CEPS RESEARCH REPORT

BARRIERS AND ENABLERS FOR IMPLEMENTING CIRCULAR ECONOMY BUSINESS MODELS

Evidence from the electrical and electronic equipment and agri-food value chains

Vasileios Rizos, Julie Bryhn, Monica Alessi
Edoardo Righetti, Noriko Fujiwara and Cristian Stroia

RR2021-01 | OCTOBER 2021

Barriers and enablers for implementing circular economy business models:
Evidence from the electrical and electronic equipment and agri-food value chains

Vasileios Rizos, Julie Bryhn, Monica Alessi, Edoardo Righetti, Noriko Fujiwara and Cristian Stroia

Abstract

The circular economy is a key element of the European Green Deal as a concept that can support the transition towards a more sustainable growth model. While in recent years there has been a growth of circular economy industrial applications, evidence suggests that the uptake of circular approaches in many sectors is still limited. This report provides evidence on barriers and enablers to the implementation of circular economy business models in two value chains that exhibit high levels of waste generation: the electrical and electronic equipment and agri-food value chains. Data and information were collected through in-depth interviews with 41 case study companies that were involved in the EU-funded CIRC4Life project, as well as from additional cases of firms putting such models into practice. The results show that companies implementing circularity approaches face a variety of barriers originating from existing policies, economic factors, supply chains, technology, consumer preferences and internal company organisation. Several facilitating factors within these categories (i.e. enablers) are also identified. This report furthermore provides insights on how the Covid-19 crisis has affected the companies' circularity activities. To help overcome existing barriers and support the circular transition in these two value chains, the authors have the following recommendations: increase the use of different forms of financial support; better align requirements stemming from different pieces of legislation; improve consumers' understanding of circular solutions; and support transparency and traceability across supply chains.

CEPS Research Reports provide in-depth analyses of a wide range of key policy questions facing Europe, drawing on state-of-the-art research methodologies and the latest literature.

Vasileios Rizos is Research Fellow and Head of Sustainable Resources and Circular Economy, CEPS. Julie Bryhn is Researcher, CEPS. Monica Alessi is Programme Manager, CEPS. Edoardo Righetti is Associate Research Assistant, CEPS. Noriko Fujiwara is Associate Research Fellow, CEPS. Cristian Stroia is Researcher, CEPS. The authors thank Beata Michaliszyn and Josephine Andersen for providing support with data collection. The content of the report is the sole responsibility of the authors and does not necessarily reflect the opinion of CEPS, the European Commission nor any person acting on behalf of the Commission.

This paper was prepared in the context of the CIRC4Life project, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776503. Another version of this paper is published as a project deliverable on the CIRC4Life website.

Contents

List of Figures

List of Tables

Executive summary

The circular economy is at the core of the process to transform Europe's industrial landscape and the move towards more sustainable economic models. Next to the central role it now has in EU policy strategies, such as the Green Deal, and economic growth and recovery, it is also increasingly being integrated into business strategies, practices and supply chains. Despite its growth in industrial applications, progress in many sectors is still limited; for instance, across the EU there are still high levels of electronic and food waste generation. Scholars have identified a variety of barriers that limit the adoption of circular practices by businesses. At the same time, several enablers also exist and have supported the uptake of circular business models. Yet, empirical evidence about these barriers and enablers is still not widely available.

The EU-funded CIRC4Life project has developed new circular economy business models (CEBMs) and has demonstrated them in the electrical and electronic equipment (EEE) and agri-food sectors. This report draws on evidence collected through in-depth interviews with companies involved in the project, as well as from additional cases of firms putting such models into practice to identify key barriers and enablers for the implementation of CEBMs in the above two sectors. Collected data also provide insights on how the Covid-19 crisis has impacted the companies' circularity activities and overall business strategy. The report concludes with a number of identified policy gaps and recommendations for addressing them.

Regarding the impacts of the Covid-19 crisis on companies implementing CEBMs in the EEE sector, 67% of the case study companies reported an impact on the demand for their products and services, either positive or negative, while over half of the companies experienced various impacts to their supply chain (57%), as well as on organisation and operations (53%). Notably, the majority of the interviewed companies in the EEE sector (62%) did not change their sustainability strategy or the way they integrate circular approaches into their business model as a result of the pandemic, although there were some companies (14%) that were actually motivated to increase their focus on sustainability.

The first key identified category of barriers to implementing circular economy practices in the EEE sector that are experienced by the majority (90%) of case study companies is concerned with the supply chain with specific barriers including difficulties in accessing products, components or materials, closed or restricted company loops and a lack of transparency across supply chains. Closely following was the category of policy and regulation (75%) with specific barriers here stemming from member state legislation and initiatives, the requirements and administrative demands related to EU chemicals legislation, the WEEE Directive (mainly due to different rules and enforcement across member states) and the existing extended producer responsibility schemes. Consumer and societal awareness came next, raised by 65% of companies. Within this category, a lack of interest or trust in circular solutions, a preference for new or cheaper products and a general lack of awareness of sustainability issues and the circular economy were some specific barriers. In addition, more than half of the companies (58%) mentioned barriers of an economic nature, such as the higher costs of more sustainable or circular approaches, a lack of access to financial resources and competition with companies implementing linear practices.

With regard to enablers for the EEE sector, consumer and societal awareness (81%) was the category most commonly mentioned. Within this category, companies specifically highlighted that there has been an increasing demand for circular or sustainable products among their customers and clients, while awareness of environmental and sustainability issues has also been on the rise, making people more interested in circular solutions. Policy and regulation was the second most frequently cited category mentioned by over half of the companies (61%). Some key specific enablers within this category were EU and national project funding programmes, the requirements and targets set by the WEEE Directive, different pieces of member state legislation and policies, existing standards on the collection and treatment of WEEE and more generally, the EU's circular economy action plan and the European Green Deal. A closely following category of enablers was company organisation (58%), with internal commitment towards sustainability and internal innovations, such as launching new business models, services or dedicated branding being some specific enablers. Financial and economic factors were furthermore highlighted by 42% of the companies with revenue or cost-saving opportunities from circular approaches emerging as the enabler most commonly cited. Moreover, almost a third (32%) of companies indicated enablers within the supply chain category, with establishing partnerships with other companies and suppliers being the most commonly mentioned enabler.

Interviewed companies from the agri-food sector experienced a variety of impacts due to the Covid-19 crisis. Specifically, more than half (60%) of the interviewed companies reported negative but, in some cases, also positive impacts on the demand for their products and services. The same share of companies (60%) experienced negative effects of a various nature on their organisation and operations. Furthermore, half of the companies reported supply chain interruptions. The majority of the companies in the agri-food sector reported no significant impact on their sustainability strategies due to the Covid-19 pandemic, even though there were some companies that were motivated to rethink and diversify their business activities.

Regarding the identified barriers in the agri-food sector, financial and economic factors along with policy and regulation were the categories of barriers identified by the largest share (70% each) of the case study companies. With regard to the former, major barriers were the higher costs entailed by more sustainable and circular approaches and the difficulties in obtaining the financial support for changing the companies' business model. With regard to the latter, bureaucratic hurdles and specific requirements stemming from member state legislation and EU policies were some identified barriers. Supply chain was the next most commonly mentioned category of barriers (60%) with companies noting challenges in establishing partnerships for their circular approach or model, as well as difficulties in convincing their partners to accept a more circular approach. The same share of interviewed companies pointed out barriers associated with consumer and societal awareness, and specifically noted a lack of interest in circular solutions on the part of consumers and a general societal lack of awareness of sustainability issues.

Policy and regulation was the enabler category selected by the largest share of companies (80%), which is largely attributed to the different forms of EU or national financial support

raised as enablers by interviewed companies. Closely following was the category of consumer and societal awareness (70%) with specific enablers referring to increasing demand for sustainable products by the companies' customers and clients and increasing awareness among consumers of the environmental impacts of food production and eco-labels. Economic-related enablers were raised by several companies (60%) with the revenue and cost saving opportunities arising from applying circular economy approaches within their business being a key enabling factor. Company organisation was the next most commonly mentioned category of enablers (50%). An important enabler within this category was having a firm internal commitment towards the company's circularity and sustainability objectives, as well as motivated employees to support these objectives.

Based on the insights gathered, four key policy recommendations have emerged that are applicable for both the EEE and agri-food sectors:

- R.1 Increase the use of different forms of financial support for circular activities and businesses. Despite the various instruments at EU and national level in place to provide support for such activities, significant barriers to implementing CEBMs persist. Forms of financial support that can be further utilised include tax incentives and increased use of both green public procurement and research and innovation funds.
- R.2 Better align requirements stemming from different pieces of legislation with an impact on circularity. In both the EEE and agri-food sectors it has been observed that requirements stemming from diverse policies, often from different policy domains, frequently may not support circularity goals. These findings indicate that efforts should be made to identify these policy conflicts and trade-offs as well as better align the goals of various pieces of legislation that have an impact on circularity.
- R.3 Improve consumers' understanding of the benefits of circular solutions. Although various companies identify a positive consumer trend towards circular solutions as an important enabler, there is still a segment of consumers that is not interested or does not trust such solutions. This suggests that awareness-raising measures, communicating the environmental benefits of such solutions in easy-to-understand language and how these are calculated, can have a positive impact on demand. Product labels can also serve as a reliable source of information about the environmental impact of products and increase consumers' motivation to choose products produced through more circular processes.
- R.4 Support transparency and traceability across the supply chain through solutions involving all actors. A lack of transparency and traceability regarding products and their associated environmental impacts, components and substances represent a barrier for companies operating a variety of CEBMs. While traceability tools and solutions already exist, all actors would need to be involved – from suppliers of primary materials, to producers and recyclers – for such solutions to roll out. In addition, such solutions would need to be designed in a way that all actors across supply chains could adopt them, including small companies that do not have large capacities or the technical know-how.

Acronyms and abbreviations

Abbreviation	Description
CE	Circular economy
CEBM	Circular economy business model
CO_2	Carbon dioxide
EEE	Electrical and electronic equipment
EPR	Extended producer responsibility
Electronic waste	E-waste
GHG	Greenhouse gas
GPP	Green public procurement
LE	Large enterprise
LED	Light emitting diode
LCA	Lifecycle assessment
POPs	Persistent organic pollutants
R&I	Research & innovation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals Directive (EC 1907/2006)
RoHS	Restriction of Hazardous Substances Directive (2011/65/EU)
SDGs	Sustainable Development Goals
SME	Small and medium-sized enterprise
QR code	Quick response code
WEEE	Waste electrical and electronic equipment

1. Introduction

Within a period of less than ten years, the circular economy has taken centre stage in the European policy debate on the need to transform the European industrial landscape and move towards a more sustainable economic model. It first emerged in high-level EU policy strategies as a concept supporting the objectives of economic growth and competitiveness,[1] while more recently it has been promoted as a crucial element of both the Green Deal, the EU's flagship policy initiative (European Commission, 2019), and the EU's efforts to achieve a green post-pandemic recovery (European Commission, 2020a). The European Commission's commitment to supporting the development of a circular economy has been demonstrated through two circular economy action plans, including a series of concrete actions and legislative initiatives (see European Commission, 2015; 2020b). Various national governments across the EU have also responded to this momentum around the concept and published dedicated circular economy strategies and programmes.[2]

The concept has broad appeal among businesses as shown by numerous accounts in research reports, articles and the media of companies deciding to integrate circularity aspects into their strategies or implementing dedicated circular economy business models[3] (CEBMs) (Velenturf & Purnell, 2021; Rizos et al., 2018). Circular economy strategies have been documented across a variety of sectors, including fast-moving consumer goods, electrical and electronic equipment (EEE), automotive, agri-food, chemicals, material recovery and recycling, textiles, the built environment, utilities and furniture (Elia et al., 2020). Among the specific circular economy practices observed in these sectors are less resource-intensive production techniques (Desing et al., 2020), reduction of waste generation across all stages of a product's lifetime (Merli et al., 2018) and innovations aimed at extending the utilisation of products (Linder & Williander, 2017).

Although the ecosystem of circular economy industrial applications is rapidly evolving across the EU, there is a general consensus among scholars that there is still great untapped potential to increase circularity in many sectors (see, for example, Trigkas et al., 2020; Shahbazi et al., 2016; Kirchherr et al., 2018). This is confirmed by evidence for different sectors indicating unsustainable consumption patterns and high levels of waste generation across the EU: for instance, Stenmarck et al. (2016) have estimated that about 88 million tonnes of food waste are produced across the various stages of food production and consumption, while according to Forti et al. (2020) the generation of electronic waste (e-waste) amounts to 12 million tonnes.

[1] See for example the European Commission's (2014) Work Programme for 2015.

[2] The European Circular Economy Stakeholder Platform provides a record of some of these strategies at the national but also regional level: https://circulareconomy.europa.eu/platform/en/strategies.

[3] Given that the circular economy is an evolving concept with no agreed definitions (De Jesus & Mendonça, 2018; Kirchherr et al., 2018), in the literature there are varying definitions of what constitutes a CEBM. While it is beyond the scope of this report to provide another definition of the CEBM, in our analysis we have taken into account the following circular economy processes identified by Rizos et al. (2017): recycling; efficient use of resources; utilisation of renewable energy sources; remanufacturing, refurbishment and reuse of products and components; product life extension; product as a service; sharing models and a shift in consumption patterns.

Limited progress towards the adoption of circularity practices by businesses has been attributed in the existing literature to a range of different barriers, but empirical evidence about these barriers and also about factors that enable CEBMs is still not widely available (Trigkas et al., 2020; Salmenpera et al., 2021).

CIRC4Life is an EU-funded project[4] that, during its course of 42 months, has developed and demonstrated new CEBMs in two sectors: the EEE and agri-food/farming sectors. The new business models have targeted four different product groups, namely computer tablets, LED lights (for the EEE sector), organic vegetables and meat products (for the agri-food sector). It has involved various activities, including improved production methods, leasing models, take-back systems and digital tools supporting the consumption of sustainable products (Wilson & Lindén, 2021a). The objective of this report is to present evidence on barriers and enablers when implementing the CIRC4Life CEBMs as well as from additional cases of firms putting such models into practice. Drawing on this evidence, the report provides recommendations for further scaling up circular economy practices across the EU.

Going into more detail on the structure of the report, section 2 provides an overview of challenges and circular economy practices in the electrical and electronic equipment and agri-food value chains. Section 3 is devoted to the impacts of Covid-19, as well as the barriers and enablers identified through the evidence collected from the case studies of firms adopting CEBMs. Section 4 concludes with policy insights and recommendations.

[4] For more info: https://www.circ4life.eu/.

2. Circular economy practices in the electrical and electronic equipment and agri-food value chains

2.1 Circular economy business models in the electrical and electronic equipment value chain

Overview and challenges

Boosted by fast-paced innovation and falling costs, world demand for electronic products has dramatically increased over the last few years. On average, the total weight of global EEE consumption increases annually by 2.5 million metric tonnes (Forti et al., 2020). Some estimates put the global consumer electronics market at around US$1.1 trillion, growing at a rate of 6% until 2024, when it will be worth $1.7 trillion.[5] In Europe, the electrical and electronic industry is among the fastest growing and most competitive engineering industries (CSES et al., 2020), and in 2018 it employed over 2.7 million people in 89,000 enterprises, with a turnover of more than €700 billion (Eurostat, 2021a). The other side of the coin of this booming consumption, however, is that due to their short lifecycles, fast obsolescence and few repair options available these products are fuelling a great amount waste, commonly referred to as WEEE or 'e-waste'. WEEE is currently one of the most rapidly growing waste streams in the world, with an annual growth rate of 4%. In 2019, the world generated 53.6 Mt of WEEE, an average of 7.3 kg per capita. In Europe, where WEEE is the fastest growing waste stream, WEEE generation reached 16.2 kg per capita in 2019, the highest level worldwide (Forti et al., 2020).

The waste generated by disposed EEE represent both a threat and an economic opportunity. On the one hand, non-environmentally sound disposal and treatment of this waste stream pose high risks for people and the environment. WEEE contains several hazardous substances, such as heavy metals (e.g. mercury, cadmium and lead), that can harm human health and the environment by entering into human food chains and bio-accumulating in living tissues (Miliute-Plepiene & Youhanan, 2019). In particular, the risks of exposure and harmful health effects are higher in unregulated waste recycling sites, where an improper management of this waste stream can affect workers' health. For instance, workers can be exposed by inhaling toxic fumes and particulate matter, through skin contact with chemicals or by ingesting contaminated food and water (Forti et al., 2020). In addition to this, the production, use and disposal of electronics entails environmental impacts, including those arising from emissions of air pollutants and greenhouse gases (GHGs). For instance, the refrigerants that are found in some temperature exchange equipment, such as fridges and air-conditioners make a contribution to global CO_2 emissions (Forti et al., 2020).[6] It is estimated that the production and

[5] See https://www.globenewswire.com/news-release/2018/06/29/1531798/0/en/Global-Consumer-Electronics-Market-Will-Reach-USD-1-787-Billion-by-2024-Zion-Market-Research.html.

