EU has collectively invested in international initiatives to endorse sustainability. One example is the EU Taxonomy Regulation, which is a classification system that defines criteria for economic activities that are aligned with the EGD. Its main objective is to support the sustainable transformation by directing investments to the economic activities that are essential for the sustainable transition and aligned to the EGD goals

[5] The CBAM Regulation entered into force on the 16 of May 2023. The transitional phase, which only involves exchange of information, will start in October 2023. It will initially only apply to cement, iron and steel, aluminium, fertilizer, electricity and hydrogen.

[6] Regulation (EU) No 517/2014.

(European Commission, 2023c). The EU Taxonomy serves (non-) financial initiatives and companies with a systematic classification of sustainable economic activities, thus scaling up investments and preventing green washing issues (European Commission, 2023c). Similarly, the Cohesion Fund supports environmental and transport infrastructures (TEN-T) in Member States with a gross national income (GNI) per capital below 90% of the EU average (European Commission, 2023d). Based on the systematic review on financial mechanisms performed by (Moreira-Dantas et al., 2022), Table 1 shows the 19 ongoing funds supporting international harmonization for a green transition in Europe. While some of these funds cover all economic sectors, food decarbonization projects are eligible to receive investments.

Table 1. Financial mechanisms to improve sustainability, decarbonization and energy efficiency

Financial Mechanisms	Period	Budget (Million Euros)
Adaptation for Small holder Agriculture Programme (ASAP)	2012 – ongoing	€ 900,0
Climate Action 100+	2017 – ongoing	€ 68.000.000,0
United Nations Environment Programme Finance Initiative (UNEP FI)	1992 – ongoing	€ 100.000.000,0
Programme for Environment and Climate Action (LIFE)	2021 – ongoing	€ 5.430,0
European agricultural fund for rural development (EAFRD)	2021 – 2027	€ 386.333.400,0
European Regional Development Fund (ERDF)	2021 – 2027	€ 200.360,0
Horizon 2020	2021 – 2027	€ 95.000,0
Just Transition Mechanism (JTM)	2021 – 2027	€ 19.200,0
Cohesion Fund (CF)	2014 – 2027	€ 392.000,0
European Green Deal Investment Plan (EGDIP)	2021 – 2027	€ 1.000.000,0
European Maritime, Fisheries and Aquaculture Fund (EMFAF)	2021 – 2027	€ 108.000,0
Recovery and Resilience Facility	2021 – 2026	€ 723.800,0
Blue Sustainable Ocean Strategy	2019 – 2023	€ 2.500,0
Joint Initiative on circular Economy	2019 – 2023	€ 10.000,0
S3FOOD	2019 – 2022	€ 5,0
The European Fund for Strategic Investments (EFSI)	2015 – 2020	€ 10.700,0
Investor Energy-Climate Action Toolkit	2018 – 2020	€ 1,5
Programme for Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME)	2014 – 2020	€ 2.300,0
EU Finance for Innovators (InnovFin)	2014 – 2020	€ 2.700,0
Total		€ 556.906.296,5

Source: Authors' elaboration based on multi-stakeholders' initiatives: Horizon 2020 ENOUGH project (Moreira-Dantas et al., 2022a & Moreira-Dantas et al., 2022b).

To allocate enough investments to low-carbon R&D technologies, it is unlikely that capital will solely come from one source. Thus, diversifying investment funds can result in positive outcomes in innovation chains (Bumpus & Comello, 2017). Funds from private, governmental, and other financing measures (e.g., those having consumers involved) may do a better job to support the green transition (Bürer & Wüstenhagen, 2009; Polzin, 2017). Yet, the defined carbon market adjustments and taxation should be accompanied by public investments, so that the transition does not disproportionately impact certain players who may have fewer financial resources to comply with the new regulations. Pianta & Lucchese (2020) state that companies remain generally reluctant when it comes to further investment in green R&D, due to the high risk involved compared to the potential financial return. Hence, the green transition should drive higher demand for sustainable goods and services, so that low-carbon technologies generate profits, jobs, and incomes (Pianta & Lucchese, 2020).

This scenario is not different for food companies, where most SMEs depend on external investment to update industrial plants to use low-energy technologies, natural refrigerants, and cooling and heating innovations. Financial stability is also of core relevance to foster competitiveness and to afford high input and service prices.

