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UNVEILING DRIVERS & BARRIERS TOWARDS CIRCULAR ECONOMY: A MULTIPLE CASE STUDY ON NORWEGIAN EPS MANUFACTURERS

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To all I feel my family

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ABSTRACT

Plastic waste is a huge problem for our environment. Apart from the problem of mismanaged waste that may pollute terrestrial, freshwater and marine ecosystems, the limited recycling opportunities for different plastic types is also an issue.

EPS is a widely used type of polystyrene with an estimated European market value of 1,884 kiloton in 2020. Due to its physical and chemical characteristics it has several applications, including packaging (e.g. fish transportation), Styrofoam production and utilisation in the construction sector (buildings as well as roads).

The task of this thesis is to investigate the main drivers and barriers that influence the transition of Norwegian companies towards a cradle-to-cradle approach in the EPS sector.

To reach this object, the transition towards CE has been analyzed considering the circular business model concept in order to take into consideration the economic, environmental and social perspectives.
Moreover this thesis intends to increase the people's awareness about EPS, trying to directly contribute to reduce EPS environmental impact.

Key-words: EPS, Circula Economy, Barriers & Drivers

ABSTRACT

I rifiuti di plastica sono un problema enorme per il nostro ambiente. Oltre al problema dei rifiuti mal gestiti che possono inquinare gli ecosistemi terrestri, d'acqua dolce e marini, anche le limitate opportunità di riciclaggio per i diversi tipi di plastica sono un problema.

L'EPS è un tipo di polistirene molto usato, con un valore di mercato europeo stimato a 1.884 kiloton nel 2020. Grazie alle sue caratteristiche fisiche e chimiche ha diverse applicazioni, tra cui l'imballaggio (ad esempio il trasporto del pesce), la produzione di polistirolo e l'utilizzo nel settore delle costruzioni (edifici e strade).

Lo scopo di questa tesi è quello di indagare i principali driver e le barriere che influenzano la transizione delle aziende norvegesi verso un approccio cradle-to-cradle nel settore EPS.

Per raggiungere questo obiettivo, la transizione verso la CE è stata analizzata considerando il concetto di modello di business circolare al fine di prendere in considerazione le prospettive economiche, ambientali e sociali.

Inoltre questa tesi intende aumentare la consapevolezza delle persone sull'EPS, cercando di contribuire direttamente a ridurre l'impatto ambientale dell'EPS stesso.

Key-words: EPS, Economia Circolare, Barriere e Driver

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BM	Business Model
B2B	Business to Business
B2C	Business to Customer
CAGR	Cumulative Average Growth Rate
CBM	Circular Business Model
CE	Circular Economy
EPS	Expanded Polystyrene
EUMEPS	Association for European Manufacturers of Expanded Polystyrene
LCA	Life Cycle Assessment
XPS	Extruded Polystyrene

1. INTRODUCTION – EPS MARKET IN EUROPE

1.1 Market View of EPS

Expanded Polystyrene (EPS), is a plastic type that is created starting from polystyrene as raw material. Its structure is composed of 98% air and 2% polystyrene. With the aim of emphasizing this characteristic, the Association for European Manufacturers of Expanded Polystyrene (EUMEPS) named it also "AIRPOP engineered air" in 2014 (EUMEPS, n.d.-b).

Starting from a wide view, the European expanded polystyrene (EPS) market was estimated to be 1,844 kiloton in 2020, and it is estimated to register a Cumulative Average Growth Rate (CAGR) of over 4% by 2026 (PlasticsEurope, 2020). The European expanded polystyrene market is concentrated, with the top 5 players accounting for over 50% of the production capacity in Europe. These five main players are BASF SE, Ravago, Sunpor, Bewi Synbra Group and Synthos. Looking at the coutry level, Germany is leading production at a worldwide level, with more than 15% of the global production. The other main European countries in this sector are Netherlands, France and Belgium (Mondor Intelligence, n.d.).

Looking at the demand side, EPS represents approximatively 3% of the overall European plastic distribution in 2019 viewing a small raise from 2018 (PlasticsEurope, 2020). This percentage value varies for each country. In absolute terms, Germany is the largest consumer of EPS in Europe, while relatively speaking, Denmark is the European country with the highest ratio between EPS and plastic consumed (Thornberry, 2020).

EPS consumption in Norway is about 70'000 tons, according to the Norwegian EPS association.

1.2 EPS Applications

The range of EPS applications is very wide, including construction and insulation, fish-boxes, electrical goods and pharmaceutical packaging, beehives and components production. Thus, all the EPS utilisations, to be better analysed, are clustered into construction, packaging, component and product applications. The four applications greatly vary in terms of EPS tonnes consumed. From the PlasticsEurope Conversion report, the construction sector represents about 80% of the European EPS demand, being undisputed the first EPS consumption industry (PlasticsEurope, 2020). Packaging usage has been measured to account for 20% of overall demand, while the EPS production for products and components is negligible (PlasticsEurope, 2020).

An interesting fact is that Norway shows an opposite trend as the average European one is, having the packaging sector, with 60% of market shares, as the leading EPS application before the construction industry, with the rest 40%, according to the Norwegian EPS Association. This outstanding characteristic in Norway is mainly driven by the tight bond between the aquactulture and EPS fish boxes.

1.2.1 Construction

In the construction industry, the EPS, thanks to its strength, durability, lightweight nature and good insulating properties, is applied for different uses, like thermal and acoustic insulation, roads or bridges infrastructure thanks to which it allows to give both stability and flexibility, absorbing possible land movements. In recent years, due to the European Commision target of increasing the Energy Efficiency by 2030 by 32.5%, in comparison to the 1990 level, trying to contrast the global warming problem, the EPS utilization in the construction market has been increasing (European Commission, 2020a). Indeed, buildings in the EU are responsible for 40% of our energy consumption and 36% of greenhouse gas emissions, and EPS, as a building component, used for both building construction or renovation, could allow to drastically reduce the households carbon emissions thanks to its good insulating properties (European Commission, 2020b).