[6] According to Forti et al. (2020), in 2019, end-of-life fridges and air-conditioners that did not reach recycling facilities meeting high environmental standards were responsible for about 98 Mt of CO_2eq, equivalent to around 0.3% of global energy-related emissions.

use of electronic devices, including PCs, laptops, monitors, smartphones and tablets will have a 14% share of global emissions by 2040 (PACE & WEF, 2019).

Meanwhile, the improper handling of WEEE results in a significant loss of scarce and valuable raw materials. In addition to metals (e.g. aluminium, iron and tin) and plastics, which are very important in terms of weight, electronics also contain several precious metals (e.g. gold, silver, copper and nickel), rare earth elements and critical raw materials[7] such as cobalt, indium and palladium (Miliute-Plepiene & Youhanan, 2019). Recovering and recycling these materials can present economic opportunities: in 2019, the value of raw materials in the global WEEE was equal to approximately US$57 billion, with Europe alone accounting for US$12.9 billion (Forti et al., 2020).

Despite the health and environmental concerns related to the disposal of WEEE, the value of raw materials in WEEE and the growing worries about the supply of virgin raw materials for electronics, recycling rates of this waste stream are still low. In 2019, only 17.4% of the WEEE generated was recycled globally (Forti et al., 2020). In Europe, the continent with the highest recycling rate, roughly 40% of WEEE is currently collected and recycled (Eurostat, 2021b).[8] In high-income countries that are responsible for the vast majority of WEEE generation,[9] around 8% of the non-recycled WEEE is landfilled or incinerated, between 7 to 20% is shipped as second-hand products to low- or middle-income countries and the rest is, for the most part, mixed with other waste streams (Forti et al., 2020).

These numbers highlight the need to substantially increase WEEE collection and recycling rates, especially in view of the rapid growth of this waste stream in the near future.[10] Moreover, due to issues related to environmental pressure from primary mining, market price fluctuations and scarcity and supply risks for certain materials, it has become necessary to improve the mining of secondary resources in WEEE and reduce the pressure on virgin raw materials (Forti et al., 2020). CEBMs for electronics can maximise the amount of WEEE that moves back into the production of new electronic products and components, thereby limiting the amount of unrecoverable waste generated by the system and providing significant economic benefits, for both consumers and producers (PACE & WEF, 2019). As described below, the benefits of CEBMs go beyond collecting WEEE and recovering materials from end-of-life products, as they can also extend the lifetime of devices and components.

[7] These materials are defined as critical due to the increasing mismatch between supply and demand, high price volatility or politically induced limitations of supply (Bakas et al., 2016).

[8] According to Eurostat (2021c), 7.13 out of 16.2 kg of waste generated per capita is currently recycled in EU.

[9] Europe and US alone contribute to almost one-half of the total waste generated annually (Gnanasagaran, 2018).

[10] Parajuly et al. (2019) have put forward several scenarios for the future growth of WEEE, depending on the degree of implementation of circular business practices and policy instruments. Assuming that the quantity of WEEE will inevitably increase as a result of a growth in GDP, in the business-as-usual ("Linear Growth") scenario, where a standard growth-based agenda remains the priority and conventional business models remains dominant, the annual global amount of WEEE generated is expected to reach 75 Mt by 2030 and 111 Mt by 2050.

Circular economy business models for the electrical and electronic equipment sector

A variety of circularity approaches and models can be implemented in the EEE sector including production and design of circular products, repair, refurbishment, reuse, product-as-service and leasing models, collection and recycling. The sections below provide a short description of these approaches.

Design and production of electronic products

The design of electronic products is the first crucial phase where circularity principles can be applied. For example, products can be designed with the objective to improve their durability and repairability and thereby extend their lifetime. Durability can be enhanced through proper selection of materials and high-quality components that can guarantee a longer lasting use of products.[11] Repairability, on the other hand, can be facilitated by simplifying the way different parts of products are assembled or attached to each other and by promoting modular designs (EEA, 2020). Modularity as a design approach holds potential to improve both durability and repairability of electronic devices, as it enables the easy repair, upgrade or substitution of single defect components of the product, avoiding its full replacement (Schischke et al., 2019). Within CIRC4Life, an example of application of modular designs has been given by Kosnic Lighting, an English lighting manufacturing company that has managed to extend the lifetime of its products by developing a fully modular LED lamp (NTU, 2020).

Besides improving durability and repairability, during the design phase potential social and health concerns related to electronic products can be addressed. First, the design can focus on keeping hazardous substances as much as possible out of products, in order to limit the potential harmful effects discussed above. Moreover, as demonstrated in CIRC4Life, the design could be conducted through a co-creation process in order to integrate stakeholder feedback in the development of new products or services. This has been the case, for instance, of ONA, a lamp manufacturing company that as part of a CIRC4Life demonstration has collected consumer opinions through surveys, reviews and workshops in order develop products that could better fit their preferences and needs (Kosnic & ONA, 2021).

As regards the production phase, circularity of electronic products can be enhanced by configuring the production process in such a way as to limit, to the extent possible, the amount of materials and energy used and reduce waste generation. For instance, greater resource efficiency in the production process can be achieved by decreasing the material input required by each product (i.e. reduce the material intensity), improving energy efficiency and curtailing the losses of material that occur at different stages of the process (Lacko et al., 2021).

[11] One example is the design of LED light bulbs, which are more durable and energy-efficient than conventional light bulbs (Rizos et al., 2017).

Reuse, repair, refurbishment and remanufacturing

Along with the prioritisation of ecodesign, companies could further increase products' lifetime by promoting their reuse. The reuse of electronic products – that is, their repurposing using a range of product life extension strategies such as repair, refurbishment and/or remanufacturing (Bovea et al., 2016), is considered to be an option offering high environmental and socioeconomic benefits (Gurunathan et al., 2021). However, repair, refurbishment and remanufacturing options for electronics are still limited, and the result is that devices that could be reused are often discarded. This might be due to complex designs, software restrictions or simply because the repair costs are high compared with the purchase of new devices (EEA, 2020; PACE, 2021a). Moreover, users' perception of used devices still represents an obstacle for the uptake of this solution. Among the main reasons deterring consumers from buying second-hand products are the simple preference for new models over old ones, the fear of inferior performance or lower quality of used devices (and the consequential lack of trust in the second-hand market) and the idea that new products ensure better value for money (Cerulli-Harms et al., 2018). Furthermore, data safety concerns often lead people to store their devices in their homes indefinitely[12] (Ellen MacArthur Foundation, 2018).

In view of these obstacles, the reuse rate of EEE can be significantly increased through repair and refurbishment services extending the lifetime of electronic devices. In addition, producers of electronics could offer buy-back or return options to customers for old products, incentivising them financially and by guaranteeing the proper management of their data (PACE & WEF, 2019). Many of the data safety issues related to used products, in fact, can be addressed through guarantees and transparency in the second-hand market, which offer assurance and confidence for customers (Ellen MacArthur Foundation, 2018). In addition, the use of communication strategies has proved to be effective in raising awareness and changing people's perception of used electronics (Miliute-Plepiene & Youhanan, 2019).

Product-as-service and leasing models

The use phase of electronic products is already seeing rather big changes due to two interlinked drivers: the process of dematerialisation and the shift from a culture of owning products towards one focused on their use (EEA, 2020). On the one hand, the rapid changes in technology, such as cloud computing and the internet of things, hold great potential to dematerialise the electronics industry, thus freeing up new resources (PACE & WEF, 2019).[13] Furthermore, by transferring the workload of devices from the actual hardware and to remote data centres, hardware capabilities become less important than connectivity and services, and

[12] A study in Norway calculated that approximately 10 million of mobile phones are kept in households without being used (Miliute-Plepiene & Youhanan, 2019). At the EU level, Rizos et at. (2019) estimated that close to 700 million mobile phones remain unused in households which shows that there is a large untapped potential for collecting this stock of devices for circular processes.

[13] One potential side effects of an expansion of the internet of things, however, is the increase in emissions due to the higher energy consumption of the network of devices.

this can provide benefits in terms of increasing product use cycles (Ellen MacArthur Foundation, 2018; Demestichas & Daskalakis, 2020).

On the other hand, new ownership models focused on the provision of services rather than ownership of physical products are becoming more widespread. Examples are leasing and rental models, where on the basis of contracts customers gain continuous access to electronic devices, which at their end of life are returned to the service provider.[14] A second type of model is given by product-as-service systems, where service providers retain the ownership of the electronic product throughout its use by the consumer, who only purchases the service itself. Finally, one other related model is the so-called sharing economy, which entails the provision sharing platforms where the products are shared among many users (EEA, 2020). These business models can be effective in reducing WEEE, as they incentivise service providers to make sure that resources are used optimally over a device's lifecycle, including when it is time for products to be reused by another customer or disposed of and recycled, to choose the most durable products available and to keep their value for as long as possible by repairing and remanufacturing them when necessary. Moreover, by shifting from a one-off transaction to an ongoing service (the so-called subscription economy) these business models can build a much closer and stronger customer relationship (PACE & WEF, 2019).

Collection and recycling

As explained above, the end-of-life phase of EEE is characterised by very low collection and recycling rates. In terms of collection, in the EU only 40% of WEEE is collected and enters official treatment, leaving large amounts untreated (Eurostat, 2021b). Among the main causes already mentioned above are data safety concerns, which may lead consumers to store indefinitely their old devices instead of disposing of them (Rizos et al., 2019; Ellen MacArthur Foundation, 2018), a lack of awareness on how to handle and where to dispose of electronic waste (PACE & WEF, 2019) and a lack of a fully developed WEEE management infrastructure (Forti et al., 2020). As regards recycling, the key challenge in raising recycling rates lies in the high complexity of electrical products, which include various different substances and elements. This can have an impact on the cost-effectiveness of recycling and recovering processes (Forti et al., 2020). In the EU, recycling of WEEE mainly focuses on the recovery of base metals such as aluminium, copper, gold, silver and steel, which are easier to extract due their high concentration level in electronic devices. The recycling efficiency rate of these metals is in fact above 50% and can rely on the availability of well-established industrial processes. At the same time, the recovery of other metals such as gallium, germanium, indium and rare earths is still challenging because they are used in very limited fractions in EEE, and the lack of proper recycling infrastructure results in recycling rates below 1% (EEA, 2021).

In view of the above challenges, a circular approach for the end of life of electronic products would require, first, to improving the collection systems of WEEE in terms of both accessibility

[14] In the context of CIRC4Life, for instance, a service leasing model was implemented by Kosnic Lighting, who now offers its products for leasing periods of 3 to 5 years, under the payment of a monthly subscription (Kosnic & ONA, 2021).

and the quality of collected waste. For this purpose, the CIRC4Life project has developed a new collection system based on 'intelligent' bins specifically designed for electronic waste and conceived a reward system to incentivise consumers to dispose of their electronic waste (Wilson & Lindén, 2021a).[15] Second, a significant upgrade of the recycling sector would be needed, in order to expand the range and the quantity of materials that can be recovered (PACE & WEF, 2019). By investing in new recycling technologies, companies would in fact maximise the amount of valuable WEEE that could move back into the production of new electronic products and components, thereby gaining economic benefits (Forti et al., 2020).

2.2 Circular economy business models in the agri-food value chain

Overview and challenges

Production of food globally has been associated with significant environmental impacts such as CO_2 emissions, increased pressure on land use, water and energy consumption (FAO et al., 2020). In more detail, the global food system[16] is among the highest contributors to climate change, releasing from 10.8 to 19.1 of $GtCO_2eq$ per year, equivalent to 21-37% of total net anthropogenic GHG emissions (IPCC, 2019). In the EU, 30% of GHG emissions comes from the food system, with the contribution of single countries ranging from 25 to 42% (Crippa et al., 2021). On top of this, food systems, and especially intensive agricultural practices, are responsible for 32% of global terrestrial acidification, 78% of global eutrophication (Poore & Nemecek, 2018) and 80% of global deforestation (FAO, 2016). Environmental impacts are also associated with the high resource intensity of food production systems: for instance, around 37% of the global land (FAOSTAT 2021) and two thirds of global freshwater resources (Poore & Nemecek, 2018) are devoted to agriculture. What is more, the food production process is becoming increasingly energy intensive, with a third of food systems' emissions being associated with energy consumption (Crippa et al., 2021).

The environmental impacts of food production are further amplified by high levels of losses across supply chains; according to UNEP (2021), nearly 17% of all food produced for human consumption in the world is wasted or lost along food supply chains, corresponding to about 931 million tons in 2019. In Europe, it has been estimated that around 20% of overall food production is lost or wasted (Stenmarck et al., 2016), while per capita food waste is among the highest in the world, with 280 kg/year[17] (FAO, 2018). Besides being an important economic loss,[18] food lost and wasted translates into a significant waste of natural resources: estimates

[15] This system was demonstrated in Spain via the CIRC4Life project partner Indumetal Recycling, a Spanish company specialised in the integral management of WEEE.

[16] According to the IPCC, the "global food system" entails "all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socioeconomic and environmental outcomes at the global level" (IPCC, 2019, p.10).

[17] Europe's levels are second only to North America, where per capita food waste generation is at 300 kg/year.

[18] In 2012, the market value associated with food loss and waste was estimated at US$936 billion (FAO, 2015).

indicate that it accounts for roughly 30% of the world's agricultural land area, 20% of freshwater consumption and 40% of the energy consumption of the food supply chain (FAO, 2011; FAO, 2013). As such, food waste represents a threat for both the sustainability and security of the whole food system, especially at a time when chronic hunger, food insecurity and malnutrition remain severe problems in many parts of the world[19] (FAO, 2018).

A sustainable production and consumption food system has been defined as a food system that "delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (Nguyen, 2018, p.1). The application of circular economy principles to the agri-food system can contribute to developing a food system where: food is produced in ways that regenerate nature; food is not lost or wasted and commonly wasted resources are used productively (PACE, 2021b). As such, a more circular agri-food system can both unlock economic opportunities and bring significant societal and environmental benefits. The Ellen MacArthur Foundation (2019), for instance, estimates that achieving a fully circular food system in cities would generate economic benefits worth of US$2.7 trillion per year by 2050, besides saving 4.3 billion tonnes of CO2 emissions and 39.3 billion cubic metres of freshwater resources. Additional benefits would include health costs saved from avoided pesticides-related illnesses, the diffusion of healthier diets and lower level of water contamination and waste pollution.

Circular economy business models for the agri-food sector

Among the key processes that can be adopted by businesses in the agri-food sector and contribute to increased circularity of resources are production and design, collection and recycling. These processes are described below.

Design and production

The design phase of food products mainly relates to the choice of the ingredients and to products' configurations. Designing food products based on circular economy principles, therefore, entails selecting ingredients and configurations that can guarantee a low environmental impact and high resource efficiency. One example of application of circular designs, for instance, is given by an American company called Apeel, which developed plant-derived coatings that keep fruits and vegetables fresh up to three times longer than they would normally last, minimising food waste across the value chain (Vieira & Shannon, 2020). In terms of ingredients selection, Ellen MacArthur Foundation (2021) identifies four specific, circular design opportunities that can be applied by food companies: selecting ingredients with lower environmental impact, for instance by switching from animal to plant-based ingredients; diversifying the ingredients, in order to promote genetic diversity and boost food supply resilience; upcycling the ingredients, that is using ingredients that would normally be discarded; and using regeneratively grown ingredients, meaning ingredients that can lead to ''healthy and

[19] In 2019, around 690 million people (approximately 8.9% of world population) suffered from undernourishment, and close to 750 million people faced severe food insecurity (FAO et al., 2020).

stable soils, improved local biodiversity, and improved air and water quality'' (Ellen MacArthur Foundation, 2021 p. 48). In the framework of CIRC4Life, for example, a company that has successfully implemented a more circular selection of ingredients as part of its demonstration activities is ALIA. By replacing soybean and other environmentally damaging sources of protein with cereals and other by-products from local industries for feed production the company has managed to improve the sustainability of its meat products (Wilson & Lindén, 2021b).

Collection and recycling

The collection and recycling of commonly wasted resources represents another opportunity to increase the circularity of the food system. Recycling nutrients contained in food waste can in fact reduce the need for new resources and minimise nutrient losses (UNEP, 2016). Today, less than 2% of the valuable nutrients in food by-products and waste generated in cities are recycled back to agriculture (Ellen MacArthur Foundation, 2019) but recently there has been an increasing interest in the development of waste processing technologies and approaches aimed at food waste reuse and recycling. Among the potential applications, food waste and by-products can be used (i) as fertilisers, reducing or substituting the need for synthetic alternatives (UNEP, 2019); (ii) as a source of textile or bioplastic fibres, reducing resource use impacts associated with textiles value chains (Esteban & Ladero, 2018); or (iii) for animal feed production, either directly or through insect-based bioconversion of food waste (Fowles & Nansen, 2020). An example from CIRC4Life in terms of food recycling is given by Scilly Organics, an organic farm that has used organic waste to produce compost and increase soil fertility (ALIA, 2019).