Financial mechanisms have been broadly designed, calling for proposals in sectors that are active in different FSC stages. Funds are often provided by the European Investment Bank (EIB) or private initiatives. Generally, funds target projects related to R&I, R&D, the circular economy, and waste management systems in SMEs. Likewise, agriculture is a central activity covered by various investment projects to leverage agrotechnology, innovation, and rural development. While such investments are undoubtedly necessary, when combined with industrial initiatives they can potentially provide opportunities for tangible achievements. Industrial initiatives financed either by private means or by public ventures are aligned to EGD objectives and aim to foster innovation and international cooperation to work on waste management and reduce agricultural emissions.

R&I links today's problems and future solutions in decarbonizing the food sector. The challenge of building sustainability within the food sector involves multiple stakeholders and their perspectives, as well as various uncertainties and trade-offs (Riccaboni et al., 2021). This complex scenario demands solutions that consider all the interlinked needs of the food sector to respect the earth's limits to bear air pollution, especially regarding the decarbonization of its supply chain operations (De Froidmont-Goertz et al., 2020; Kok et al., 2019). Therefore, investing in R&I and R&D is key to ensure efficient solutions that accounts for the FSC's complexity. In the last three decades, R&D has made progress in tackling specific problems concerning the food sector, but with a narrow focus on increasing food availability at reasonable prices. This ensured affordable food to accompany a rapidly growing population, however, it did not solve nutritional challenges, biodiversity loss, and the significant GHG emissions throughout the sector (Garnett, 2013). In this scenario, actors from the entire FSC, from producers to the government, have a distinct importance in encouraging R&D focused on reducing GHG emissions and communicating where and how to innovate (Herrero et al., 2020; Riccaboni et al., 2021).

Riccaboni et al. (2021) reviewed recent R&I initiatives throughout the FSC, which were aimed at improving sustainability from primary production to consumption. Initiatives from farmers focused especially on the sustainable use of soils and their management. For example, the combined use of land for livestock and crops limits the overuse of nutrients, and precision agriculture techniques with sensor-based monitoring systems generate more efficiency and higher yields. Other business operators have innovative initiatives related to reducing food waste, integrating networks to improve processes, and empowering actors to choose more sustainable processes (Riccaboni et al., 2021). These actions of private actors must be accompanied by the effective involvement of not only policymakers but also of consumers and research centers (Riccaboni et al., 2021), considering that

there are economic and social barriers to the adoption of these innovative techniques (Clapp & Ruder, 2020). The literature on technology adoption points to high-value enterprise farmers having a higher adoption rate while adoption is lower for small-scale farmers or for those located in distant areas (Bollington et al., 2021; Bongiovanni & Lowenberg-Deboer, 2004; Fuglie et al., 2022; Groher et al., 2020; Visser et al., 2021). For this reason, even though investment in international agricultural R&D has shown to generate high returns, innovation is key for the achievement of proposed sustainability milestones (Rosegrant et al., 2022). Thus, impacts vary depending on the focus of the research undertaken (Fuglie et al., 2022).

In line with the need to foster R&D, the Horizon 2020 (H2020) program was implemented as part of the EU's Common Strategic Framework (CSF) for R&I. Its main goal was to finance R&I (over the period 2014-2020) with a total budget of around €80 billion. The projects implemented were related to not only fostering innovation but also its applications to industry, covering various fields from agricultural and natural sciences to engineering, technology, and social sciences. Beyond this clustering, the domain of application is considered for the choice of projects as well. Figure 1 illustrates an analysis of the Community Research and Development Information Service (CORDIS) database by field of application, clustering projects during the period from 2021 to 2027, and have some applicability in the FSC, which we called "food-related projects". We found a total budget of €1,2 billion addressed to climate change and environment projects with 20% of it targeting food-related projects. Meanwhile, projects related to food and natural resources received €85,4 million of investment with 54% of projects related to the food sector.