Because EPS holds superior qualities over insulation alternatives, the EPS European market in the construction sector is expected to have an CAGR of 5% in the next five years in terms of volume sold (BEWI, 30 September 2021).

In Norway, according to Norwegian EPS Association, about 30’000 tons of EPS are used in the construction sector every year.

1.2.2 Packaging

According to the Norwegian EPS Association, Packaging is the most used EPS application in terms of volume in Norway

Some of the reasons of its very broad utilization in this sector are (Thornberry, 2020):

- It is relatively cheap;
- It works extremely well in terms of protecting items in transit;
- It adds very little weight to the consignment;
- It can provide a large degree of temperature stability;

On the other hand, after it has been used, its characteristics make it uncomfortable to be managed. Indeed the 98% of air makes little sense to transport it in its original form once it becomes a waste product.
The EPS is used along the whole supply chain, to delivery products from the factory to the warehouse or to transport them to the end-user.
Moreover, Airpop packaging is used in several industries, like automotive sector to transport fragile car components, electronic and electrical market and the fruit and vegetable industry.

At the European level, the packaging sector is forecasted to have a CAGR OF 4% from 2021 to 2026, growing in pace with demand for consumer goods, passing from 302'000 tons in 2021 to 365'000 tons in 2026 (BEWI, 30 September 2021).

Focusing more on the Norwegian situation, according to the Norwegian EPS association, most of the packaging is used for fish boxes, and they consist of about 40'000 tons per year, and are necessary to export seafood all over the world. Indeed, in Norway, there is a strong correlation between the packaging and aquaculture sectors, viewing the strong growth of the fishing industry boosting also the EPS one. For instance about 2.7 million tonnes of seafood were exported in 2019 (Norwegian Seafood Council, 2020).

In Norway, the recycling rate of these fish boxes is higher than 90% on average (EUMEPS, n.d.-a).

1.2.3 Components

Thanks to its shock and sound absorbency qualities and its low weight, EPS is a component of several car instruments, like car bumpers, dashboards structure and seats. Other applications as components are bicycle helmets, baby and child seats or surf boards (Thornberry, 2020).

Also for this sector, the CAGR is expected to be 5% in the following five years in the European market, due to the utilsation of EPS allows to reduce the weight, increase the fuel efficiency and improve safety (BEWI, 30 September 2021).

The EPS component volumes are negligible in Norway.

1.2.4 Products

Widespread EPS products are beverage cups, takeaway food and ice-cream con tainers and disposable containers for fish bait. Other uses for EPS include molds, forms and voids, for use by the manufacturers of items such as tubing and bespoke components for engineering uses and electrical equipment (Thornberry, 2020).

However, thanks to the EU Directive on the reduction of certain plastic products in favour of the environment, that entered in force on 3rd July of 2021 and that bans several single-use plastics, some specific EPS products like cups or takeaway food containers, are going to decrease their shares (European Commission, 12 June 2019).

Like for the component sector, these specific EPS products are not as relevant as the construction and packaging sector in Norway and will therefore not be the focus in this thesis.

1.3 EPS market actors

Given the broad range of applications, in order to satisfy such a high demand level, the network of EPS suppliers is as expansive as the users` one. EPS Manufacturers and Transformers, about 1,000 companies, are represented at EU level by EUMEPS. Indeed, 23 national associations of EPS in Europe, composed of EPS converters, raw material and additive suppliers, recyclers and machinery providers, create all together EUMEPS (EUMEPS, n.d.-c).

The Norwegian EPS Association is composed by 14 EPS manufacturers.

The size of the EPS manufacturing companies varies. In EUMEPS, most of the firms are small and medium-sized enterprises (SMEs), with a discrete percentage of family-run businesses, that usually supply local markets. At the same time, the operation systems size varies a lot among EPS producers, passing from production lines of few machines to bigger facilities, national or international, producing a wide variety of EPS components, packaging, and customized products (EUMEPS, n.d.-c).

Geographically speaking, the manufacturers positions in all countries reflects the EPS characteristics, seeing companies allocated really close to the market they serve.

Indeed, being composed of 98% of air, EPS is uncomfortable to be transported, arising the need to minimize the distance from the manufacturing site to their end-use location.

An interesting example that confirms this point is the BEWI plant producing EPS fish boxes in Frøya (Norway) that is located only a few kilometers from the Salmar salmon factory, to minimize transportation costs and package the fish as freshly as possible.

Italy has the highest number of EPS manufacturers in Europe. However, although such a large number of companies, Italy is not in the top five exporter countries, mostly due to a lower EPS quality of its exports (Thornberry, 2020).

Looking at the Norwegian situation, according to its national EPS association, the total number of EPS manufacturer is 15, where 14 out of these 15 are part of the association.

1.4 Waste Management

After the use phase, EPS has three alternatives:

- Landfilling: EPS disposal.
- Recycling: process that uses EPS wastes to manufacture products.
- Waste to Energy (WtE): process that generates energy through the EPS incineration.

Looking at the European level, of the 335,000 EPS tonnes consumed in 2015, 27% was recycled, 33% landfilled and 40% incinerated (Thornberry, 2020).

In Norway, of the 6,392 EPS tonnes collected in 2018, 70% was recycled , 29,6% was incinerated and the remaining part was landfilled. Moreover, it is interesting to notice that 90% of the recycled EPS came from the fishing industry (Thornberry, 2020). The whole 70% of recycled EPS is send to European countries to be recycled.

1.4.1 Recycling

Recycling can occur in two main ways (Thornberry, 2020):

I. Taking the waste EPS from production and customer take-back services and putting it through the manufacturing process again (EUMEPS advised this as standard practice); or
II. Recycling the compacted EPS into another EPS product, such as insulation, or putting it through an injection-moulding process or other process to manufacture a new PS product. In this path EPS could be subjected to chemical process to be made suitable for the production of other polystyrene objects.