3. Barriers and enablers

3.1 Methodology

This sub-section describes the methodology adopted for identifying specific barriers and enablers faced by companies implementing CEBMs in the EEE and agri-food value sectors. The study adopts a qualitative approach based on thorough analysis of case studies (Voss, et al., 2002) with the objective of collecting rich empirical evidence on barriers and enablers. Each case study represents a company that implements a CEBM or is offering a circularity solution that fits in one or more of the categories identified in sections 2.1 and 2.2. As explained below, multiple case studies were selected for each sector with the aim of covering the different CEBM models implemented in the CIRC4Life project but also capturing the variety of CEBMs and circularity approaches observed in the EEE and agri-food value sectors.[20]

3.1.1 Case study selection and sample

In order to build a sample of case study companies we employed the method of 'judgement sampling' (see Patton, 2002) and aimed at selecting information-rich cases that would help us acquire in-depth information for our analysis. The identification and selection of case studies took place in two phases. During the first phase the companies that have implemented CEBMs and been part of the CIRC4Life EU-funded project were selected and provided the backbone of the analysis for both the EEE and agri-food value sectors. CIRC4Life features 17 partners across the EU, of which six are companies implementing CEBMs or solutions for circularity (four in the EEE value chain and two in the agri-food). These include the design and production of new products (EEE and agri-food sectors), reuse, repair and refurbishment (EEE sector), leasing and product-as-service models (EEE sector), and collection and recycling (EEE and agri-food sectors). All companies involved in the project were selected and interviewed to provide their perspectives from applying circularity approaches in the project (see more details in section 3.1.2 below). In a second phase the research team complemented the samples for both sectors with further company cases to collect additional empirical findings from companies implementing CEBMs similar to the ones developed in the project and to increase the robustness of the results. These were identified through desk-based research, use of the network of CIRC4Life companies involved in the various activities[21] of the project as well as through asking the representatives from case study firms to recommend other companies putting CEBMs into practice in their sector.[22]

[20] Other authors that have applied multi-case study analysis to investigate barriers and enablers to implementing circularity approaches include Rizos et al. (2016); Tura et al. (2019) and Vermut et al. (2019).

[21] Such activities included interactive 'living labs' that were used to test circularity solutions developed in the project with a variety of stakeholders such as scientists, companies, public authorities, civil society and policymakers (see: Purola et al., 2019).

[22] In the literature the method of expanding the sample through suggestions by the selected case study representatives is often referred as 'snowball sampling method' (see, for example, Saunders et al., 2009).

As shown in Table 1 and Table 2, we selected 41 companies for the analysis, of which 31 operate in the EEE sector and 10 in the agri-food sector. The sample for the EEE sector was larger in order to sufficiently cover all the diverse circularity approaches for electronics carried out in the CIRC4Life project. In addition, to reflect the variety of challenges and opportunities experienced by different firms, an effort was made to interview both small and medium-sized enterprises (SMEs) and large enterprises (LEs), as well as to cover different geographical regions in Europe.[23] A general overview for the EEE and agri-food sectors can be seen below in Figure 1.

Figure 1. Number of firms included in the sample (by region and size)

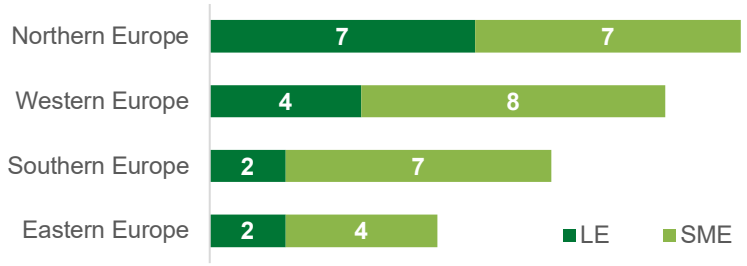


Table 1 below provides information about the 31 firms included in the analysis for the EEE sector. The sample included both SMEs and larger companies, with a slight majority of the former (58%). Companies located in northern and western Europe represented around 74% of the sample, while companies from southern and eastern Europe about 26%. The majority of companies interviewed in the EEE sector (71%) have integrated several circular activities into their business models, while 29% have only one. Regarding the representativeness in the sample of different circular processes, 15 companies were involved in collection or sorting activities, 14 in refurbishment or remanufacturing, 12 in circular design and production, 11 in reuse, 8 in repair, 7 in product-as-service or leasing models and 6 in recycling.

Table 1. Overview of case study EEE firms

Firm	Region	Size	CE activities
1	Northern Europe	LE	Multiple
2	Northern Europe	SME	Multiple
3	Western Europe	LE	Multiple
4	Northern Europe	SME	Multiple
5	Western Europe	LE	Multiple
6	Southern Europe	LE	Multiple
7	Northern Europe	LE	Single
8	Western Europe	SME	Multiple
9	Northern Europe	SME	Multiple
10	Northern Europe	LE	Single

[23] Note that UN area codes were used for classifying the regions, see https://unstats.un.org/unsd/methodology/m49/.

11	Western Europe	LE	Multiple
12	Northern Europe	SME	Multiple
13	Northern Europe	SME	Multiple
14	Western Europe	SME	Single
15	Northern Europe	SME	Multiple
16	Western Europe	SME	Single
17	Western Europe	SME	Multiple
18	Northern Europe	LE	Multiple
19	Eastern Europe	LE	Multiple
20	Southern Europe	SME	Multiple
21	Southern Europe	SME	Single
22	Western Europe	LE	Single
23	Southern Europe	SME	Single
24	Northern Europe	LE	Multiple
25	Southern Europe	SME	Multiple
26	Southern Europe	SME	Single
27	Northern Europe	LE	Multiple
28	Southern Europe	SME	Multiple
29	Western Europe	SME	Multiple
30	Northern Europe	LE	Multiple
31	Western Europe	SME	Single

Among the 10 companies included in the analysis for the agri-food sector, 7 qualify as SMEs while 3 are large companies (see Table 2). Contrary to the EEE sector, the majority (70%) of sampled agri-food companies are located in southern and eastern Europe, while around 30% are in northern and western Europe. The sample was also divided in terms of whether companies implement one or multiple circular approaches. The following processes were represented in the sample: 9 companies were active in circular design and production, 7 in recycling and 4 in collection.

Table 2. Overview of agri-food case study firms

Firm	Region	Size	CE activities
1	Northern Europe	SME	Multiple
2	Southern Europe	LE	Multiple
3	Eastern Europe	SME	Multiple
4	Western Europe	SME	Multiple
5	Southern Europe	SME	Multiple
6	Eastern Europe	SME	Single
7	Eastern Europe	LE	Single
8	Eastern Europe	SME	Single
9	Western Europe	LE	Single
10	Eastern Europe	SME	Single

However, due to an absence of responses from some firms on certain topics, the sample sizes for all aspects analysed are not always equivalent to the full sample size for each sector. For example, while all 31 interviewed EEE companies provided input on policy suggestions and gaps, only 8 out of the 10 interviewed companies in the agri-food companies did.

3.1.2 Data collection and analysis

For the collection of data on barriers and enablers from each company, the research team utilised semi-structured interviews, which allowed in-depth discussions with company experts about the barriers and enablers they face in the implementation of their circular business model. In order to provide a basis for the discussion, the team prepared and sent to participants in advance of the interview a questionnaire. The questionnaire first provided an introduction covering the general objectives of the assessment conducted in the context of the CIRC4Life project and then included four parts. The first part invited participants to explain the circularity elements in their business approach. This helped the research team to develop a good understanding of whether the company carries out one or multiple circular activities as well as to categorise them. Then there was a section where participants could indicate whether the Covid-19 crisis has affected their circularity activities and their overall business strategy. The third part was devoted to the barriers and enablers encountered by the sampled companies. Based on a literature review,[24] the team developed a list of categories of general barriers and enablers in order to help collect and later analyse the data in a structured way. The general categories of both barriers and enablers that were featured in the questionnaire were the following: 'policy and regulation', 'economic/finance factors', 'supply chain', 'technology', 'consumer and societal awareness', 'company organisation' and 'others'. The discussion based on this part of the questionnaire followed an open format where participants could freely provide their perspectives since there was no limitation to strictly follow the categories in the questionnaire. In addition, there was no limitation on the different barriers and enablers that each company could raise, with many of them identifying multiple barriers in assorted categories. The fourth part of the questionnaire first invited participants to provide their general views about the effectiveness of the current EU policy framework and then describe specific gaps that should be addressed by policy action. In addition, participants received a consent form that described the study methodology and clarified that all collected data will be presented in the report in an anonymous way.

Interviews for the EEE sector were organised between April and October 2020, while for the food sector they took place a few months later from March to June 2021. There was one interview for each case study, thus 31 interviews for the EEE sector and 10 for the agri-food sector, which lasted between 45 minutes and 1.5 hours. In several interviews, and especially for the EEE sector, the company was represented by more than one expert; 37 different experts were present in the interviews for the EEE sector and 11 for the agri-food sector. The majority of interviewed experts held senior positions (see Table 3 below).

[24] To develop the list of barriers and enablers the team draw on previous work by Rizos et al. (2016) and Rizos et al. (2015) as well as other authors such as Shahbazi et al. (2016), Kirchherr et al. (2018), De Jesus et al. (2018) and Vermunt et al. (2019).

Table 3. Positions of interviewed experts

Sector	EEE sector	Agri-food sector
Position*	Director/Head of Department (16); Manager/Senior Expert (11); CEO/Owner (5); Consultant/Expert (5)	CEO/Owner (6); Manager/Senior Expert (2); Director/Head of Department (2); Consultant/Expert (1)

* Numbers in brackets indicate how many interviewed experts held each position. Note that interviewed CEOs/owners came from SMEs.

Following each interview, the research team prepared a detailed interview write-up[25] and grouped the various barriers and enablers according to the identified general categories described above. The next step in the process involved coding the specific barriers, enablers and Covid-19 impacts in order to group the collected data. This allowed the team to determine the share of companies that experienced different impacts from the Covid-19 crisis, barriers, enablers and policy gaps, and to draw common patterns across the various case studies.

3.2 Results

This subsection presents the results of the analysis of data collected from interviewed companies. There are two parts for each of the two value chains covered by the study. The first part is devoted to the impacts, from both an operational and strategic point of view, of the Covid-19 crisis and lockdowns experienced by the sampled companies. Then the second part presents the key barriers and enablers encountered by the companies in implementing their CEBMs.

3.2.1 Electrical and electronic equipment value chain

3.2.1.1 Covid-19 impacts

Impacts from the Covid-19 pandemic have been felt across the globe. Beyond impacts on societies and people, businesses have also had to adapt to health and safety measures. This was indeed observed in our sample for the EEE sector, with almost 70% of the companies[26] reporting an impact on demand, either positive or negative (see Figure 2 below). Over half of the companies also experienced an impact on their supply chain as well as on organisation and operations due to the pandemic.

[25] Given that at the time of the interviews for the EEE sector the interviewed companies involved in the CIRC4Life project were still in the phase of developing some of the circularity aspects in their business model, write-ups for these companies were further complemented in the period May-June 2021 with additional information retrieved from the companies.

[26] As described in footnote 27 below, this figure refers to the firms that provided answer to the questions on the Covid-19 pandemic.

Figure 2. EEE firms mentioning Covid-19 impacts (% of firms), N=30[27]

Notably, demand impacts were mainly positive, with almost half of the interviewed companies seeing an increase in demand due to the pandemic (see Table 4). Several of the interviewees remarked that the change to teleworking and staying at home had resulted in more companies and people looking to buy electronic equipment, such as laptops, headphones and smartphones. This had a positive impact on demand for companies involved in reuse, repair and refurbishment activities. Among them, some highlighted that the lower price of their products may have been increasingly attractive due to increased financial uncertainty among some customers. Public stimulus also contributed to increased demand for at least one company. On the other hand, eight companies (27%) experienced a decrease in demand. The reasons for this varied among companies, which, located in different countries, experienced disparate situations and restrictions. Especially those relying on physical retailers to sell their products faced a significant drop in demand as shops closed, which nonetheless largely returned to normal after reopening. Within the CIRC4Life project, one company noted a direct drop in demand for a short period, explained by financial uncertainty tied to the pandemic among their corporate customers. However, two of the companies that experienced a decrease in demand also experienced an increase. For these companies, this reflected changes in demand for alternative product lines. For example, sales of desktop computers decreased, while sales of laptops increased.

Supply interruptions were experienced by almost half (47%) of the companies. Two main causes were generally mentioned for this: the closure of factories and reduced supply of used devices. The former affected both manufacturing and access to spare parts for repairs. This also affected the companies in CIRC4Life, which experienced manufacturing delays because of periodic factory closures due to Covid-19 restrictions. Still, as restrictions eased, the factories in their supply chain were largely able to resume their operations. Several of the companies also found ways to mitigate the issue by diversifying their supply chains and cooperating with companies that were not facing the same restrictions at the same time. With regard to the reduced supply of used devices, this was a particular problem faced by companies offering refurbishment and remanufacturing services. According to the companies, reasons for this could have been that it became more difficult for customers to deliver their used devices or that it became less of a

[27] Note that one out of the 31 sampled companies did not provide input to this question, and as such the percentage is calculated as a share of the total number of companies that answered the question which in this case was 30. In addition, multiple categories may be counted for each firm, thus the bars are independent from each other and may not add up to 100%.

priority for them to do so. This was also raised by one company involved in CIRC4Life, which faced an interruption in the supply of used devices because of collection sites closures due to the pandemic. Yet, during the project implementation collection was still made possible from schools, which allowed for testing the circular business model (Wilson & Lindén, 2021a). Meanwhile, and within the overall sample, three companies involved in recycling, refurbishment and repairs experienced an increase in collected devices. One of the theories provided was that people and companies may have had more time to go through their old devices and drop them off or discard them in a proper manner.

Almost a third (30%) of the companies had negative effects on their operations as a result of the pandemic. The risk of getting Covid-19 and associated measures to limit the number of people in offices or factory buildings were the main reasons for this. Having to close down or limit operations for certain periods was also noted by some. Within CIRC4Life, restrictions on physical distance posed constraints in terms of reaching and interacting with customers, as well as showcasing product prototypes. This posed some challenges to the introduction of new circular business models and new more circular products. It also affected demand to some extent, as it became more difficult to find and engage with new customers. Increased digitalisation of operations and a focus on online retail was another impact of the pandemic, which was reported by seven of the companies interviewed. This applied to internal functions being moved online where possible through telework, as well as to an increased focus on engaging with customers directly online. Both aspects were expected to continue to some degree post-pandemic.

In general, the uncertainty associated with how long the pandemic and restrictions would last, especially in the first phase of the pandemic, was another factor. This made it difficult to make choices on how to adapt at an early stage of the pandemic.

Table 4. EEE firms mentioning Covid-19 impacts (% of firms (number))

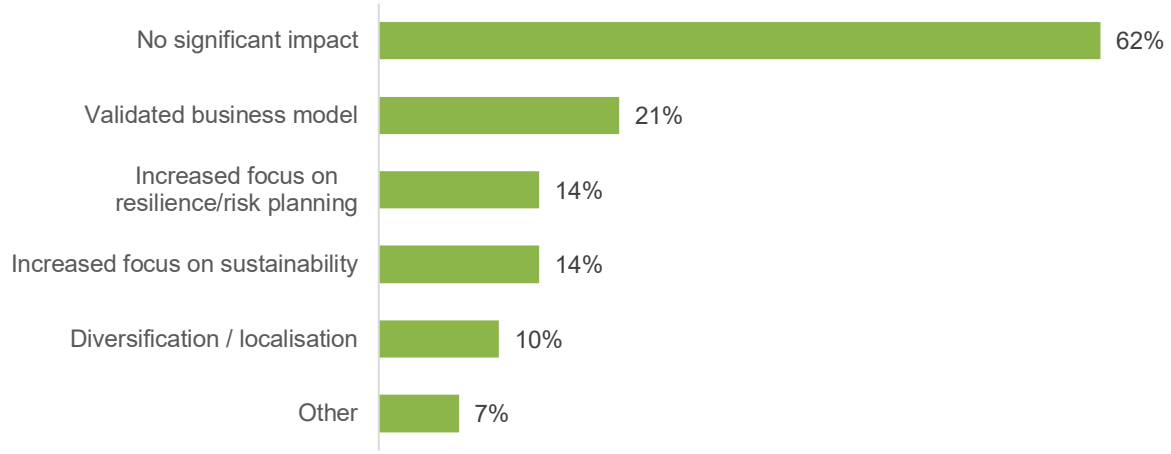
Category	Impact	Firms	
Demand	Increased demand	47%	(14)
	Decreased demand	27%	(8)
Organisation/operations	Negative effects on operations	30%	(9)
	Increased online operations / digitalisation	23%	(7)
	Changes to logistics/transportation	10%	(3)
Supply chain	Supply interruptions	47%	(14)
	Improved supply	10%	(3)

The majority of the companies in the EEE sector that provided input (62%) did not change their sustainability strategy or the way they integrate circular approaches in their business model as a result of the pandemic, as can be seen in Figure 3. This was also the case for all but one of the CIRC4Life companies in the EEE value chain. For many of the companies interviewed, the circular economy is a core part of their business model, and thus not subject to change due to Covid-19. Indeed, one out of five (21%) specifically noted that the crisis provided an additional

validation of the added value of their business model. In particular, some of the interviewees felt that the pandemic had illustrated the need for circular and sustainable solutions. The need for electronic products was also highlighted, as it can facilitate telework and online communication and learning.