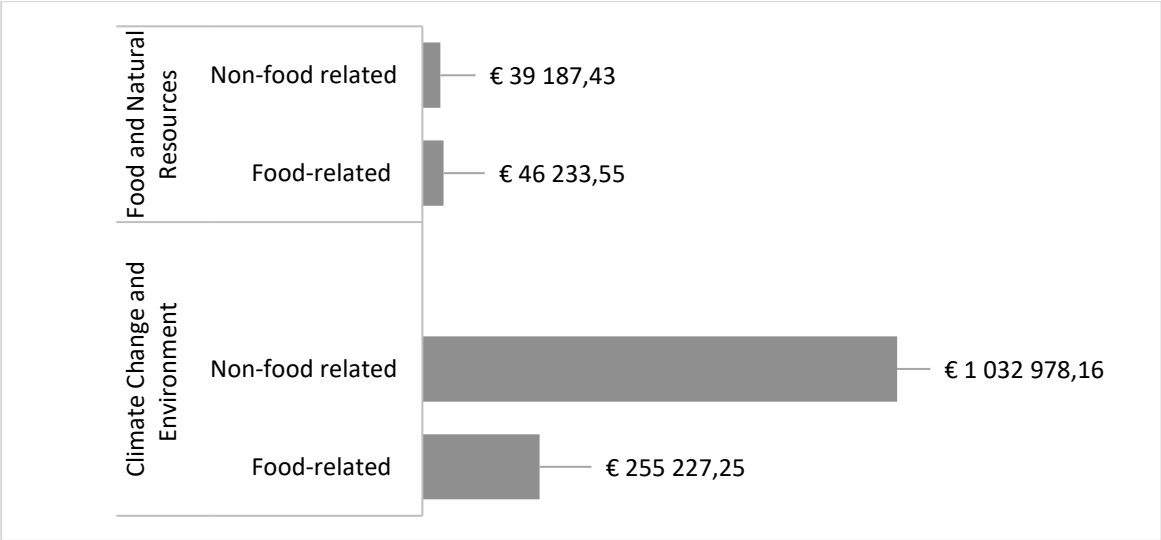

Figure 1. Distribution of food-related projects across domain of application (in € 1.000).
Source: Authors' elaboration based on: Community Research and Development Information Service (CORDIS). https://cordis.europa.eu/projects/en. Period covered: 2020-2027.

According to Kok et al. (2019), In the future, R&D and innovation should focus on harmonizing the many ongoing digital platforms, standards, and initiatives at the EU level. By considering the specificities of each context as a base for policy proposals and implementation, as well as a structure that enables science and society to work together toward solving complex societal challenges, it is possible to build data-driven solutions that are effectively achieving zero net carbon emission in the food sector (De Froidmont-Goertz et al., 2020).

4 CONCLUSION

The EU has been a major player in the world economy in terms of implementation of environmental regulations, and putting in place the necessary mechanisms that pave the way towards a low-carbon economy. The EGD envisions long term laws and regulations to not only decarbonize the EU economy, but also to make it irreversible. With this aim, the green agenda must remain the main political priority in the long run. Additionally, EU institutions should coordinate and integrate financial resources and civil engagement in the direction of low-emission strategies, while international cooperation is indispensable to support the use of new clean technologies and sustainable markets, rather than continuously finance existing past technologies.

More specifically to the FSC, all stages from food production to waste management need to go through considerable transformations to promote the phase out of fossil fuels and GWP refrigerants when producing, transporting, cooling, and handling food products. When analyzing the directives, policies, and regulations, we observe that the political directionality is somewhat general and existing regulations are not designed to take into account the specificities and challenges of all FSC stages. Food production –including agriculture and land use change– has special interest and there have been proposals specifically designed for this sector. Considering the emission-reduction potentials of food packaging, transport, refrigeration, and consumption, more emphasis should be placed on the technicalities that concern stages beyond the farm gate. Moreover, monitoring tools to quantify corporate emissions data, in particular from SMEs, are still insufficient. The creation of a harmonized monitoring system is central to the development of an emissions benchmark, and in designing strategies to achieve net-zero emissions.

Feasible policies shall facilitate investments in human capital, R&I, R&D, support sustainable consumption, and guarantee synergies with existing policies. Moreover, political interventions have to target all FSC stages while accounting for specific challenges and demands. A net-zero food sector depends on a good system to ensure energy reporting and monitoring and to spot where incentives are needed, as well as to evaluate emissions patterns across countries and industries.

All in all, we conclude that climate finance is crucial to make clean energy sources and technologies more accessible. Yet, there is some divergence regarding where current investments should be allocated. Although investments that target R&D and technology demonstrations should be prioritize, there is insufficient investment in these fields. Meanwhile, the green transition should support and incentivize the demand for sustainable goods and services, so that low-carbon technologies generate profit, jobs, and incomes. When assessing the EU R&D projects under the Horizon 2020 program, we identify an unequal distribution of investments and industrial projects across FSC stages. Ideally, public investments should prevent disproportional impacts of the regulations in place on players who may have fewer financial resources and that suffer the consequences of weak market integration. Harmonizing R&D and R&I digital platforms, standards and initiatives would help to identify where the needs for policy proposals and investments are, as well as provide with a structure that enables science and society to work together toward solving complex societal challenges.

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