At the European level, the most common recycling processes are (BEWI, 30 September 2021):

a. Recycling extrusion: it is the well established mechanical recycling process and it is the first process used in Europe. It allows to obtain EPS or Extruded Polystyrene (XPS) as final products. EPS and XPS from mechanical recycling are generally used in the construction sector.
b. Dissolution process: It is a physical process, not chemical due to it does not interact with the EPS molecule. It consists of a separation process that removes impurities and other plastics from EPS, reaching a higher quality recycled product. For this reason dissolution allows for more contaminated feedstock. The phase after the dissolution is the extrusion operation.
c. Chemical recycling: The core oeration of the chemical recycling is the depolymerization, i.e.breaking EPS down from polymer to monomers.

In Europe, according to Thornberry (2020), highly recycling countries are UK, Germany and the Netherlands, while low recycling capacity states are Ireland, Sweden or Switzerland. Norway does not have any recycling plants today, and so all used EPS products are compacted locally and sent to be recycled abroad. Those recycled materials do not come back to Norway.

This high variation in the recycling capacity among European countries is explained by the fact that EPS is usually exported to be recycled in nations such as the Netherlands and Germany, which have enough recycling capacity.

The compacting activities are made near the collection point on-site before being transported abroad (EUMEPS, 2018a).

Figur 1.1 - EPS Compactor in a Fish Plant in Norway

An interesting point is the difference between the Business to Business (B2B) and the Business to Customer (B2C) markets in terms of EPS recycling organization and infrastructures. This diversity is mainly driven by different degree of complexity, awareness and processes between the two supply chains.

Indeed, the B2B market has usually better EPS waste management systems, including reuse, recycle and disposal processes. Some of the factors that enable this superior organization are (Thornberry, 2020):

- Large volumes of industrial waste that allow to reach economies of scale;
- The possibility to forecast reasonably the production waste quantity in order to invest in infrastructure (machines, resources and labor) for the EPS treatment.
- The type of waste is known in advance, be it packaging or construction waste;
- Levels of contamination can be predetermined and therefore deemed acceptable, such as that relating to EPS fish-boxes;
- Businesses have to comply with EU Packaging Directives and in many countries, there are mandatory packaging compliance schemes.

Instead the B2C supply chain, being more complex, has to deal with some factors that could make the EPS waste treatment operations more difficult. These adverse elements are (Thornberry, 2020):

- Lack of sufficient volumes to reach economies of scale. In fact, the production of EPS waste by a single household is low and it may not have a separate collection bin. Although the EPS waste volumes of a city could reach a discrete quantity, specific activities for the waste treatment of EPS like collection and transportation are difficult to be carried out.
- Contamination. Especially for the packaging industry, EPS items are usually contaminated by food that could compromise their recyclability or decrease the quality of the recycled end-product.
- Lack of awareness. The majority of final users do not know how to collect the EPS waste properly, mistakenly throw it in the wrong bin and not allowing its recycling. At the same time the customers willingness and awareness about environmental issues impacts on the EPS recyclability degree, changing how people inform themselves about possible collection points or recycling initiatives made available by the local authorities. Unfortunately, the

perception that EPS is either, difficult to recycle or is not suitable for recycling at all, still persists by consumers, and, although in a lower level, by many businesses and industry organizations.

1.4.2 Incineration

Incineration is seen as a better waste solution than landfills, especially for all those items that were contaminated by food and so not able to be recycled.

The issues of EPS for incineration is the high Calorific Value (CV). Indeed, having a higher CV, EPS burns faster than the other garbage typologies, increasing the average operating CV of the plant. In this way the incineration system reaches faster its thermal capacity, decreasing the amount of waste that the plant can burn. This problem has led some European incinerators not to accept too much EPS waste, making its after-use treatment more difficult (Lassen, February 2019).

Incineration is the main alternative undertaken in the B2C market, when collecting home wastes. This fact is caused because EPS is not separated by the other waste types when thrown away and by the possible crumbling of EPS waste during the compacting operation. Therefore, incineration results as the best choice from an economic point of view.

1.5 Environmental Issues

The triple bottom line model by John Elkington is initially used to address the EPS sustainability issues in order to highlight also the possible social and economic problematics that could arise from the Airpop usage in addition to the environmental ones (Mukhopadhyay & B.K.Mukhopadhyay, 2020). However in literature, only the environmental sphere is deeply treated, leaving a gap for the social and the economic perspective.

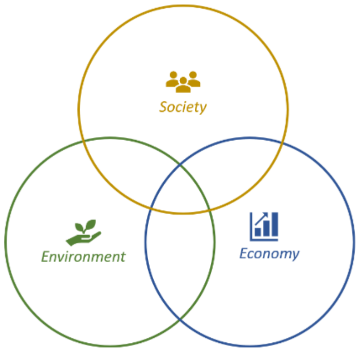


Figure 1.2 - Triple Bottom Line Model

- *Environmental impacts* – The main risk of this sphere is represented by the possibility of EPS of becoming marine litter, polluting the environment and being ingested by animals that mistakenly considered it to be food. Other environmental issues related to the EPS network are greenhouse gas emissions and other impact chategories, that are already analyzed by EPS companies and associations through the LCAs that they perform on the different EPS products. For instance, looking at the early stages of the EPS supply chain, the whole European polystyrene production consumes around 36,500 barrels of crude oil per day (Ten Brink & Howe, October 2016).
- *Social impacts* – Risk to human health, especially in the marine environment, because if EPS is mistakely realesed in the environment, it coud be ingested by animals that are then eaten by people. The social impact, although the low risk degree, could negatevly affect the public health (Institute for European Environmental Policy, 2017).
- *Economic impacts* – The presence of marine litter on the environment could impact on non-correlated EPS sectors, like tourism (Van Sluis, 2014). Moreover, the increasing awareness of people about the presence of microplastic in the water could lead to negative effects on the fishing industry, decreasing the demand. Indeed, in the European Commission opinion, the tourism and recreation industry and fisheries are the main affected sectors in monetary

terms by plastic pollution, with costs of up to € 630 million and € 62 million, respectively (Van Sluis, 2014).