Nevertheless, several companies were also motivated to change their strategies because of the pandemic. Specifically, 14% took the opportunity to increase their focus on sustainability (see Figure 3). While this was often expressed as a general sentiment, one interviewee remarked that the pandemic had illustrated the need to adapt to future crises and that greater emphasis on circular approaches could help prepare the company for future crises. Another found that the pandemic had allowed them to fast-track internal sustainability approaches. Moreover, 14% of the companies pointed to an increased focus on resilience and risk planning. This often involved looking at the supply chain and addressing risks by developing risk plans, as well as re-evaluating the profitability of certain areas of their business in light of increased uncertainty. In a similar vein, 10% of the companies specifically aimed to diversify their supply chains and concentrate on more local markets to reduce risks. Within CIRC4Life, one company was inspired to re-evaluate its processes and interactions with customers, and as a consequence decided to invest in demonstration or showcase spaces.

Figure 3. EEE firms mentioning strategy changes from Covid-19 (% of firms), N=28[28]

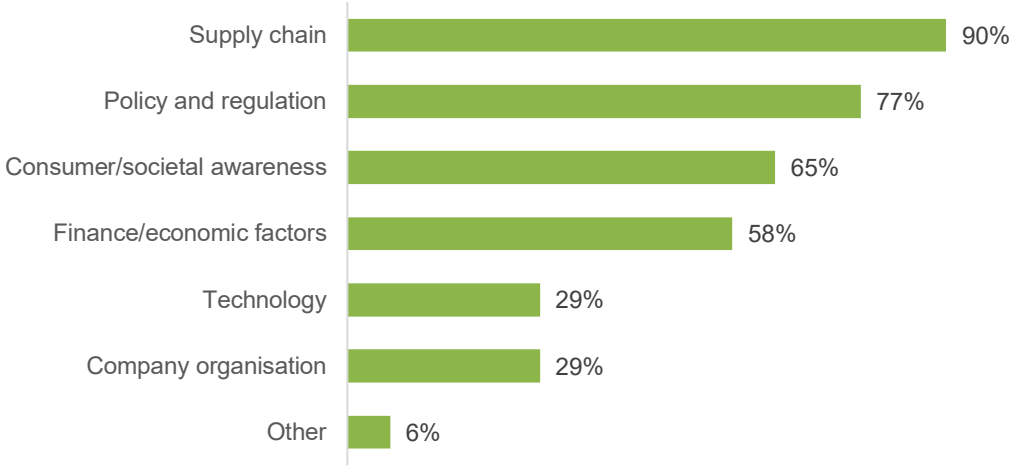


3.2.1.2 Barriers

Supply chain barriers were experienced by an overwhelming majority (90%) of the companies interviewed, as can be seen in Figure 4. Closely following was policy and regulations, which more than 75% of the companies found to engender some form of challenge to their circular activities. More than half of the companies also mentioned consumer and societal awareness (65%) and finance or economic factors (58%) as barriers. The least mentioned barrier categories were technology and company organisation, followed by other factors.

[28] Note that not all firms provided input to this question, and as such the percentage is calculated as a share of the total that answered the question. In addition, multiple categories may be counted for each firm, thus the bars are independent from each other and may not add up to 100%.

Figure 4. EEE firms mentioning the barrier category (% of firms), N=31[29]



Within the supply chain category, hard-to-access products, components or materials was the most common barrier faced by the EEE companies interviewed (see Table 5). For those engaged in refurbishment, remanufacturing or repair services, this often related to struggles to attain used devices or the right spare parts. Consumers holding onto their devices[30] without disposing of them, as well as challenges to attain a wide variety of models being demanded were barriers particularly related to smaller electronic equipment. Within CIRC4Life, one company also noted that the quality of what is collected can also be an issue: if parts of a device are broken during collection, it can be difficult to refurbish. These problems were also experienced by three companies involved in the production of new equipment. Among them, one company that uses parts from old equipment in the production of new equipment reported problems in ensuring access to the relevant equipment. Another company experienced a barrier in retaining access to components over time in order to support use of their products for a longer period, while another one reported lack of access to recycled materials.

Closed or restricted company loops was a barrier that appeared for around one out of five of the EEE companies interviewed. This blockage was generally brought up by companies involved in refurbishment and repair services, which mentioned that getting certified by the manufacturer could be complicated. This was connected to the difficulty of accessing certified spare parts and the reported higher costs of these compared with non-brand alternatives. According to three of the companies, using non-certified parts could lead to liability issues. One company also noted that a lack of circular or easy-to-repair designs made their jobs more challenging. Another noted that registration of serial numbers in the cloud hinders the

[29] Note that multiple categories may be counted for each firm, thus the bars are independent from each other and may not add up to 100%.

[30] The mobile phone devices remaining unused in households are often described as 'hibernating' devices, see Rizos et al. (2019).

movement of used devices between markets, as the devices may be locked to the market in which they were first sold.

Six companies also found a lack of transparency in their supply chain to be problematic. This was mentioned especially by companies involved in collection, recycling and production. With regard to recycling, not knowing the exact content of each component creates difficulties, as some may make them unsuitable for recycling. While certain products do have labels, these are sometimes of insufficient quality or readability. For those involved in production, lack of transparency for materials was the main issue. Tracing the materials across the supply chain can be hard, especially for smaller companies. Within CIRC4Life, lack of transparency in the supply chain also created obstacles. In line with the overall sample results, within the project not knowing the exact materials and substances in products and components hampered recycling and refurbishment/reuse. Estimating the EEE products' impacts without having information from the supply chain was another dilemma experienced in the project.

Lack of a circular mentality and compliance with circular approaches was a barrier faced by five of the companies interviewed. For some, this related to difficulties in convincing partners to adopt circular methods or activities. In a couple of cases the companies offered training for their partners, while another chose to monitor compliance. Two other companies found that they had little influence on the lack of circular approaches taken by supply chain partners. For one company in CIRC4Life, this mainly related to the struggle to influence supply chain partners that also deliver to several other companies. This barrier illustrates that in complex and large supply chains, it can be tough for smaller actors to convince large suppliers to adopt more circular approaches. However, as showcased by another CIRC4Life company, such barriers related to the lack of a circular mindset among partners can also be experienced in shorter supply chains. Specifically, the company faced difficulties in convincing a supplier of the importance of providing them with materials that have been properly sorted beforehand.[31]

Table 5. EEE firms mentioning supply chain barriers (% of firms (number))

Barrier	Firms	
Difficulty in accessing products/components/materials	39%	(12)
Closed/restricted company loops	19%	(6)
Lack of transparency	19%	(6)
Lack of compliance and circular mentality among partners	16%	(5)
Other	16%	(5)
Reverse logistics issues	13%	(4)
Unofficial and/or illegal activities	10%	(3)
Quality issues regarding recycled material	6%	(2)
Transportation challenges	6%	(2)

[31] It should be noted though that despite these issues the long relationship based on trust with the supplier was also an enabling factor for the implementation of this company's CEBM (see section 3.2.1.3).

The second most common category of barriers was policy and regulation. Within this category, legislation or initiatives specific to EU member states was highlighted as an impediment by around a quarter (26%) of the companies interviewed in the EEE sector. While these varied from country to country, many were considered to have unintended negative consequences for circular initiatives or were perceived not to adequately take into account the particularities of circular activities according to the interviewees. The low cost of landfilling was identified as a barrier within CIRC4Life, as it does not incentivise investments in circular and more sustainable approaches.

At the EU level, a common barrier was EU chemicals legislation, with seven companies specifically mentioning the REACH Regulation 1907/2006, RoHS Directive 2011/65/EU and Regulation (EU) No 2019/1021 on persistent organic pollutants (POPs). Among them, three companies reported that the requirements and administrative demands related to these pieces of legislation often create hurdles to recovering and recycling plastic from EEE. They also noted that this material frequently ends up in incinerators. One other company reported that due to these policies it is hard for them to access recycled plastic in order to use it in the production of new EEE.

The WEEE Directive 2012/19/EU was mentioned as a barrier by five companies. The flexibility in implementing the directive at the national level, according to some of the companies, has led to different rules and enforcement across member states. This arguably gives rise to difficulties for companies operating across different countries. One company also found that due to existing rules, proof that the equipment is functional is required in order to move it across borders, thereby complicating intra-EU trade of used equipment for repairs. While local repairs are possible, the cost levels in higher-wage countries could make some repairs economically unprofitable according to the company. Extended producer responsibility (EPR) schemes were also brought up by five companies as posing challenges to their circular activities, which generally related to the way in which the national frameworks for EPR schemes have been set up in different countries. In one country, targets are set on an annual basis and are specified a few months into the year in which they apply, thus making planning and investment tougher for companies participating in the EPR schemes. Without visibility of future targets, longer-term planning for investments becomes difficult. Investments are also constrained by the absence of long-term contracts provided by the existing schemes due to their competition based on price. In another country, it was brought up that the EPR scheme has a very rigid structure regarding the management of collected EEE equipment, leaving little room for developing new sorting and recycling plants in different regions.

Several other barriers were brought up during the interviews, including the absence of specific policy actions[32] and lack of enforcement or compliance with existing legislation, which were

[32] Specifically, the following missing policy actions were reported: lack of requirements/regulations for sharing data across supply chains, lack of policies to support lower-skilled jobs required for refurbishment, repairs and reuse of EEE and lack of policy support for refurbishment activities in general.

mentioned by three companies each. Three companies also found that there is an excessive focus on waste and recycling in existing circular economy policies at the expense of other processes such as refurbishment and reuse. For companies engaged in international trade and sales, customs and other trade issues were seen as a barrier. Lack of legislation on circularity or sustainability in third countries, as well as enforcement, were related challenges.

Table 6. EEE firms mentioning policy & regulation barriers (% of firms (number))

Barrier	Firms	
Member state legislation/initiatives	26%	(8)
EU chemicals legislation (REACH, RoHS, POPs)	23%	(7)
WEEE Directive	16%	(5)
EPR regime	16%	(5)
Lack of certain policy action	10%	(3)
Lack of enforcement/compliance	10%	(3)
Legal barriers to reusing devices or components	10%	(3)
Excessive focus on waste and recycling	10%	(3)
International trade and customs	10%	(3)
Lack of circular/green public procurement	10%	(3)
Lack of legislation or enforcement in third countries outside EU	6%	(2)
Other	6%	(2)
Lack of common standards and definitions	6%	(2)
Bureaucracy and administration	6%	(2)

Within the consumer and societal awareness category, lack of interest or trust in circular solutions was the barrier most commonly experienced. Indeed, over half of the companies interviewed in the EEE sector saw this as a hindrance, although as described in the enablers section below many also noted that interest in circular solutions has been increasing. One of the common reasons mentioned, especially by companies involved in refurbishing or remanufacturing, was that they found people to be sceptical about the quality and reliability of refurbished products. Preference for owning a device was also observed by companies offering leasing models. Within CIRC4Life, problems also arose during activities aimed at communicating sustainability information to the customers. In particular, the eco-point method and app that were developed as part of the project were seen as complex by some, which complicated the project's efforts to promote circular products over others. Nevertheless, with efforts to clarify and increase awareness, some of this was improved.

In more general terms, lack of awareness of sustainability issues and the circular economy was brought up by four companies. This also related to a lack of awareness of how to properly recycle WEEE. This issue was likewise identified within the CIRC4Life project, as well as the existence of limited incentives for consumers to engage in more sustainable behaviour. As such, efforts were made during the project to communicate the importance of circular solutions and raise awareness as well as to provide incentives for reuse or recycling (see Wilson & Lindén, 2021a).

In a similar line, four companies specifically mentioned that they found the main drivers of purchasing decisions to be price and a desire to have completely new devices. Competing only on price could be challenging for companies implementing CEBMs, which may occasionally have different costs from companies with more linear activities.

Table 7. EEE firms mentioning consumer/societal awareness barriers (% of firms (number))

Barrier	Firms	
Lack of interest/trust in circular solutions	52%	(16)
Preference for new/cheaper products	13%	(4)
Lack of awareness	13%	(4)
Other	6%	(2)
Misleading/inaccurate information	6%	(2)

The barrier of higher costs for more sustainable or circular approaches was mentioned by over a quarter (26%) of the companies interviewed, and was the most common barrier among the financial and economic factors (see Table 8). The reasoning provided by the companies varies. Some found that utilising used equipment or parts could be expensive, while others reported that the processes of collecting, sorting and depolluting EEE are costly. One other company involved in collection and refurbishment of EEE reported that the financing terms offered to them by companies selling their used equipment required paying the full amount in advance, which is usually not the case when buying new equipment. Related to this are also specific predicaments associated with the leasing and product-as-service models, which were noted by two companies. One found that such models lead to particular financial challenges due to the fact that production costs are covered at a much later time compared with selling a device, while the other experienced issues in collecting payments from clients and occasional theft of devices that were provided to clients as part of the leasing model.

Another barrier that was mentioned by eight companies was that of accessing financial resources, either for operations or investment. This was particularly mentioned by SMEs, of which three highlighted that initial investment costs were high or hard to finance. Two SMEs also mentioned that finding the necessary finance to scale up a circular economy activity was a challenge. Some also found it difficult to access funding for specific activities, with one noting they did not have the resources for quantifying their environmental impact. Nevertheless, one large enterprise also brought up this issue, noting that sustainability or circular initiatives were often the first to have their resources reduced in difficult times.

Competition, especially with linear companies and products, was mentioned as a barrier by almost one out of five companies (19%). This often related to the higher cost of circular approaches (as mentioned above). Similarly, the low cost of virgin materials was seen as a constraining factor on the increased use and availability of secondary raw materials by five companies involved in different circular activities.

Table 8. EEE firms mentioning finance/economic barriers (% of firms (number))

Barrier	Firms
Higher cost of more sustainable/circular approaches	26% (8)
Lack of access to financial resources	23% (7)
Competition (incl. with non-circular products/processes)	19% (6)
Low cost of virgin materials	16% (5)
Other	10% (3)
Payment issues related to leasing	6% (2)

Barriers mentioned within the technology field varied significantly between companies. Nevertheless, four companies mentioned one as being a lack of consistency or predictability. In more detail, three companies reported that due to the increasing variety of models, the designs and technologies for developing and putting refurbishment and remanufacturing processes in place for EEE is becoming a complex task. As reported by one recycler, this can also complicate depollution and recycling processes, which may have to be adapted to new materials or designs. Design or product characteristics posed specific issues for three companies, with some noting that embedded and slim designs made repairs more difficult, among other things. Software issues were mentioned by two companies, with one facing particular hurdles snags related to software licencing. While not listed in the barriers included in Table 9 below, it is worth noting that limitations related to data inconsistencies were encountered in CIRC4Life and specifically during the collection of information for the LCA (e.g. energy expenditure, time and transportation). This was due to the local suppliers using data stored in different (non-standardised) formats and methods, which complicated the process (Kosnic & ONA, 2021). Finally, four companies noted a variety of other barriers that have been listed in Table 9 as 'other'.[33]

Table 9. EEE firms mentioning technology barriers (% of firms (number))

Barrier	Firms
Lack of consistency/predictability	13% (4)
Other	13% (4)
Issues related to design/product characteristics	10% (3)
Issues related to software	6% (2)
Limited availability of technological solutions	6% (2)

With regard to company organisation, lack of time and internal resources was the most commonly mentioned barrier within the category. This was experienced by both SMEs (three)

[33] These included technical constrains in further improving the resource efficiency of EEE, new technology cycles providing only marginal resource and energy efficiency benefits, the existence of a technology gap between what the manufacturers design/produce today and what the recyclers collect for recycling years later and challenges for refurbishing and reusing IT equipment due to the different layouts of keyboards across countries.

and larger companies (two). For the larger companies, it generally related to prioritisation of resources for different circular activities and initiatives and having to choose which to prioritise. For SMEs, it more generally related to lack of time and internal resources. In larger companies, which often did not start up as a company with circular activities but have moved towards more circular processes in later years, lack of knowledge of the circular economy together with a linear mindset was also seen as a barrier. One company noted that this created tensions between different departments within the company, because of a lack of mainstreaming of circularity targets and benefits across the company as a whole.