1.5.1 Marine Litter

For the EU fishing fleet the total cost of marine litter, considering every type of garbage, is € 61.7 million per year (Van Sluis, 2014).

The EPS, due to its many applications, has a high probability of becoming littered. Indeed, one of the uses with the highest likelihood for Airpop to enter in the sea, it is when it is used directly in contact with the marine environment, like for net floats. At the same time EPS can easily reach the sea due to losses during land applications, after it has been transported by wind or water flows (Thornberry, 2020). Looking at its physical characteristics, EPS is buoyant, having lower density than the water. Thus, it is subject to all the climate factors, being easily crumbled and distributed globally.

Indeed, the EPS low physical stability and flexibility make it more subject to mechanical degradation than other plastics types, becoming marine debris and crumbling more and more into small particles (Thornberry, 2020).

In Norway, the annual total volume of microplastic emission, in general, is approximately 8.000 tones, with a great share that could reach water bodies or that is directly lost in the sea (Norwegian Environment Agency, 4th December 2014).

The degradation phenomenon leads to two possible environmental issues. The first mechanism that could harm the marine organism is the ingestion of small EPS parts because wrongly confused as food. The second damaging consequence of the fragmentation process is the leak in the environment of chemical components that are present in the EPS (Lassen, February 2019). Those hazardous chemicals could be:

- Impurities from manufacturing retained in the materials,
- Environmental degradation products of polymers or additives,

- Plastic additives like flame retardants added to the materials during manufacturing,
- Chemicals from the surrounding environment that can be adsorbed to the plastic.

Additives are chemicals that are added during manufacturing to enhance the properties of the plastic for its specific purpose. The main additives in EPS are flame retardants added for building materials and some electronics products.

In the past hexabromocyclododecane (HBCDD) was the main flame retardant used for EPS, with a concentration up to 1%. However, due to HBCDD is not covalently bound to the polymer, it can easily be released from the plastic into the environment. For this reason, starting from 2016 thanks to the Stockholm Convention, its utilization was denied and other flame retardants took its place (UN Environmental Programme). One example is PolyFR, that has been analyzed and defined less environmentally toxic and less water soluble, however it takes more time to be disposed and its possible health and ecological impacts have not been already studied properly (Lassen, February 2019).

Fortunately, differently from the other typologies of marine latter, EPS does not represent a risk of entanglement for the animals

1.5.2 EPS losses along the whole supply chain

To understand how EPS becomes an environment threat, the supply chain stages has been analyzed to see where some EPS losses could occur (Lassen, February 2019).

In the first stage of the process, when polystyrene is not already expanded, plastic pellet releases could occur due to some mistakes during operations like transportation, production or loading into packaging (Lassen, February 2019).

To produce EPS, converters receive pellets that are going to be expanded.

EPS may be released from conversion and transport along the following pathways (Lassen, February 2019):

- Releases through doors and gates to the surrounding and outdoor drains
- Releases during loading and unloading of trucks
- Losses during transport (i.e. on ships)

During the use phase, the level of EPS losses is negligible (Lassen, February 2019).

The end of life stages are the EPS lifecycle steps that have the highest likelihood of losses, from the disposal to the waste treatment. In this part of the supply chain, the risk of becoming an environmental litter diverges depending on the EPS application. Indeed EPS waste coming from construction and insulation has a lower risk than EPS garbage from marine uses, demolition sites or the take-away industry. Take-away packages, especially rely on the customers` responsibility, have a high probability of being dispersed in the environment. According to a review of European beach litter survey, food containers (including EPS packaging) account for 4.5% of the whole litter on the beaches (Addamo, 2017).

At the same times releases of EPS could happen during several waste treatment actions, such as waste collection, transportation and separation.

Speaking about reverse supply chain, some operations of the recycling process, could lead to EPS losses, like waste collection, transportation, compression and other steps inside the recycling system.

Another distinction that can be made based on the risk of becoming a marine litter is between B2C and B2B market. Usually, moving along to the supply chain, EPS items that have as final user a customer have a higher probability of environment release than the ones supplied and used by business. This difference is mainly driven by the lower complexity degree of B2B supply chain and also the strict regulations that business have to respect, like the extended producer responsibility (EPR) for packaging recycling.

Looking at the Norwegian situation, thanks to the Grønt Punkt Norge scheme, both industries and municipalities collaborate to prevent the harmful effects of the EPS losses (EUMEPS, 2018a).

Some possible measures to reduce the EPS losses in the environment could be:

- Enhance waste collection management in the construction industry, to both decrease EPS and chemical components releases from demolition and renovation.
- The already mentioned EU Directive that denies the utilization of single use plastic can have a great positive impact as a prevention of marine litter.
- EPS could be substituted in the manufacturing of sea floats to reduce the direct contact with the marine environment and the consequential losses.
- Improvement of the attention and technical skills in all the operations of waste management that are likely to release EPS in nature.

1.6 Ongoing Projects on reducing EPS environmental impact

As seen above, the space of action to prevent and reduce the environmental impact of EPS is still broad. Indeed, specific industry organizations and authorities are incentivizing some projects with the hope of reducing EPS harmful effects.

One of the most powerful regulation in the plastic field, and already mentioned, is the EU Single-Use Plastic Directive. This Directive prohibits, for instance, the production of all the EPS take-away packages and cups, reducing the likelihood of those items to become marine litter, and limiting their food contamination that could prevent their recyclability (European Commission, 12 June 2019).

Another relevant turning point was during the Basel Conference of the Parties in 2019, where governments modified the Basel Convention to include plastic waste in a legally-binding framework which will make global trade in plastic waste more transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment (UN Environmental Programme). This modification makes plastic regulations more stringent, leading Europe to think new and more sustainable strategies for plastic, as well as EPS collection and recycling. For sure this commitment will impact also on the re-design of most of plastic items and their supply chains, improving the plastic circular economy (UN Environmental Programme).

At the same time EUMEPS, submitting a Voluntary Pledge to the EU Plastic Pact, set specific targets to be reached by 2025 with the aim of enhancing the recycling degree of several EPS items in all the member countries (EUMEPS, 2018b). The targeted recycling rates per application are:

- EPS Fish-boxes – 50%
- EPS Protective Packaging – 50%
- Building Deconstruction – 27%
- New Build and Renovation – 80%
- Civil Engineering and New Build and Deconstruction – 90%

It's estimated that the volume of "waste" EPS by 2025 will be 560,000 tonnes per year and the overall targeted or pledged recycle rate is 46%. More specifically the total estimated recycling quantity by EUMEPS will be 257 kt, with a total recycling quota for building and construction waster of 38% and total recycling quota for packaging waste of 50%.

Finally, at a worldwide level, the Operation Clean Sweep, started in the autumn 2017, is an ongoing commitment through which various actors, on voluntary base, prevent plastic pellets loss in the environment along the whole supply chain (PlasticsEurope, 2019). Obviously this program requires effort and a strong collaboration of all partners and stakeholders of the plastic sector. Some of the developed implementations towards this hard goal are the enhancement of workers skills and internal procedures, performances audit to monitor operations trends and an increased partnership among actors of the supply chain.

2. LITERATURE REVIEW

A literature review of the circular business model (CBM) concept has been carried out, to give definitions of this theory and to show the importance that this concept represents nowadays within companies, especially when the transformation toward CE, with correlated structural and logistics change, has to be implemented.

The literature review was conducted using the SCOPUS database for paper collection. The strings "circular" AND" business" AND" model" were considered to obtain all papers on the researched topic. A first filtering phase was conducted; thus, the results were filtered by:

- Year: considering only papers from 2010
- Language: considering only "English" and "Italian" as paper language
- Subject: taking into consideration only "Environmental Science", "Engineering, Business, Management and Accounting", "Energy", "Decision Sciences" and "Economics, Econometrics and Finance".

In a second filtering phase, papers were filtered by journal ranking, then by title and abstract, and ultimately screened by their content's relevance. In the end, a cross-reference snowballing approach was adopted to include other papers to the identified set of publications.

2.1 Business model

The concept of business models became famous starting from 1990s, when the emerging e-commerce developed new revenues streams (Christoph Zott, 2011).

Indeed, in its first attempts, a BM is used to explain in a simplified but complete way those new mechanisms to investors.

The business model can be defined as simplified representations of the elements of a complex organisational system and the interrelation between these elements. It determines the organisation's value proposition, value creation, delivery, and value capturing and aims at analysis, planning, and communication in face of increasing complexity (Geissdoerfer et al., 2018).

In other words, Zott et al. (2011) define the BM as a system level concept, centred on activities and focusing on value, allowing to understand how a firm manages its activities to create value. Teece (2010) declares that BM is the "design or architecture of the value creation, delivery, and capture mechanisms" of a business.

2.2 Circular Economy

The concept of Circular Economy (CE) was first defined and conceptualized in the Ellen MacArthur Foundations report (2013), as "an industrial system that is restorative or regenerative by intention and design".

CE derives from environmental economics and industrial ecology with a focus on technological innovation.

It tries to close the loops of traditional "take, make, dispose" linear models to minimise the resources utilisation, increase as much as possible the product lifetime exploiting its intrinsic value and minimising the wastes (Stahel, 2016).

The modern understanding of the Circular Economy is based on different schools of thought, such as Cradle to Cradle, Laws of Ecology, Looped and Performance Economy, Regenerative Design, Industrial Ecology, Biomimicry, or the Blue Economy (Geissdoerfer et al., 2018).

The Cradle to Cradle concept, which is adopted in this thesis work, is based on three main principles (Ünal et al., 2018):

(i) Eliminate waste,
(ii) Use renewable energy,
(iii) Celebrate diversity (local production and supply chain).

For these reasons CE is considered a solution for waste generation, resource scarcity, and sustaining economic growth (Geissdoerfer et al., 2018).

Within the current literature, circular economy has been studied considering three different analysis level (Merli et al., 2018):

- Macro-perspective: it is based on policy maker and legislations;
- Meso-perspective: it studies the several and structural changes that are needed to implement CE within the supply chain and the company's network;
- Micro-perspective: it focuses on how companies move from their linear business model (BM) to a circular one (CBM), considering CE principles.

Focusing more on the micro perspective, the concept of CBM has been studied extensively over the years. Indeed, a circular business model, that, differently from the linear and traditional one in which the product value is lost after the usage phase, aims at preserving not only the product or service economic value, but also the environmental one ((Clift & Druckman, 2015);(Nußholz, 2017)). Bocken et al. (2016), more environmentally oriented, define the CBM as a BM that incorporates elements that slow, narrow, and close resource loops to decrease the company's resource input and minimise the waste and emissions. Instead, incorporating also the social dimension, CBM has the potential to lead to private and social benefits in addition enhancing the customer value (Boons & Lüdeke-Freund, 2013). For Stubbs and Cocklin the cooperation among stakeholders and their interests alignment, thank to the value creation in the environmental, social and economic dimensions is a key point of the CBM (Stubbs & Cocklin, 2008).

Moreover, several studies in the literature, analyse the proper way to appply CE concepts without focusing on the BM components.

Mentink (2014) defines CE as "an economic system with closed material loops" and a CBM "the rationale of how an organization creates, delivers and captures value with and within closed material loops" that, differently from the previous business models, does not aim at balancing the economic, environmental and social needs. Another interesting literature contribution is the Linder and Williander' one, that declares a CBM as "a business model in which the conceptual logic for value creation is based on utilizing the economic value retained in products after use in the production of new offerings.