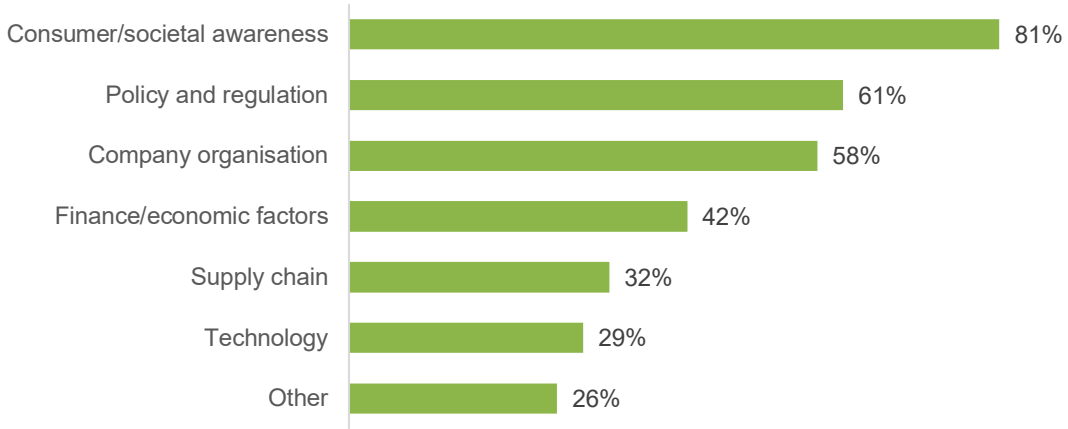
Table 10. EEE firms mentioning company organisation barriers (% of firms (number))

Barrier	Firms
Lack of time and internal resources	16% (5)
Linear mindset/lack of circular economy knowledge	13% (4)
Linear company processes	13% (4)

3.2.1.3 Enablers

As shown in Figure 5, consumer and societal awareness was the category most commonly mentioned as an enabler. Indeed, most of the sampled EEE companies (81%) reported that they had experienced enablers within the category. Policy and regulation was the second most frequently mentioned category of enablers mentioned by over half of the companies (61%). Company organisation was another key enabler in the sample noted by more than half of the companies (58%). Finance and economic factors were highlighted by 42% of the companies, while the supply chain category was mentioned by almost a third (32%). Technology and 'other' were the categories least mentioned.

Figure 5. EEE firms mentioning the enabler category (% of firms), N=31[34]



[34] Note that multiple categories may be counted for each firm, thus the bars are independent from each other and may not add up to 100%.

Increasing demand for circular or sustainable products was mentioned as an enabler by over half of the firms (52%) interviewed in the EEE sector (see Table 11). Considering the fact that the same number of firms mentioned lack of trust or interest in circular solutions as a barrier, this illustrates that there are different attitudes among customers. Some companies highlighted that the demand from certain consumer segments that are interested in circular solutions has been crucial to developing their circular business models. This was also experienced in the CIRC4Life project, where involving customers in the design and production of new circular products and services through co-creation methods was used in the project to help ensure a more collaborative process – in which the supply of new circular products and services matches consumer demand and concerns (see Wilson and Lindén, 2021a and Kosnic & ONA, 2021). Similarly, increasing awareness of environmental and sustainability issues more generally was noted by 14 firms. This was considered a more general enabler in the way that it may make people more interested in circular solutions or more aware of how to dispose of their devices in a way that extends the life of the devices or properly recycles them. However, some companies noted that increased awareness did not necessarily guide purchasing decisions. Awareness programmes, which also play into this, were specifically mentioned by two companies as having had a positive effect on people's awareness. Another two SMEs mentioned that customer loyalty was an enabler, which for one of them had helped them to use crowdfunding when needed.

Table 11. EEE firms mentioning consumer and societal awareness enablers (% of firms (number))

Enabler	Firms	
Increasing demand for circular/sustainable products	52%	(16)
Increasing awareness	45%	(14)
Awareness programmes	6%	(2)
Customer loyalty	6%	(2)

With regard to the category of policy and regulations, public funding (including project funding) was the enabler most commonly mentioned. Among the eight companies that pointed to this enabler, most had benefited from EU project funding and some also from national funding programmes. Such funding had helped them mitigate the challenges of limited financial and other resources, and enabled them to go beyond their usual operations, innovate and focus on circularity. For one company, such support had also been fundamental in starting up and developing the company, centred around circularity. Within CIRC4Life, project support was naturally a chief enabler. Through the funding, as well as cooperation and knowledge transfer among partners, the companies involved were able to demonstrate different new CEBMs. Seven companies reported a multitude of policies at various levels that acted as enablers for them, which are listed in Table 12 as 'other'. These included the EU single market, voluntary industry agreements underpinned by EU legislation, the Conflict Minerals Regulation (EU) 2017/821, the Paris Agreement and the Sustainable Development Goals (SDGs).

Notably, the WEEE Directive was brought up as an enabler by five companies. Considering five companies also mentioned it as a barrier, this illustrates that there have been mixed impacts from the directive according to the companies interviewed. Two of the companies noted that setting targets for reuse and recycling had been an important enabler, while one believed that it specifically had supported the collection and recycling of small WEEE. Two companies highlighted the prioritisation of reuse over recycling as an enabler.

Different pieces of member state legislation and policies were highlighted as having positive effects by five companies. In some cases, this related to legislation and policy with the intention of promoting a circular economy, such as partial reimbursement of repair costs at the sub-national level, green public procurement, national ecolabels, and broad circular policy and strategies. More generally, the EU's circular economy action plan and the European Green Deal were brought up as enabling circular business models by four companies. A variety of standards were furthermore mentioned by four companies as enablers. These included the standards on collection and treatment of WEEE by the European Committee for Electrotechnical Standardization (CENELEC) as well as the EPCIS standard that was used in CIRC4Life for sharing, in a standardised form, information about products across supply chains.[35]

Table 12. EEE firms mentioning policy and regulation enablers (% of firms (number))

Enabler	Firms	
EU/national funding (incl. projects)	26%	(8)
Other	23%	(7)
WEEE Directive	16%	(5)
Member state legislation/initiatives	16%	(5)
Standards	13%	(4)
EU circular economy package & European Green Deal	13%	(4)
Ecodesign Directive	6%	(2)
Reporting requirements	6%	(2)

More than half of the companies mentioned enablers within the overall category of company organisation, with internal commitment, motivated employees and internal innovation being the most common. The former was mentioned by nine companies, both large and SMEs. For some, it related to having dedicated departments or business lines focused on sustainability, while for others the knowledge and commitment of their employees or company as a whole were highlighted. Enablers related to internal innovation were varied and included new or adapted activities, such as launching new business models, services or dedicated branding. One company overcame issues related to accessing spare parts by developing their own depot, while another decided to acquire its own plastic shredder to further expand its circular activities. In addition, four companies mentioned their size as an enabler but provided contrasting views, since three noted that their small size benefited their capacity to innovate, while one large company mentioned that the global size of its business enabled it to quickly take on circular economy innovations and invest in them.

[35] For more details see Schmittner and Schwering, 2019.

Table 13. EEE firms mentioning company organisation enablers (% of firms (number))

Enabler	Firms
Internal commitment and motivated employees	29% (9)
Internal innovation	26% (8)
Company size	13% (4)

Slightly fewer than half of the companies interviewed in the EEE sector noted enablers related to finance and economic factors. Revenue or cost-saving opportunities from circular approaches was the enabler most commonly mentioned. Considering that the higher costs of circular approaches was mentioned as a barrier by a similar number of companies (eight), this illustrates that depending on the specific CEBM and market conditions in place, the financial benefits or costs entailed by circular economy processes can vary significantly. Among the nine companies that mentioned revenue or cost-saving opportunities as an enabler, several noted that the inherent value in used equipment was an important feature. Others observed that circular approaches have provided new revenue streams for their company. One company also reported that retaining ownership of the devices through their leasing model motivated further circular approaches and design. Another company noted that financial benefits may also arise for customers, who can, for instance, spread the cost over a longer period with leasing. A further notable enabler was demand for high-end EEE, which was highlighted by three companies active in refurbishment or remanufacturing. According to these companies, the presence of a high-end market for smaller electronics such as mobile phones has been an important enabler for their business model.

Table 14. EEE firms mentioning finance/economic enablers (% of firms (number))

Enabler	Firms
Revenue/cost-saving opportunities from CE	29% (9)
Demand for high-end products	10% (3)
Access to flexible sources of finance	6% (2)
Other	3% (1)

Under the category of supply chains, establishing partnerships with other companies and suppliers was the most commonly mentioned enabler. Such partnerships have helped them to utilise and occasionally share outside expertise, resources and capacity, as well as to implement circular solutions through dialogue and cooperation. In most cases, this assisted them in overcoming barriers in a variety of areas, such as finance and economic issues, technology and supply chains. For one company, for example, the establishment of a partnership helped them to overcome barriers regarding the prefinancing and manufacturing of small batches of components. Within CIRC4Life, good relations with and trust of suppliers was also an important enabler in order to facilitate the implementation of circular approaches in production. According to one of the companies, long-standing relationships with suppliers were important for getting the suppliers onboard with the new practices required.

Table 15. EEE firms mentioning supply chain enablers (% of firms (number))

Enabler	Firms
Establishing partnerships	29% (9)
Good relations with and trust of suppliers	3% (1)

Four of the interviewed companies mentioned technological or digital solutions as enablers. The solutions varied among the companies, with artificial intelligence mentioned by one, the internet of things by another, digitalisation of processes by a third and online sales by a fourth. Within CIRC4Life, several technological and digital solutions were utilised. The development of an app and eco-point system allowed communication of the sustainability impacts to the customers, helped to inspire more sustainable behaviour and provided information at the point of purchase about where and how to deposit devices for recycling or reuse. The latter was made possible by an 'intelligent' bin that enabled consumers who dispose of devices to receive financial rewards in their account and to follow what would eventually happen to the device. Although this electronic system was only demonstrated on a small scale within the project, also due to Covid-19 restrictions, there were indications that it could have a positive effect on consumer willingness to engage in circularity activities (Wilson & Lindén, 2021a). Traceability solutions were specifically highlighted by two companies, of which one stressed that innovations in blockchain technology could be a key enabler in the future by allowing tracing and verification of recycled content in remanufactured devices.

Table 16. EEE firms mentioning technology enablers (% of firms (number))

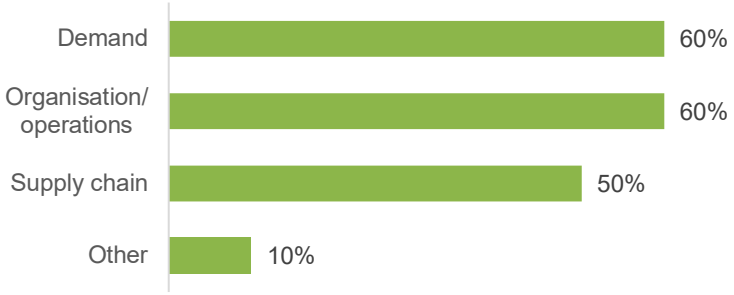
Enabler	Firms
Technological/digital solutions	13% (4)
Traceability solutions	6% (2)
Benefits related to design	6% (2)
Longer innovation cycles for hardware	6% (2)

3.2.2 Agri-food value chain

3.2.2.1 Covid-19 impacts

Within the agri-food sector, more than a half of the interviewed companies reported Covid-19 impacts on demand and organisation/operations. In addition, half of the companies reported impacts on supply chain.

Figure 6. Agri-food firms mentioning Covid-19 impacts (% of firms), N=10[36]



With regard to demand impacts, four companies noted decreased demand (see Table 17). One company within CIRC4Life found that the lack of tourists and the lockdown restrictions caused a significant decrease in demand, such as orders at cafes and other premises. Another one reported that the sales of products have decreased in stores and despite the progressive lifting of the restrictions the number of orders has not returned to the level before the pandemic. One other company noted a decrease of grain prices in the agricultural commodities market. By contrast, three companies experienced increased demand for their products and services. Among them, one company found that following the first wave of the pandemic there was greater demand from big clients for innovative products produced through more circular processes, while another one mentioned that due to the rise in demand they had decided to diversify the products they offered. Additionally, two companies had to adapt to a change in the products demanded because people changed their habits and started preparing meals at home.

Six companies observed negative effects on operations. One company that was also involved in CIRC4Life found that restrictions of direct contacts made it more difficult to gather clients' opinions and feedback for the development of their CEBM. Another company mentioned that the market launch of their product produced through food residues had to be postponed due to the closure of companies that were supplying them with these residues. One reported that due to severe restrictions they were not able to continue promoting organic farming through educational activities, while another company mentioned that active participation in trade fairs, conferences and workshops to promote its product significantly decreased, with this lack of direct contact having a negative impact on the knowledge development of employees.

Five companies highlighted supply interruptions. Among them, one company mentioned that it was impossible to receive the food waste required for its product, thereby forcing it to cease all operations. Another one noted similar challenges in receiving the food residues required for its CEBM. Notably, two companies experienced a disruption in the supply of packaging materials. Finally, one company reported difficulties in engaging with potential investors in order to obtain the financial resources required for its CEBM, which has been included in the 'other' category in Table 17.

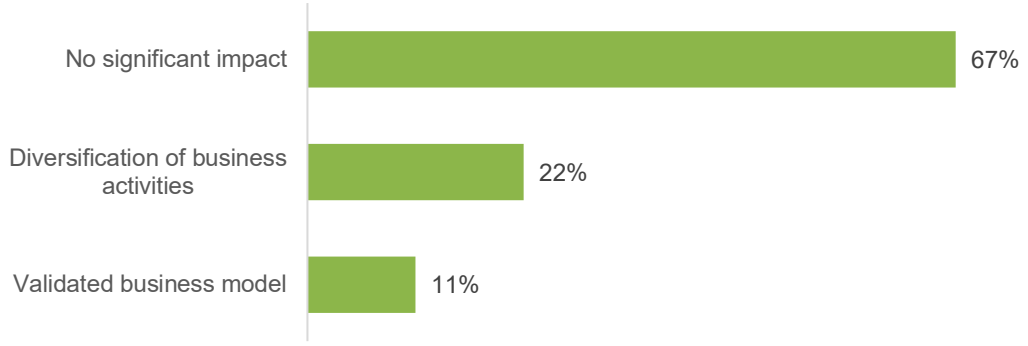
[36] Note that multiple categories may be counted for each firm, thus the total does not add up to 100%.

Table 17. Agri-food firms mentioning Covid-19 impacts (% of firms (number))

Category	Impacts	Firms
Demand	Decreased demand	40% (4)
	Increased demand	30% (3)
	Change in product demand	20% (2)
Organisation/operations	Negative effects on operations	60% (6)
Supply chain	Supply interruptions	50% (5)
Other	Difficulty in accessing investment	10% (1)

As shown in Figure 7 below, the majority of the companies in the agri-food sector reported no significant impact on their sustainability strategies or the way they integrate circularity in their business models due to the Covid-19 pandemic, reflecting that circularity or sustainability is the key business focus for many of the sampled companies. However, there were two companies that reported a diversification of their business activities. According to the first company, its original business idea was based on a waste-to-energy approach; nevertheless, the pandemic motivated a re-think and move towards a model based on utilising food residues from local partners for the production of by-products. The second company reported that the pandemic had brought the realisation that it had the potential to cover a niche market of good destined for large companies and that its model, based on a circular approach, could be a competitive advantage in this market. Finally, one company noted that the pandemic had highlighted the importance of healthier lifestyles as well as environmental sustainability, thereby providing a token of validation of its business model based on the organic production of food. Environmental strategies and the activities undertaken have acquired special value and importance with the emphasis on healthy diet.

Figure 7. Agri-food firms mentioning strategy changes from Covid-19 (% of firms), N=9[37]

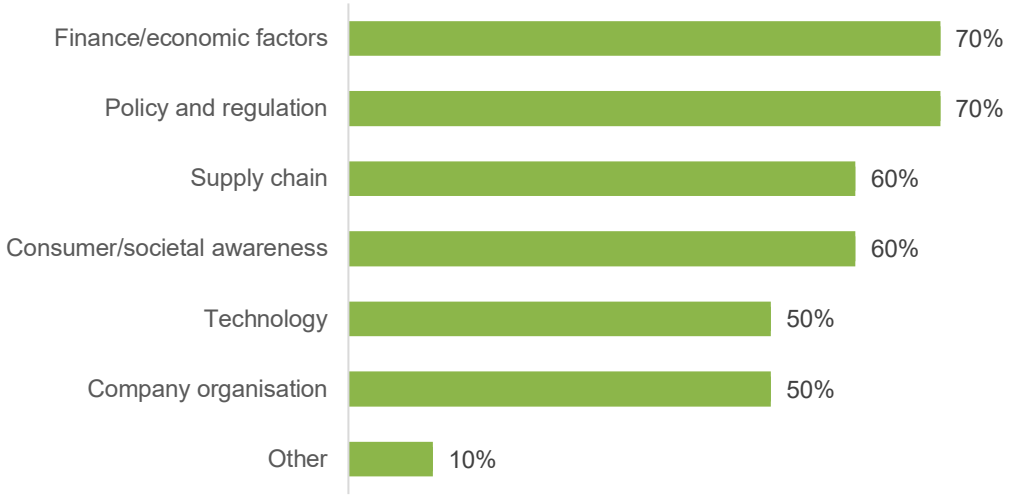


[37] Note that not all firms provided input to this question, and as such the percentage is calculated as a share of the total that answered the question for each category. In addition, multiple categories may be counted for each firm, thus the bars are independent from each other and may not add up to 100%.