2.3 Business Model Changes

Due to the increasing importance of CE concept and the instrumental need of creating and capturing value from CE principles (for instance by redesign products and processes, by creating new partnerships or revenues streams) the transition from traditional BM to CBM is exhaustively treated in the literature, under a theoretical perspective.

However, considering a more practical perspective, there is a significant gap in knowledge.

An increasing number of research is focusing on the business model innovation (BMI) to reach a more sustainable business. For example, Schulte (2013) states that if a company aims to become more circular, both organisational and technological or product innovations are needed.

More specifically, by definition BMI is an organizational process that aims at modifying and enhancing the business model of a company due to internal or external factors (Geissdoerfer et al., 2018). While Osterwalder and Pigneur (2010) think a BMI as an instrumental tool to implement changes thanks to its usefulness and easiness in analysing, structuring, planning, and communicating in face of the increasing complexity of organisational configurations and activities.

More specifically, focusing on organisational changes towards CE, Gauthier and Gilomen (2015) define different levels of transformation that a company can undertake to modify its BM:

> (1) Business model as usual—if there are no transformations to business model elements.
>
> (2) Business model adjustment—if marginal modifications to one element of BMs occur.
>
> (3) Business model innovation—if major BM transformations are implemented.
>
> (4) Business model redesign—if a complete rethinking of organizations' BM elements results in radically new value propositions.

Some studies also define the elements of the company business model that should be modified to reach a sustainable innovation.

Boons and Lüdeke-Freund (2013) declare that changes in four BM component are needed :

- Value proposition - to reflecte the balance of economic, ecological and social needs.

- Supply chain – to engage suppliers into sustainable supply chain management (materials cycles).
- Customer interface – to motivate customers to take responsibility for their consumption.
- Financial model - to reflect an appropriate distribution of economic costs and benefits among actors involved in the business model.

Mentink (2014), similarly to Boons et al., states that to develop a more circular model, the following changes have to be implemented:

- Value propositions (what?)— Products has to be redesigned to become fully recyclable or reused.
- Activities, processes, resources and capabilities (how?)—Redesigning the operations, activities, network and adding the reverse supply chain is necessary and it requires structural changes in the company resources.
- Revenue models (why?)— New revenues streams can be exploited.
- Customers or customer interfaces (who?) – A company, introducing circular products, may have to target different customers clusters than missing word.

There are other academic compositions related to tools and methods to perform a BMI toward CE. As an example, Renswoude et al. (2015) create a business model scan, a methodology to help organisations to perform the transition into a more circular business model, based on six stages in which several questions are asked. Value proposition, design, supply, manufacturing, use, and next life are the topic of the questions (Joustra, April 2015). Instead, the inventors of the business model canvas define five stages of the design process to create a CBM, that are mobilise, understand, design, implement and manage (Osterwalder & Pigneur, 2010). The business model canvas has been used to study and apply circular business models over the years.

Differently from what mentioned before, few studies pinpointe that the transition towards a CBM involves two main components of a business model ((Ünal et al., 2018); (Urbinati et al., 2017)). The first one is the value creation, that is the way how an organization creates value, from the supply chain to the key network relationships management (Konietzko et al., 2020).

In this area, an organization, if it encompasses CE principals, could preserve economic and environmental value, through the efficient usage of resources and closed loops (Nußholz, 2017). Indeed, in CBM, value creation includes maintenance of products and processes, the combination of resources and materials and the purchasing of upcycled waste, the total recycling of resources, the dematerialization of products, and on-demand production processes (Lewandowski, 2016).

Moreover, in the value creation part of a CBM, companies design and create a product following the eco-design principles in order to achieve a long-term sustainability (Geissdoerfer et al., 2018).

The second dimension that is involved in this transformation process is the value capture, defined as the practices to capture the value, so to convert the value creation into economic value (Franzò et al., 2021).

So, the value capturing can be performed by a company through additional revenues streams, with cost reduction or value preservation (Nußholz, 2017).

At the same time, in a CBM, value capture has to allow companies to preserve natural resource and social wellbeing (Geissdoerfer et al., 2018).

Recently, Centobelli et al. add, to the previous two dimensions, the value transfer, a third instrumental dimension that has to be consider in the BM change towards CE, and that contains managerial practices for customer segmentation and customer relationship management (Centobelli et al., 2020).

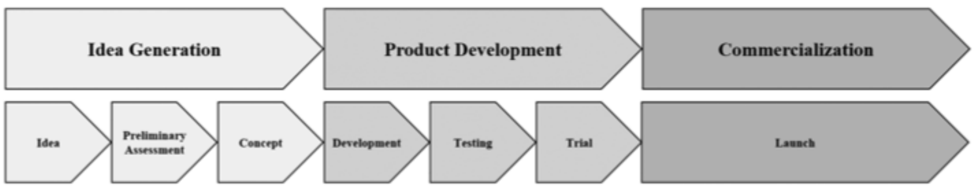
2.3.1 Product Development Model toward CBM

A recent and interesting process toward a CBM, that consider both product development and circular economy concepts is the one developed by Franzò et al. (Franzò et al., 2021).

This model, that I will use as the main project structure to define the barriers and drivers that arise when moving toward a cradle-to-cradle approach in the EPS market, defines three main stages that an organization has to pass through:

1. Idea generation: the moment during which the firm decides to undertake the CE transition, usually defining and conceptualizing the circular product;
2. Product development: in this phase the company develops the new circular product and the operations needed.
3. Commercialization: the company launch its new circular product into the market.

This process by (Franzò et al., 2021) is created clustering the phases of the products' lifecycle Cooper's model (Cooper, 1983) into the three main ones explained above.



Figur 0.1 - Phase Model for analysing circular economy transition in new product development by Franzò et al. (2021)

Moreover Franzò et al., thanks to the empirical analysis performed, define the main managerial practices for each of three main phases (Franzò et al., 2021). For the idea generations and product development phases the main practices are the selection of partners along the supply chain and the intervention on key activites (production system). Instead, looking at the commercialization stage, offering the right value to the right customer (selection of customer) is the principal practice performed by a company moving toward CE.