3.2.2.2 Barriers

Finance and economic factors along with policy and regulation were the categories of barriers identified by the largest share of sampled companies in the agri-food sector, followed by the categories of supply chains and consumer/societal awareness (see Figure 8). In addition, half of the sampled companies mentioned barriers related to technology and company organisation. It is worth noting that the majority of the companies spotlighted barriers in all these categories.

Figure 8. Agri-food firms mentioning the barrier category (% of firms), N=10[38]



Within the finance/economic factors category, five companies mentioned that more sustainable and circular approaches entail a higher cost. Some of the processes that entailed higher costs were collection and treatment of side streams from food production, the cost of buying electric machinery to replace diesel ones and costs of using biodegradable and compostable plastic packaging. One company specifically highlighted the financial challenges associated with developing new processes to use waste as raw material, while another one mentioned that price represents the main barrier when adopting a circular model for animal feed products, as farmers are highly sensitive to price changes.

Moreover, three companies reported lack of access to financial resources as a barrier. One of them mentioned that as a medium enterprise it had limited access to external funds to support the implementation of a new CEBM, while another reported difficulties in obtaining the financial support required to make its production model financially sustainable, especially in its early stages of development. There was also a start-up that found that the pandemic complicated its efforts to access investments. Two companies furthermore saw competition as a barrier. In particular, the first mentioned that as a small company offering a product produced through a circular process it faces higher labour costs, higher costs for packaging and smaller

[38] Note that multiple categories may be counted for each firm, thus the total does not add up to 100%.

margins compared with large competitors. The second company observed that food products are not priced highly enough because they do not include negative externalities, which makes it hard for farmers to produce food more sustainably and compete with industrial producers, as they have to sell with higher margins.

Table 18. Agri-food firms mentioning finance/economic barriers (% of firms (number))

Barrier	Firms
Higher cost of more sustainable/circular approaches	50% (5)
Lack of access to financial resources	30% (3)
Competition (incl. with non-circular products/processes)	20% (2)

With regard to the policy-related barriers, four companies highlighted bureaucracy and administration. Among them, two companies noted that getting official recognition for their circular process based on using leftovers from agri-food production required excessive administrative requirements, while one pointed to the long-process associated with proving that using black soldier fly frass as fertiliser is safe, which was a significant burden on implementation of its CEBM. Another company noted that the national agency responsible for granting subsidies for organic production has put in place very complex procedures.

Three companies singled out member state legislation/initiatives. One company highlighted that the strict national rules in place for using leftover vegetables from restaurants for animal feed focus on the origin of these leftovers (i.e. whether they originate from restaurants) rather than their actual composition. It argued for the composition check to prioritise assessing whether it is safe to use them for animal feed. Another company mentioned a national act on biocomponents that includes restrictions on sales of biofuels between farmers, while another encountered difficulties in convincing partners to support it in its CEBM due to the national rules in place for using leftovers from agri-food production but also to the absence of a clear EU legislative framework for such processes.

Two companies mentioned EU policy in general. The first commented that although food and agricultural policy is generally moving in the right direction, more needs to be done in terms of creating a level playing field where environmental externalities are properly incorporated in the prices of food. The second one that is also involved in CIRC4Life noted that current EU rules restrict the use of agricultural residues and leftovers and suggested that having more flexibility in this respect could enhance the opportunities for circularity. Additionally, one company noted the lack of EU rules for using black soldier fly frass as fertiliser, one mentioned that due to an incoherent implementation of the Novel Food Regulation (EU) 2015/228 across member states the market for using insect proteins for animal feed is often restricted and one that public support in the form of subsidies for organic farming are insufficient.

Table 19. Agri-food firms mentioning policy and regulation barriers (% of firms (number))

Barrier	Firms
Bureaucracy and administration	40% (4)
Member state legislation/initiatives	30% (3)
EU policy in general	20% (2)
Lack of EU rules	10% (1)
Lack of coherence in implementing EU legislation	10% (1)
Insufficient public support/funding	10% (1)

From a supply chain perspective, three companies noted challenges in establishing partnerships. The first, a start-up company, stressed that a lack of a well-established business network make it more difficult in the beginning to find customers or partners. The second highlighted the need to look for equipment providers abroad due to a shortage of domestic suppliers. The third company reported that it was very hard to find a supply chain partner for the logistics and convince the partner to work with it, largely owing to the legal administrative burdens linked to the national rules in place for using leftovers from agricultural production. Moreover, two companies mentioned problems in convincing their partners to accept a more circular approach, one noted issues linked to the complex logistics of its business relying on the collection of agricultural production leftovers from multiple locations and finally one encountered obstacles in identifying a proper natural colouring agent required for its food product.

Table 20. Agri-food firms mentioning supply chain barriers (% of firms (number))

Barrier	Firms
Establishing partnerships	30% (3)
Difficulty convincing partners to accept circular approach	20% (2)
Collection issues (incl. quality of items)	10% (1)
Difficulty in accessing products/components/materials	10% (1)

Under the category of consumer/societal awareness, four companies referred to lack of interest/trust in circular solutions. One company noted that when it comes to ecological issues society is divided, while such issues are often politicised – leading to lack of trust among people. Another company argued that although many consumers are in general interested in products produced through more sustainable processes, in the end they prioritise the price and prefer products they are already familiar with. One other emphasised struggles to engage with customers because of challenges in getting their attention and communicating business products in a short timescale. The same company found that the CIRC4Life project had shown that it is difficult for consumers to understand the concept of LCA and its benefits. A fourth company suggested that despite some consumers changing their preferences, there remains a segment uninterested in circular approaches like using by-products as a valuable resource and

therefore educational programmes are needed on the part of public administrations and governments. Additionally, two companies mentioned the lack of public awareness as a barrier, with the first noting that in its country sustainability is not covered sufficiently by the media and the second arguing that a share of the public still does not understand why there is a need for more sustainable consumption patterns and does not pay attention to how products are manufactured. Finally, one company pointed out that many consumers are still not ready to change their eating habits and adopt a healthier lifestyle (included as 'other' in Table 21).

Table 21. Agri-food firms mentioning consumer/societal awareness barriers (% of firms (number))

Barrier	Firms
Lack of interest/trust in circular solutions	40% (4)
Lack of awareness	20% (2)
Other	10% (1)

Under the category of technological barriers, complexity and the limited availability of solutions were each raised by three companies. On technological complexity, one company commented that CIRC4Life had shown that integrating the eco-point system developed by the project into supermarkets to communicate sustainability impacts to customers could be challenging. Specifically, supermarkets use certain hardware to issue receipts, which cannot easily integrate another system like that developed by the project for eco-points. Thus, consumers may end up receiving two different receipts, the supermarket one and the eco-point ticket, which is not optimal and can cause confusion. This highlights that developing integrated technical solutions from the beginning, involving all actors, can have the most optimal results. A further lesson from CIRC4Life raised by another company is that in terms of traceability, it might be difficult for small companies to use the same solutions adopted by supermarkets (i.e. QR codes) and the different needs and technical capacities of companies across supply chains should be carefully taken into account in the development of digital solutions. The same company also mentioned the complexities for a small company to collect data in different formats regarding the environmental impacts of food products. With regard to the limited availability of technical solutions as a barrier, one company noted technical challenges in minimising plastic packaging and finding more sustainable alternative solutions. Another mentioned the limited availability of reliable solutions for properly assessing the content of residues from the food industry, and one observed limited options in the market for electric tractors to replace diesel ones.

Table 22. Agri-food firms mentioning technological barriers (% of firms (number))

Barrier	Firms
Technological complexity	30% (3)
Limited availability of technological solutions	30% (3)

Two companies mentioned an internal lack of knowledge and experience as a barrier (see Table 23 below) – with one noting a general lack of experience among its founders on business management issues (i.e. accountability, logistics, communications and marketing) and one a general lack of know-how in the company yet also among local actors, as they were the first to use a specific bio-based technology. One other company noted a linear company culture as a barrier which is largely attributed to an internal generation gap and reluctance to change by the senior managers. In addition, one company mentioned that it was hard to find local people with the appropriate qualifications and experience required for its CEBM. Another reported low internal efficiency in implementing circular economy practices owing to multiple objectives in place and one mentioned that due to its small size it lacks the capacities to compete with larger companies. Finally, one involved in CIRC4Life found that despite the resources made available by the project it was sometimes difficult for a small company with limited time and capacities to follow all the technical updates of the project.

Table 23. Agri-food firms mentioning company organisation barriers (% of firms (number))

Barrier	Firms
Internal lack of knowledge/experience	20% (2)
Linear mindset/lack of circular economy knowledge	10% (1)
Linear company culture	10% (1)
Low efficiency	10% (1)
Company size	10% (1)
Lack of time and internal resources	10% (1)

3.2.2.3 Enablers

As shown in Figure 9, policy and regulation was the enabler category selected by the largest share of companies, followed by consumer/societal awareness and finance/economic factors. Moreover, half of the companies referred to company organisation. Technology and supply chains were the last two categories of enablers specified.

Figure 9. Agri-food firms mentioning the enabler category (% of firms), N=10[39]

[39] Note that multiple categories may be counted for each firm, thus the total does not add up to 100%.

Provision of EU or national funding was indicated as an enabler by seven companies. Among them, five specifically noted that available funding for projects was instrumental in the development and implementation of their CEBMs. This was also the case with the CIRC4Life project, with one company reporting that in addition to the provided financial resources the project had helped it to work with other partners and better understand (through an LCA assessment) the environmental impact of its food product. Similarly, a company involved in an EU-funded social entrepreneurship programme mentioned that during the first phase of implementing its CEBM the programme had helped it to find local contacts and create the necessary network to start the business. Two other companies identified financial support in the form of agri-environmental subsidies as an enabler.

In addition, two companies mentioned labels. The first company argued that product labels, such as ecolabels or organic farm labels, enable the consumer to make an informed decision when shopping, knowing that the quality of the product has been verified by an independent institution/organisation. Another company found that certification of its products by the EU ecolabel to be very useful because it is well-known in the country and it shows that the company's products are of better ecological quality than others on the market. Two companies furthermore suggested that high-level policy initiatives, like the EU circular economy package and the European Green Deal, are catalysing attention on circular business models and also make it easier to attract potential investors. Finally, one company identified the Single Use Plastics Directive, banning certain single-use plastic items, to be an enabler, while another one noted that the SDGs and high-level global policy initiatives generate interest in more sustainable products and also provide signals to companies about the need for more sustainable practices.

Table 24. Agri-food firms mentioning policy and regulation enablers (% of firms (number))

Enabler	Firms	
EU/national funding (incl. projects)	70%	(7)
Labels	20%	(2)
EU circular economy package & EGD	20%	(2)
Single Use Plastics Directive	10%	(1)
Global climate/sustainability policy	10%	(1)

Within the category of consumer/societal awareness, six companies highlighted increasing demand for circular/sustainable products. Four of them held that consumers increasingly look for and choose sustainable products on the market while their interest in more sustainable production methods that also entail higher costs compared with traditional methods is growing as well. Additionally, two companies (one of which is also involved in CIRC4Life) specifically mentioned that business-to-business clients have been particularly interested in circular processes for corporate social responsibility reasons as well. Increasing awareness among consumers of the environmental impacts associated with the production of food was a related

enabler raised by three companies. Finally, the positive influence of labels was indicated by two companies involved in CIRC4Life, which mentioned that the eco-labels developed through the project had helped them to better inform their clients about the environmental impact of their products.

Table 25. Agri-food firms mentioning consumer/societal awareness enablers (% of firms (number))

Enabler	Firms
Increasing demand for circular/sustainable products	60% (6)
Increasing awareness	30% (3)
Labels	20% (2)

With regard to economic-related enablers, five underscored the revenue/cost saving opportunities arising from applying circular economy approaches. According to two companies, the main driver for their CEBMs had been the opportunity to diversify products and to be more competitive by gaining a 'first-mover advantage' through the adoption of new solutions like the ecolabel. Another company reported that economic factors had encouraged it to change production practices and to undertake concrete actions for closing the loop, which has significantly reduced its costs. Two other companies mentioned that in their models utilising food waste or unused organic matter at low cost had provided them with economic opportunities. One other company noted that the circular business model had helped it to look critically at its business structure and reduce costs. Moreover, there was one company that reported access to financial resources as an enabler and specifically emphasised that having a group of investors that – partly motivated by the Covid-19 pandemic – decided to invest to the company's CEBM was a key enabler and had helped it to survive.

Table 26. Agri-food firms mentioning finance/economic enablers (% of firms (number))

Enabler	Firms
Revenue/cost-saving opportunities from CE	50% (5)
Access to financial resources	10% (1)

Four companies found that having an internal commitment and motivated employees to be an enabler. One company remarked that internally there had been greater awareness of the environmental impacts of their activities and of the financial benefits that could be achieved through avoiding of waste/wastewater generation and better utilising raw materials. Another company identified the self-motivation to develop new innovative solutions based on utilising waste as an enabler, while yet another one stressed the importance of having employees who are highly interested and committed to the business idea. Furthermore, one company indicated that internal training and workshops had increased both the efficiency of its employees and the quality of its products. One company identified the knowledge of a researcher who was among the co-founders as an enabler, while another one mentioned that its small size and structure

based on a small number of management levels helped internal information flow. Finally, one observed that prioritising innovation within the company had helped it to become a front-runner in processing waste streams from the food industry.

Table 27. Agri-food firms mentioning company organisation enablers (% of firms (number))

Enabler	Firms
Internal commitment and motivated employees	40% (4)
Training/upskilling activities	10% (1)
Internal knowledge	10% (1)
Company size	10% (1)
Internal innovation	10% (1)

On the technology front, four companies identified technological/digital solutions as an enabler. According to two companies, food processing technologies have made great progress in terms of time and energy savings, extended shelf life in retail and stimulated the development of circular solutions – such as using by-products from food production and from processing in the preparation of new products. One company in CIRC4Life reported that tools developed as part of the project to trace the carbon footprints of products across supply chains have been very useful. What is more, one company also involved in CIRC4Life stressed that environmental accounting tools such as LCA and carbon footprint studies can help companies understand where the main impacts of their production are.

Table 28. Agri-food firms mentioning technological enablers (% of firms (number))

Enabler	Firms
Technological/digital solutions	40% (4)
Environmental accounting tools	10% (1)

Regarding supply chain enablers, four companies focused on the importance of establishing partnerships. Among them, two companies specifically highlighted partnerships with universities that had helped them establish their processes based on using waste and side streams, while one noted that its new CEBM had paved the way for collaborating with new business partners who also perceived it as an opportunity to enhance their circular business models as well. Additionally, there was one company that specified that its model relied on building good relationships with food producers, which supplied them with leftovers from food production.

Table 29. Agri-food firms mentioning supply chain enablers (% of firms (number))

Enabler	Firms
Establishing partnerships	40% (4)
Good relations with and trust of suppliers	10% (1)

4. Policy insights and recommendations

This section draws policy insights and recommendations based on the results of this study and features three parts. It first presents findings for each value chain drawing on the views of the interviewed experts on the effectiveness of current EU policies in the field and the key policy gaps. This information was collected during the last part of the interview discussions (see section 3.1.2). Then for both value chains there is a discussion based on the study's main observations on barriers and enablers and proposals for different forms of policy action. The section concludes with a number of policy recommendations.

4.1 Electrical and electronic equipment value chain

4.1.1 Policy effectiveness and gaps

Within the EEE sector, most of the interviewed companies had a positive or mixed view of EU policy effectiveness with regard to promoting circular economy approaches in the sector. Several interviewees were positive about the overall direction of EU policy and expressed optimism about future policy developments. Both the European Green Deal and the circular economy action plan were mentioned as encouraging initiatives by some of the companies. Specific policy initiatives such as the extended producer responsibility requirements and the WEEE Directive were also mentioned by some. However, many also believed there to be room for improvement and some expressed a wish for policy to develop faster. This was also reflected in the policy suggestions provided, where three companies called for increasing the speed and ambition of policy on the circular economy (see Table 30). A few of the interviewees did not believe that EU policy had had a significant and positive impact on their activities and the market conditions in place. Among the companies interviewed, less than a third found EU policy to be ineffective. Many of these believed EU policy could go further in supporting and incentivising circular business models.

With regard to the policy gaps as observed by the interviewed companies, a wish for further financial support for circular activities or companies was highlighted by more than a third of the companies (12) as can be seen in Table 30. One of the main ideas, proposed by nine of the companies, was tax incentives in the form of VAT reductions for circular activities or other types of tax reductions for circular activities or businesses. A few companies also wished for financial support, such as public funding. Notably, none of the companies that provided this action point had also mentioned EU or national funding as an enabler. This could indicate that while some companies benefit from public funding, others may still struggle to access it. In a similar vein, four companies proposed further support for research and development, which can help provide new or improved circular solutions. The importance of project funding was moreover demonstrated in the CIRC4Life project, where through such funds several companies were able to implement and demonstrate new circular solutions, products and business models.