Applying the already mentioned practices to the EPS sector, the two most important practices that a company has to address are the *intervention on key activities* and the *selection of stakeholders along the supply chain.*

For this reason, a literature review for these two practices is performed.

2.3.1.1 Intervention on key activities

To perform the transition to CE, in terms of material flows, relevant changes in the organisation are needed, from incorporating sustainability principle in the product design to the reshaping of operations.

So operations management is a key activity to perform the shift toward CE, due to it makes decision on how performing structural changes from the product development to production and supply chain management to incorporate reverse cycles, cascading, reuse and remanufacturing processes (Batista et al., 2018). Therefore, also resource and capabilities of a company have to be reshaped to be adapted to new BM.

The main challenges that arise in the operation management when moving to CE are the uncertainty regarding the quality, quantity and timeframe for return of materials and components to be remanufactured, refurbished or reused, in addition to the cost and revenues analysis of the new closed-loop supply chain (Milios et al., 2018). At the same time the complexity of the organisation logistic increases due to higher amount of partnerships that are instrumental to close the loop, due to the information exchange and collaborations (Herczeg et al., 2018).

2.3.1.2 Selection of stakeholders along the supply chain

Why are partnerships extremely important in circular economy?

For Singh and colleagues, to create a CBM, innovations are needed (Singh & Ordoñez, 2015), and the new capabilities to such innovations come from stakeholders' network. Moreover the type of relationships is another relevant aspect in circular economy, due to this new business model requires a systems approach (Bocken et al., 2016). So, a company that wants to perform the transition toward CE, has to create new partnerships and network than the already existing ones (Ünal et al., 2018), to discover and exploit new instrumental capability capabilities to implement a circular innovation, thus creating value.

Indeed, CE requires to shift the attention from company as individual to a company as part of a network based on collaborations among valuable stakeholders (Veleva & Bodkin, 2018). Obviously, as Tukker affirms, implementing in reality a circular business is a hard challenge due to the supply chain complexity increase, risks raise and uncertainties coming from the different partnerships (Tukker, 2015).

The reverse supply chain implies redesign in operations, product and distribution, that increases the overall complexity and that requires so collaborations among the several actors along the whole supply chain and non-industry partners (Bocken et al., 2016).

The advantages of partnerships, for Hong et al. (2008), are the increase in the market knowledge and margins, and the following mastery of reverse logistics operations by the company . As well, Bernon et al. (2018), emphasize that logistics imposes inter-organizational collaboration since a firm cannot fully implement reverse logistics on its own.

However, the lack of empirical studies on partnerships and reverse logistics implementations is still a literature gap. Indeed, although CE has been introduced by quite time, we still know little about which collaboration channels are more fruitful for a firm to introduce reverse logistics and whether many collaborations would be better than fewer ones.

2.4 Barriers & Drivers of Circular Economy

In this case the literature was conducted using the SCOPUS database for paper collection. The strings "circular" AND "economy" AND "barriers" OR "drivers" were considered to obtain all papers on the researched topic.
Both of the two filtering phases were conducted exactly as for the previous literature review.

Due to the transition process proposed by Franzò is an emerging model (Franzò et al., 2021), specific barriers and drivers for each of the three main phases has not been treated in literature yet. For this reason, a literature review of the factors that can inhibit or favour the adoption of CE practices in a general context is performed. In the literature, drivers are all those factors that enable or encourage the transition of companies towards a Circular Economy (e.g. incentive regulations, scarcity of resources, volatility of prices etc.). Instead barriers are those factors that hinder the transition of companies to a Circular Economy (e.g. financial capability, managerial adversity to change, regulatory disincentives, etc.) (De Jesus & Mendonna, 2018).

Following the same approach of Tura and colleagues (2019), both drivers and barriers are grouped into seven main categories, as made in Table 3.4 and 3.5.

Table 0.1 - Circular Economy Barriers

BARRIERS			
CATEGORY	BARRIER	REFERENCES	DESCRIPTION
ENVIRONMENTAL	-	-	-
ECONOMIC	Lack of financial capability and support	Bechtel et al. (2013); Gumley (2014); Rizos et al. (2017)	Many general complaints about access to funding and finance.High initial investments driven by structural changes needed, i.e. supporting infrastructure for CE (e.g. reverse logistics), R&D, and the certification and compliance processes needed for new CE models.
	Lack of tools and methods to measure long-term benefits of CE		Low capability of measuring long-term CE benefits. This barrier can generate financing problems.
	High investments costs ad the time needed for breakeven	Gumley (2014); Metta and Badurdeen (2013) ; Urbinati et al. (2021)	High initial investments driven by structural changes needed, i.e. supporting infrastructure for CE (e.g. reverse logistics), R&D, and the certification and compliance processes needed for new CE models.
SOCIAL	Lack of social awarness (or misleading)	Bechtel et al. (2013) ; Liu and Bai (2014)	Low awarness of product characteristics (i.e. recyclability degree, environmental impact) by customers
INSTITUTIONAL	Complex and overlapping regulation	Bechtel et al. (2013); Gumley (2014)	This includes an absence of global consensus around policy support for CE, and a lack of targets beyond the basics of landfill diversion
	Lack of governmental support		The lack of a consistent regulatory framework
TECHNOLOGICAL AND INFORMATIONAL	Lack of information and knowledge to perform transition toward CE	Bechtel et al. (2013); Rizos et al. (2017);	Lack of knowledge to redesign product and operations in more sustainable way
	Lack of technologies and technical skills		Technical challenges regarding material recovery