Increased policy support for circular business models was put forward by nine companies. For many of these, it represented a general sentiment of wishing for a move towards more policy focus on circularity for all stages of a product's life or to promote new circular business models. The proposals were both general and related to specific areas such as repairs, refurbishment

and leasing. Indeed, additional policy support for leasing as a business model also emerged as an idea from a company involved in CIRC4Life. Overall, the message among many of the nine companies was often that in order to overcome many of the barriers experienced, additional policy support that promotes circular activities and companies would be welcome. At the same time, six of the companies interviewed in the EEE sector also expressed a wish for policy initiatives to avoid an undue burden on companies or unintended negative consequences.

Awareness raising was another idea that could help improve the case for CEBMs. Eight companies raised this suggestion, with some emphasising that messaging should also focus more on the positive aspects and benefits of circular solutions. Increased awareness could lead to increased demand and calls for circular products and services as well as help ensure that people dispose of their devices correctly so that they can be reused or recycled. The importance of this was also highlighted during the CIRC4Life project implementation, in which several awareness campaigns were implemented (Wilson & Lindén, 2021a). For example, such campaigns can motivate people to deliver their devices for recycling or reuse, which would be important to enable these business models.

Certain gaps and suggestions focused on reforming or improving existing policies and legislation. Among them were proposals to reform the framework for extended producer responsibility, which was mentioned by seven of the companies. Three aspects were brought up in this regard: stronger enforcement, proposals for how to improve implementation in member states where the national schemes were considered to generate barriers (see section 3.2.1.2) and modulated fees. Ecodesign was seen as an area where EU policy could do more. Stricter, product-specific and clearer ecodesign obligations and targets were among the recommendations provided by five companies. One also mentioned that clarity and coherence would be important for it to have the best effect, while another noted a concern regarding whether imported products would also be covered. Furthermore, four companies highlighted inconsistencies in waste legislation and improvements they would like to see, including increased policy focus on reuse and other stages before products reach the waste stage as well as less room for different interpretations and implementation among member states of the WEEE Directive. Five companies also urged that policy support for improved collection of WEEE could be useful.

Support for collaboration and knowledge exchange was moreover brought up by five of the companies interviewed. Different ways of achieving this were suggested. One company proposed that workshops could be useful, one thought to consult businesses and industries further, while another highlighted that ways to connect and involve smaller companies and organisations would also be important. With regards to SMEs, another company advised that an EU platform or toolkit could prove useful. Project support is another way in which collaboration and knowledge exchange can be facilitated, by providing an arena for different actors to engage and help each other reach common goals. This was demonstrated in CIRC4Life, where the collaboration of different partners, including collectors, recyclers, companies offering digital solutions and research organisations, allowed for the development of new more circular products and demonstration of circular business models.

Six companies advised that policy could help improve transparency across supply chains. Two added that this could be a tool to help consumers make more informed and sustainable purchasing decisions. This would necessarily depend on the information shared being available to consumers in an accessible format. One also noted that improved traceability could help improve the management of EEE during its lifetime. For example, it could provide useful information to recyclers. However, concerning the idea of collecting information on sustainability or emissions in a database, some cautioned that the complexity would need to be taken into account. For example, a modular device may have higher associated emissions from production, but if its lifetime is longer, it may overall have a lower impact compared with a non-modular one with a shorter lifetime. The same company also advocated for the impact of transportation to be taken into account.

Standards or labels can be important tools for promoting a circular economy. Three companies mentioned this as a gap in current EU policy, two of which held that the lack of standardisation for circular products and materials is a gap in EU policy. The important role of labels was identified throughout CIRC4Life, where labels were developed to showcase sustainability information about the products (see Wilson & Lindén, 2021a). Labels could provide consumers a reliable source of information when choosing products and may to some extent enable more sustainable products to compete with products produced through more linear processes.

Table 30. EEE policy gaps and suggestions (% of firms (number)), N=31

Policy gaps and suggestions	Firms	
Increase financial support for circular activities/companies	39%	(12)
Increase policy support for circular economy business models	29%	(9)
Awareness raising	26%	(8)
Reform the EPR scheme	23%	(7)
Avoid undue burden or negative consequences from regulation	19%	(6)
Improve transparency across supply chains	19%	(6)
Promote ecodesign (obligations)	16%	(5)
Support better collection of WEEE	16%	(5)
Support collaboration and knowledge exchange	16%	(5)
Other	16%	(5)
Further support R&D	13%	(4)
Support a market for secondary materials	13%	(4)
Improve policy coherence	13%	(4)
Address inconsistencies in waste legislation	13%	(4)
Increase the speed and ambition of policy changes	10%	(3)
Facilitate movement across borders	10%	(3)
Create EU standards/labels	10%	(3)
Improve green public procurement (GPP)	10%	(3)
Reduce distance between SMEs and policymaking at EU level	10%	(3)
Promote international standardisation & policy coherence	6%	(2)
Address illegal exports of e-waste	6%	(2)

4.1.2 Discussion

Several messages can be drawn based on the interviews with the 31 companies in the EEE sector and lessons from the CIRC4Life project. Increased financial support for circular activities and businesses was the suggestion provided by most of the companies interviewed, even though finance and economic factors were only the fourth most commonly mentioned category of barriers. This could reflect increased financial support possibly helping to alleviate issues in other areas. For example, barriers in other categories may entail additional costs or resources that may be easier to handle with increased financial support. Financial incentives could also help improve the business case for CEBMs overall, and could assist existing circular businesses and incentivise both new ones and linear companies to move towards circularity. Several options are available, such as dedicated project funding and economy-wide solutions like tax incentives, which were proposed by some of the companies interviewed. The importance of project funding for developing and piloting circular solutions was shown in CIRC4Life, where more circular production, efforts to promote sustainable consumption and recycling were all demonstrated. Nevertheless, not all companies may be able to access these funding sources and further support for scaling up such solutions could be useful to promote the circular economy. As such, other economic incentives may be needed.

Beyond economic incentives, several companies interviewed also wished for further policy support for circular business models and activities. Such policy support could take various forms, from obligations to incentives and efforts to increase demand. For example, targets for circular public procurement could help create a larger market for circular solutions and ensure demand for them. In terms of obligations, these could help address a variety of barriers. For example, the 'right to repair' initiative that is part of the EU circular action plan might help support various circular activities. Requirements on recycled content would be another approach that could help support especially the recycling of materials. Yet these are only a few of the measures that could be effective in supporting the circular economy. Revision of existing legislation also comes into play in this regard, such as the WEEE Directive and Ecodesign Directive, the former of which was identified as a barrier among the companies interviewed.

Most of the companies interviewed experienced supply chain barriers. Difficulties in accessing products, components or materials, restricted company loops and lack of transparency were the most common ones mentioned. As such, policy efforts to improve these aspects could be helpful in supporting circular business models. Encouraging transparency across supply chains could be one important avenue for policymakers. Depending on implementation, it could provide valuable information to consumers and actors in the value chain, such as those engaged in repairs, refurbishment and recycling. The information could also potentially be utilised to verify sustainability claims or provide other types of information about products. Indeed, in the EU's circular economy action plan, a European data space for smart circular applications is envisaged, which may provide an "architecture and governance system to drive applications and services such as product passports, resource mapping and consumer information" (European Commission, 2020b, p. 21). Still, for traceability solutions to work well, having all actors in the value chain onboard and sharing information is important, including

manufacturers and suppliers of primary materials. These were not part of the CIRC4Life project and as such traceability of information regarding EEE across the supply chain was only partially demonstrated.

Related to a need for enhanced transparency, providing reliable information to consumers remains important. In this regard, labels or standards at the EU level may be most effective. Various consumer surveys that took place during the CIRC4Life project indicated that labels can increase consumer confidence in circular processes, while consumers appeared to put more trust in labels with the EU logo (see Michelena & Ledroit, 2019). While labels were developed and tested in CIRC4Life, it became clear that these would be most effective if implemented across similar products and at a larger scale. This would enable consumers to more easily differentiate between similar products and compare their sustainability information. Adoption on a larger scale could also help people become familiar with the information displayed and could thus require less effort on the side of the consumer in a longer-term perspective. For companies, one EU-wide scheme could also be advantageous over different national or regional ones, as it could simplify the systems and standards they would need to adapt to.

4.2 Agri-food sector

4.2.1 Policy effectiveness and gaps

In the agri-food sector, around half of the interviewees had a generally positive view regarding the effectiveness of the current policies in place to support circularity in the sector. Two key factors were brought up as the reasons for this positive view. The first related to the product ecolabels and especially the EU-wide ones that, according to some interviewees, have improved consumers' perceptions of the reliability of their products. The other key factor concerned the Covid-19 recovery process and the policy momentum around both the pandemic and the climate crisis, which are creating a favourable environment for investments in circularity and sustainability. The remaining companies were either negative towards the existing policies or had an indifferent view. An issue raised was that the speed of adoption of policies is often slow and not consistent with the speed of innovation in the sector. Another was that existing policies do not support re-utilisation of food waste sources in the sector, while the Novel Food Regulation (EU) 2015/228 was identified as a piece of legislation that has not been implemented consistently across the EU.

A variety of different policy gaps and proposals were pinpointed by the companies. Three key ideas brought forward by two companies each (see Table 31) were to "incentivise sustainable agriculture and food production", "support increased standardisation or certifications" and "increase financial support for circular activities/companies". With regard to the first action point, there was a view that in general policymakers should identify policy tools that take into account the full negative impacts of agri-food companies' business models and encourage them to produce in a more sustainable way. A specific example raised during the interviews of a policy tool that could encourage more sustainable production was a carbon tax, which would ensure that companies and consumers pay for the external costs of food production. Concerning the

second suggestion on standardisation, one company argued that companies should report the environmental impact of their products in a more standardised way. As showcased during the CIRC4Life project implementation, tools to account for the environmental impacts of products across their full lifecycle stage already exist but in the absence of a standardised way to report this information consumers can get confused. It was also noted that there is currently a gap related to the lack of an official and independent system to guarantee the reliability of food producers' green declarations. Finally, in relation to the third proposal on financial support, companies mentioned the need for incentives to support investments in low-carbon technologies as well as subsidies for cultivating organic vegetables and fruits.

Moreover, there were 11 additional policy gaps and suggestions brought up by the companies, each of which was only mentioned once but which convey notable points. One interviewee raised the need to identify mechanisms to better engage small companies in EU public stakeholder consultation processes and EU policymaking in general, while another proposed improving coherence across different policy domains such as those on health, agriculture and food. In another case it was put forward that local authorities of different member states need to better collaborate so as to help countries where CEBMs are currently being developed to learn from countries where they are already well-established. One interviewee noted that policies that incentivise instead of prohibit the utilisation of food waste and agricultural by-products as raw material for different uses are required. It is worth noting that during the CIRC4Life it has not been possible to use collected meat waste for other uses beyond anaerobic digestion due to the legal rules in place.

Table 31. Agri-food policy gaps and suggestions (% of firms (number)), N=8[40]

Policy gaps and suggestions	Firms	
Incentivise sustainable agriculture and food production	25%	(2)
Support increased standardisation or certifications	25%	(2)
Increase financial support for circular activities/companies	25%	(2)
Reduce distance between SMEs and policymaking at EU level	13%	(1)
Improve policy coherence	13%	(1)
Support collaboration and knowledge exchange	13%	(1)
Incentivise productive use of food waste	13%	(1)
Need for specific EU legislation	13%	(1)
Awareness raising	13%	(1)
Review legislation more frequently	13%	(1)
Avoid undue burden or negative consequences from regulation	13%	(1)
Improve GPP	13%	(1)
Increase number and quality of audits	13%	(1)
Increase stakeholder engagement in policymaking	13%	(1)

[40] Note that not all firms provided input to this question, and as such the percentage is calculated as a share of the total that answered the question. Multiple categories may be counted for each firm; thus the total does not add up to 100%.

Another company held that there is a need for specific legislation for the use of black soldier fly frass as fertiliser, to be applied consistently across the EU member states. A further case elicited the view that more education/awareness campaigns, especially targeted at public administrations, are required. One interviewee noted that the pieces of legislation on the use of food waste and agricultural by-products should be reviewed and updated more frequently. In one case it was stated that excessive bureaucracy – which is a big burden for small companies like organic farms – should be avoided. Improving the use of GPP across the EU, increasing the number and quality of audits for the food industry and increasing stakeholder engagement in the process of developing new rules for using of food waste and agricultural by-products were three other suggestions aired.

4.2.2 Discussion

Based on the analysis of company case studies several key barriers and enablers to implementation of CEBMs in the agri-food sector can be identified. Although the sample size is relatively small, the interviews enable us to capture useful insights about the factors influencing adoption of circularity practices by companies in the sector and identify areas where there are policy gaps as well as how they could be addressed through concrete actions.

Finance and economic factors alongside policy and regulation were the most frequently mentioned categories of barriers in the sample. With regard to the former category, it appears that various companies face hurdles stemming from the higher costs entailed by more sustainable or circular approaches, while others have difficulties accessing the investment funds required for new circular innovations. Competition with the largest agri-food companies that have well-established production models and face lower production costs is a related challenge faced by small companies attempting to establish a circular process. This implies that despite the existence of several funding instruments across the EU, there is still large scope for introducing forms of financial support to support companies, and especially small ones, in making the transition to a CEBM and competing with other companies in the sector implementing more traditional models.

Concerning the policy category of barriers, a key factor was bureaucracy and administration, in particular the specific requirements for using leftovers from agri-food production as by-products or in another case the procedures for receiving subsidies for the production of organic food. In other cases, specific barriers stemming from national legislation were raised, such as laws prohibiting the sale of biofuels to other farmers or rules not allowing the use of food waste or agricultural production residues in by-product creation applications. This indicates that in many cases the goals of different pieces of legislation on food production and consumption may not be consistent with circularity objectives.

Supply chain and consumer/societal awareness were the two other most frequently categories of barriers. From a supply chain perspective, an important constraint experienced by the sampled SMEs is the difficulty of establishing partnerships with other organisations in order to fully roll out their CEBMs. This shows that effective implementation of a CEBM in the agri-food sector is often contingent upon the involvement of different supply chain actors, which can be

sceptical towards a new circular solution coming from an SME with low bargaining power or a small established business network. On consumer/societal awareness, there is still a segment of consumers that is not interested in agri-food products produced through more circular approaches. Reasons for this include a preference for products they were already familiar with, the cost of more sustainable products and lack of trust regarding the environmental benefits of these products. The CIRC4Life project has shown that the latter can often be attributed to the consumer's difficulty in understanding how the environmental impacts of products are calculated via lifecycle assessment tools.

Barriers can also stem from technological factors and company organisation as shown in the sample. Challenges of technological nature were particularly encountered in the CIRC4Life project. It was observed that although digital solutions like traceability tools and QR codes providing information about the environmental impacts of products can be developed and in some cases are already available, their application across all actors in the supply chain is not easy. Large (e.g. supermarkets) and small actors (e.g. farms producing organic vegetables and fruits) may have different technical capacities and their needs should be taken into account at the early stages of development of such solutions; otherwise, there may be imbalances across supply chains or even exclusion of small actors from some circular solutions. From a company organisation perspective, the project illustrated that particularly for small companies, lack of technical know-how and small internal capacities can contribute to limited engagement in circular solutions or even in initiatives with financial resources available, such as CIRC4Life.

The study furthermore provides evidence on critical factors that can support the transition to a CEBM (i.e. enablers). Policy appeared to be the most important barrier in terms of frequency of mention in the sample; however, this is largely attributed to the different forms of EU or national financial support raised by interviewees such as funding for R&I projects and subsidies for more environmentally-friendly production. In conjunction with the financial constraints appearing to be a major barrier in the sector as discussed earlier, our findings underline the crucial role that access to finance through support programmes and incentives can play in motivating companies to transition to a new model. EU-wide ecolabels were perceived to have a positive influence on consumers' trust in these products. High-level strategies such as the EU Green Deal were also identified as enablers by some companies, especially for communication purposes. Consumer/societal awareness also appeared to be a fundamental enabler in the sample with many interviewees observing a positive change in the demands of both their business-to-business customers and final business-to-consumer consumers. This indicates that there is a divide between the preferences of consumers, since the low interest of a consumer segment in more sustainable products and services is also a barrier as noted above. Notably, the CIRC4Life project has demonstrated that the use of labels enabling consumers to compare the environmental impacts of different products can have a positive influence on consumer demand for these products provided that these impacts can be well-understood (as discussed earlier).

Interviewees furthermore raised economic factors as enablers. These included competitiveness advantages from entering a new market for circular approaches, opportunities for diversifying the business activities and identifying new sources of income and economic benefits through utilising food waste or unused organic matter. Company organisation was also seen as an enabler by various companies with interviewees emphasising the significance of having internal commitment towards circularity objectives as well as motivated owners and employees. Technology and supply chains were the two other enabler categories raised in the sample. With regard to the former, it appears that innovations in areas such as food proc essing and technologies enabling utilisation of by-products from agri-food production can encourage companies to consider the adoption of a CEBM. The use of technical tools as part of CIRC4Life, for instance traceability modules and LCA tools, also helped participating companies to better trace the carbon footprints of their products. Under the supply chain category, key enabling factors were the establishment of partnerships and forms of industrial symbiosis where waste and by-products from some companies became a useful resource for others.

4.3 Policy recommendations

Based on the insights gathered, four key policy recommendations emerge that are applicable for both the EEE and agri-food sectors.

R1. Increase the use of different forms of financial support for circular activities and businesses. The higher costs of more circular approaches as well the lack of access to financial resources for such innovations emerged as prominent barriers in the samples for both the agri-food and EEE sectors. In addition, the need to increase financial support for circularity was highlighted by companies from both sectors. This indicates that despite the array of instruments at the EU and national levels in place to provide support for circular activities, significant barriers of a financial nature persist. Various other studies[41] have identified lack of financial support as a barrier to the circular economy transition and our findings reiterate this conclusion. Forms of financial support that can be further utilised include tax incentives, increased use of GPP and R&I funds. With regard to the latter, EU and national programmes financially supporting circular innovations and projects like CIRC4Life was an important enabler identified, illustrating the effect of such instruments.

R2. Better align requirements stemming from different pieces of legislation with an impact on circularity. In both the EEE and agri-food sectors it was observed that requirements stemming from different policies, often from diverse policy domains, frequently may not support circularity goals. Specifically, various companies mentioned challenges in recovering and recycling materials from assorted types of EEE equipment due to the strict rules and administrative requirements emanating from EU chemicals legislation. In the agri-food sector, it was reported that using leftovers from agri-food production in by-product applications is very restricted due to the EU or national laws in place prioritising food safety.

[41] See for example, Rizos et al. (2016), Kirchherr et al. (2018) and Salmenpera et al. (2021).

These findings indicate that effort should be made to identify these policy conflicts and trade-offs, as well better align the goals of different pieces of legislation that have an impact on circularity.

R3. Improve consumers' understanding of the benefits of circular solutions. Although companies identified a positive consumer trend towards circular solutions as an important enabler, there is still a segment of consumers that is not interested or does not trust them. The CIRC4Life project has demonstrated that although there are already some solutions in the market, consumers have difficulties in understanding how their environmental impacts are assessed (e.g. through LCAs), which may have an effect on their trust. This suggests that awareness-raising measures, communicating the environmental benefits of such solutions in easy-to-understand language and how these are calculated, can have a positive impact on demand. As shown in the CIRC4Life demonstrations, product labels can also serve as a reliable source of information about the environmental impact of products and increase consumers' motivation to choose those produced through more circular processes.

R4. Support transparency and traceability across the supply chain through solutions involving all actors. A lack of transparency and traceability regarding products and their associated environmental impacts, components and substances was a barrier in our study for companies operating a variety of CEBMs.[42] The European Commission envisaged in its 2020 circular economy action plan the development of a digital product passport to address this challenge, indicating that improving transparency across supply chains is a priority area. One notable lesson from CIRC4Life is that while traceability tools and solutions already exist, all actors would need to be involved – from suppliers of primary materials, to producers and recyclers – for such solutions to roll out. Otherwise, there could be missing data at different points of sale preventing the achievement of full traceability. Another lesson from a technical point of view is that such solutions would need to be designed in a way that all actors across supply chains could adopt them, including small companies that do not have large capacities or the technical know-how.

[42] Lack of transparency across supply chains has been identified by various other authors such as Vanner at al. (2014), Rizos et al. (2018) and Vermunt et al. (2019).

References

ALIA (2019), "Report on pathways for the reuse and recycle food waste", Deliverable 2.2, CIRC4Life – A circular economy approach for lifecycles of products and services.

Bakas, I., M. Herczeg, E. B. Vea, A. Fråne, L. Youhanan and J. Baxter (2016), "Critical metals in discarded electronics. Mapping recycling potentials from selected waste electronics in the Nordic region" Denmark, Nordic Council of Ministers.

Bovea, M.D., V. Ibáñez-Forés, V. Pérez-Belis, P. Quemades-Beltrán (2016), "Potential reuse of small household waste electrical and electronic equipment: methodology and case study", *Waste Management*, 53, pp. 204-217

Cerulli-Harms, A. et al. (2018), "Behavioural Study on Consumers' Engagement in the Circular Economy - Final report".

Crippa, M., E. Solazzo, D. Guizzardi, F. Monforti-Ferrario, F.N. Tubiello and A. Leip (2021), "Food systems are responsible for a third of global anthropogenic GHG emissions", *Nature Food*, Vol. 2, pp. 198-209.

CSES, KMU Forschung Austria, IDEA Consult, Prognos AG, DECISION Etudes and Conseil (2020), "Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation", Study for the European Commission – Executive Agency for Small and Medium-sized Enterprises.

De Jesus, A. and S. Mendonça (2018), ''Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy'', *Ecological Economics*, Vol. 145, pp. 75-89.

Demestichas, K., E. Daskalakis (2020), "Information and Communication Technology Solutions for the Circular Economy", *Sustainability*, Vol. 220, 12, 7272.

Desing, H., D. Brunner, F. Takacs, S. Nahrath, K. Frankenberger and R. Hischier (2020), ''A circular economy within the planetary boundaries: Towards a resource-based, systemic approach'', *Resources, Conservation and Recycling*, Vol. 155, 104673.

EEA (European Environmental Agency) (2020), "Electronic products and obsolescence in a circular economy", Eionet Report – ETC/WMGE 2020/3.

EEA (European Environmental Agency) (2021), "Europe's consumption in a circular economy: the benefits of longer-lasting electronics" (https://www.eea.europa.eu/publications/europe2019s-consumption-in-a-circular/benefits-of-longer-lasting-electronics).

Elia, V., M.G. Gnoni and F. Tornese (2020), ''Evaluating the adoption of circular economy practices in industrial supply chains: An empirical analysis'', *Journal of Cleaner Production*, Vol. 273, 122966.

Ellen MacArthur Foundation (2018), "Circular Consumer Electronics: an initial exploration".

Ellen MacArthur Foundation (2019), "Cities and Circular Economy for Food".

Ellen MacArthur Foundation (2021), "The big food redesign: Regenerating nature with the circular economy".

European Commission (2014), Commission Work Programme 2015 – A New Start, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2014) 910 final.

European Commission (2015), Closing the loop – An EU action plan for the Circular Economy, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2015) 614 final.

European Commission (2019), The European Green Deal, Communication from the Commission to the European Parliament, the Council, the European Council, the European Economic and Social Committee and the Committee of the Regions, COM(2019) 640 final.

European Commission (2020a), Guidance to Member States Recovery and Resilience Plans, Commission Staff Working Document, SWD(2020) 205 final, Part 1/2.

European Commission (2020b), A new Circular Economy Action Plan for a cleaner and more competitive Europe, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020) 98 final.

Eurostat (2021a), "Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E)" (https://ec.europa.eu/eurostat/databrowser/view/SBS_NA_IND_R2__custom_981894/default/table?lang=en).

Eurostat (2021b), "Recycling rate of e-waste", (https://ec.europa.eu/eurostat/databrowser/view/T2020_RT130/bookmark/table?lang=en&bookmarkId=a69be825-957e-473c-a81f-f02866dc9141).

Eurostat (2021c) "Waste electrical and electronic equipment (WEEE) by waste management operations" (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_waselee&lang=en).

Esteban, J., and M. Ladero (2018), "Food Waste as a Source of Value-Added Chemicals and Materials: A Biorefinery Perspective", *International Journal of Food Science & Technology*, Vol. 53, pp. 1095-1108.

FAO (2011), "Energy-smart food for people and climate", FAO, Rome.

FAO (2013), "Food wastage footprint; impacts on natural resources. Summary Report", FAO, Rome.

FAO (2015), "Food Wastage Footprint & Climate Change", FAO, Rome.

FAO (2016), "State of the World's Forests 2016, Forests and agriculture: land-use challenges and opportunities", FAO, Rome.

FAO (2018), "Food loss and waste and the right to adequate food: making the connection", FAO, Rome.

FAO, IFAD, UNICEF, WFP and WHO (2020), "The State of Food Security and Nutrition in the World 2020: Transforming food systems for affordable healthy diets", FAO, Rome.

FAOSTAT (2021), "Land Use" (http://www.fao.org/faostat/en/#data/RL/visualize).

Forti, V., C.P. Baldé, R. Kuehr and G. Bel (2020), "The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential", United Nations University (UNU)/United Nations Institute for Training and Research (UNITAR) – co-hosted SCYCLE Programme, International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn, Geneva, Rotterdam.

Fowles, T. and C. Nansen (2020), "Insect-Based Bioconversion: Value from Food Waste", in E. Närvänen, N. Mesiranta, M. Mattila and A. Heikkinen (eds), *Food Waste Management*, Palgrave Macmillan, Cham.

Gnanasagaran, A. (2018), "E-waste chokes Southeast Asia", Basel Action Network (https://www.ban.org/news/2018/11/5/e-waste-chokes-southeast-asia).

Gurunathan A., P. Shanmugam, G. Mark and M. Kaliyan (2021), "Reuse assessment of WEEE: Systematic review of emerging themes and research directions", *Journal of Environmental Management*, Vol. 287.

Hill, J. (2015), "The circular economy: From waste to resource stewardship", Part I, *Proceedings of the ICE – Waste and Resource Management*, ISSN 1747-6526/E-ISSN 1747-6534, Vol. 168, No. 1, pp. 3-13.

Hill, J. (2016), "Circular Economy and the Policy Landscape in the UK", in R. Clift and A. Druckman (eds), *Taking Stock of Industrial Ecology*, Springer, Cham (doi.org/10.1007/978-3-319-20571-7_13).

IPCC (2019), "Summary for Policymakers", in *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*.

Kirchherr, J., L. Piscicelli, R. Bour, E. Kostense-Smit, J. Muller, A. Huibrechtse-Truijens and M. Hekkert (2018), "Barriers to the Circular Economy: Evidence rrom the European Union (EU)", *Ecological Economics*, Vol. 150, pp. 264-272.

Kosnic and ONA (2021), "On-site Demonstration for industrial and domestic lights", Deliverable 6.1, CIRC4Life – A circular economy approach for lifecycles of products and services.

Lacko, R., Z. Hajduová, M. Zawada (2021), "The Efficiency of Circular Economies: A Comparison of Visegrád Group Countries", *Energies*, Vol. 14, 1680.

Linder, M. and M. Williander (2017), ''Circular Business Model Innovation: Inherent Uncertainties'', *Business Strategy and the Environment*, Vol. 26, pp. 182-196.

Merli, R., M. Preziosi and A. Acampora (2018), "How do scholars approach the circular economy? A systematic literature review", *Journal of Cleaner Production*, Vol. 178, pp. 703-722.

Miliute-Plepiene, J. and L. Youhanan (2019), "E-waste and Raw Materials: from Environmental Issues to Business Models", IVL Swedish Environmental Research Institute.

Michelena, O. and E. Ledroit (2019), "Report on Consumer Satisfaction Surveys", Deliverable 3.4, CIRC4Life – A circular economy approach for lifecycles of products and services.

Nguyen, H. (2018), "Sustainable Food Systems: Concept and Framework", Food and Agriculture Organization.

NTU (2020), "Report of sustainable design and manufacturing methods", Deliverable 1.5, CIRC4Life - A circular economy approach for lifecycles of products and services.

PACE and World Economic Forum (2019), "A New Circular Vision for Electronics – Time for a Global Reboot".

PACE (2021a), "Circular Economy Action Agenda: Electronics".

PACE (2021b), "Circular Economy Action Agenda: Food".

Parajuly, K., R. Kuehr, A. Awasthi, C. Fitzpatrick, J. Lepawsky, E. Smith, R. Widmer and X. Zeng (2019), "Future E-waste Scenarios", StEP (Bonn), UNU ViE-SCYCLE (Bonn) & UNEP IETC (Osaka).

Patton, M.Q. (2002), *Qualitative Research & Evaluation Methods*, 3rd ed., Thousand Oaks: Sage Publications.

Poore, J. and T. Nemecek (2018), "Reducing food's environmental impacts through producers and consumers" *Science*, Vol. 360, pp. 987-992.

Purola, A. (2019), ''Living Labs Concepts and Implementation Plan for CIRC4Life-project", Deliverable 7.1, CIRC4Life – A circular economy approach for lifecycles of products and services.

Rizos, V., A. Behrens, E. Drabik, D. Rinaldi and K. Tuokko (2018), ''The Role of Business in the Circular Economy'', Report of a CEPS Task Force, CEPS, Brussels.

Rizos, V., A. Behrens, T. Kafyeke, M. Hirschnitz-Garbers and A. Ioannou (2015), "The Circular Economy: Barriers and Opportunities for SMEs", CEPS Working Document No. 412, CEPS, Brussels.

Rizos, V., A. Behrens, W. van der Gaast, E. Hofman, A. Ioannou, T. Kafyeke, A. Flamos, R. Rinaldi, S. Papadelis, M. Hirschnitz-Garbers and C. Topi (2016), "Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers", *Sustainability*, Vol. 8, No. 11.

Rizos, V., J. Bryhn, M. Alessi, A. Campmas and A. Zarra (2019), "Identifying the impact of the circular economy on the Fast-Moving Consumer Goods Industry: opportunities and challenges for businesses, workers and consumers – mobile phones as an example", Study for the European Economic and Social Committee.

Rizos, V., K. Tuokko and A. Behrens (2017), "The Circular Economy: A review of definitions, processes and impacts", CEPS Research Report No. 2017/08, CEPS, Brussels, April.

Salmenpera, H., K. Pitkanen, P. Kautto and L. Saikku (2021), ''Critical factors for enhancing the circular economy in waste management'', *Journal of Cleaner Production*, Vol. 280, 124339.

Saunders, M., P. Lewis and A. Thornhill (2009), *Research methods for business students*, 5th ed., Edinburgh: Pearson Education Limited.

Schischke, K., M. Proske, N. Nissen, M. Schneider-Ramelow (2019), "Impact of modularity as a circular design strategy on materials use for smart mobile devices", *MRS Energy & Sustainability*, Vol. 6.

Schmittner, S. and G. Schwering (2019), "Development Report and Documentation for Traceability Components and Tools", Deliverable 5.2, CIRC4Life – A circular economy approach for lifecycles of products and services.

Shahbazi, S., M. Wiktorsson, M. Kurdve, C. Jönsson and M. Bjelkemyra (2016), "Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies", *Journal of Cleaner Production*, Vol. 127, pp. 438-450.

Stenmarck, Å., C. Jensen, T. Quested and G. Moates (2016), "Estimates of European food waste levels", FUSIONS EU project.

Trigkas, M., G. Karagouni, K. Mpyrou and I. Papadopoulos (2020), "Circular economy: the Greek industry leaders' way towards a transformational shift", *Resources, Conservation and Recycling*, Vol. 163, December 2020, 105092.

Tura, N., J. Hanski, T. Ahola, M. Ståhle, S. Piiparinen and P. Valkokari (2019), "Unlocking circular business: a framework of barriers and drivers", *Journal of Cleaner Production*, Vol. 212, pp. 90-98.

UNEP (2016), "Food Systems and Natural Resources", Report of the Working Group on Food Systems of the International Resource Panel.

UNEP (2019), "Frontiers 2018/19 Emerging Issues of Environmental Concern", United Nations Environment Programme, Nairobi.

UNEP (2021), "Food Waste Index Report 2021", United Nations Environment Programme, Nairobi.

Vanner, R., M. Bicket, S. Withana, P. ten Brink, P. Razzini, E. van Dijl, E. Watkins et al. (2014), "Scoping study to identify potential circular economy actions, priority sectors, material flows & value chains", Study prepared for the European Commission, DG Environment.

Velenturf, A.P.M and P. Purnell (2021), "Principles for a sustainable circular economy", *Sustainable Production and Consumption*, Vol. 27, pp. 1437-1457.

Vermunt, D.A., S.O. Negro, P.A. Verweij, D.V. Kuppens and M.P. Hekkert (2019), ''Exploring barriers to implementing different circular business models'', *Journal of Cleaner Production*, Vol. 222, pp. 891-902.

Vieira, J. and T. Shannon (2020), "Life Cycle Assessment of Apeel Produce", Apeel Sciences.

Voss, C., N., Tsikriktsis and M. Frohlich (2002), ''Case Research in Operations Management", *International Journal of Operations & Production Management*, Vol. 22, pp. 195-219.

Wilson, K. and H. Lindén (2021a), ''Report on Demonstrations of CEBMs", Deliverable 6.5, CIRC4Life – A circular economy approach for lifecycles of products and services.

Wilson, K. and H. Lindén (2021b), "On site demonstration of CEBM for meat supply chain", Deliverable 6.4, CIRC4Life – A circular economy approach for lifecycles of products and services.

About the CIRC4Life project

CIRC4Life is an EU-funded project that has developed and demonstrated new circular economy business models in the electrical and electronic equipment and agri-food sectors. The new business models have targeted four different product groups, namely computer tablets, LED lights, organic vegetables and meat products. The business models aim to engage consumers in the transition towards a circular economy using 3 approaches: co-creation of products and services with end-users, sustainable consumption and collaborative recycling/reuse. For information on the project, see https://www.circ4life.eu/.

List of partners