	Uncertainty about quantity and quality of products from reverse supply chain	Cooper and Gutowski (2015); Urbinati et al. (2021)	A low quantity in the reverse supply chain could not justify CE investmentS
	High product complexity	Despeisse et al. (2017); Metta and Badurdeen (2013); Franco (2017); Urbinati et al. (2021)	High level of product complexity (both in terms of materials used and number of components) could increase the difficulty in performing the Rs practises, as well as the related reverse logistic management.
SUPPLY CHAIN	Lack of partnerships and collaboration along the supply chain (industrial inertia)	Bechtel et al. (2013); Gumley (2014); Rizos et al. (2017);	Lack of interest, knowledge/skills and engagement throughout the value chain (suppliers, customers, and internal).
	Supply chain complexity in terms of geographical boundaries and number of partnerships	Bechtel et al. (2013) Despeisse et al. (2017); Gumley (2014) ; Urbinati et al. (2021)	A high numerosity or a high dispersion of customers and/or supply chain partners increase transportation costs, as well as logistic management complexity, especially in industries where focal firms rely on numerous third parties along the supply chain.
	High required customisation	Govindan et al., 2016; Metta and Badurdeen (2013); Urbinati et al. (2021)	A high customization level may imply difficulties in implementing circular economy practices.
	High speed of change of market requests	Franco (2017); Urbinati et al. (2021)	Industry with a high innovation degree may not be favorable for long-lasting product
	Fear of risks	Bechtel et al. (2013); Despeisse et al. (2017); Gumley (2014)	Managers' risk adversity could discourage the experimentation of circular business model.
	Lack of managerial support		CE practices implementation may be obstacle by a non favorable managment

	High organisational inertia	Liu and Bai (2014) ; Urbinati et al. (2021)	Organizational inertia (e.g., related to big companies with highly structured and established mechanisms, also including players along the supply chain) can be a brake on the adoption of new business models.

Table 0.2 - Circular Economy Drivers

DRIVERS			
CATEGORY	**DRIVER**	**REFERENCES**	**DESCRIPTION**
ENVIRONMENTAL	Raw materials constraints and opportunity to reduce environmental impact	Ellen MacArthur Foundation (2013); Ghisellini et al. (2016); Murray et al. (2017)	The circular approach offers developed economies an opportunity to reduce dependency on resources due to reduced impact on virgin material extractions
ECONOMIC	Improvement of the value capture (cost reduction, new revenues streams,..)	Ghisellini et al. (2016); Liu and Bai (2014); Murray et al. (2017); Rizos et al. (2017)	Reuse and better design in a circular economy can significantly reduce the material bill and the expense of disposal
	New economic/market opportunities		Businesses that provide circular solutions and services along the reverse cycle have more attractive growth opportunities
	Resource price reduction	Ghisellini et al. (2016)	High price of raw materials or components represents an incentive for implementing CE practises.
	High volatility of input resources' price	Geng et al. (2012); Urbinati et al. (2021)	Highly volatile prices of raw materials or components is an incentive for implementing CE practises.
SOCIAL	Potential to increase the recyclability awareness degree of the product	Mathews and Tan (2011)	Increase customers' awarness about product recyclability and environmental gains
	Creation of new job opportunities		Creating a 'user-centric economy' especially in the tertiary

			(services) sector will lead to increased rates of innovation, employment, and capital productivity, all of which are important multipliers
INSTITUTIONAL	Supportive funds, taxation and subsidy policies		National or international supportive schemes
TECHNOLOGICAL AND INFORMATIONAL	Potential for improving existing operations	Ellen MacArthur Foundation (2013); Ghisellini et al. (2016); Mathews and Tan (2011)	Potential for improving existing operatons represents an opportunity to increase efficiency and reduce costs.
	New technologies		Design of new CE operations and machines
	Higher information share thanks to collaborations/partnerships		Value chain engagement activities are identified as way of overcoming cultural barriers
	Availability of technical solutions for CE practices	Bakker et al. (2014); Urbinati et al. (2021)	The availability of technical solutions is important for establishing an effective reverse supply chain, e.g., information and communication technologies are fundamental both for monitoring returned products and information sharing with reverse supply chain partners.
SUPPLY CHAIN	Strong partnerships along the supply chain	Bakker et al. (2014); Urbinati et al. (2021)	Collaboration with supply chain actors can drive toward joint value and innovations creation. Forming longer term relationships and partnerships is another way of developing value chain engagement, and also of resisting short-term blinkers
	Geographical proximity of supply chain partners/customers	Cooper and Gutowski (2015); Urbinati et al. (2021)	The geographical proximity of the supply chain partners/customers can facilitate the adoption of circular economy practicies
ORGANISATIONAL	Company image enhancement	Bocken et al. (2016)); Ellen MacArthur Foundation (2013); Geng et al. (2012)	The strenghtening of corporate image, due to the increasing sustainable attention by customers, can lead to some advantages, i.e. company's profits growth

	Development of skills and capabilities for CE (internal know-how)		Development of internal knowledge about CE practices
	Management environmental awareness	Bocken et al. (2016); Geng et al. (2012); Urbinati et al. (2021)	Management awareness of the environmental impact caused by current linear operations. If management shows sensitivity towards the environment and sustainability, a company will be more inclined to undertake circular practices.
	Competitive advantage	Ellen MacArthur Foundation (2013)	CBM requires structural changes that cannot be copied easily by competitors.

2.5 Literature Gap

The literature review about Circular Business Model and CE Drivers & Barriers has been performed to study and show the actual knowledge level in these fields in order to properly build the interview survey and so develop the empirical analysis.

However, performing the literature review activity, very few or no articles and papers about the CE implementation in the EPS sector have been found, and as a consequences, neither about CE drivers and barriers that companies have to challenge in the same field.

As previously seen, the circular economy concept is a well-established notion nowadays and indeed it is widely discussed, however studies of its implementation in several specific sectors, i.e. the EPS one, are still not properly carried out.

As mentioned in the introductive chapter, the circular economy possibility is well discussed among the actors of this market due to the economic, social and environmental improvements that it could lead to, however nobody has already deeply studied and published articles on how to develop it.

Therefore a literature gap about the circular economy in the European EPS sector is present, and more specifically the concepts that are not treated in articles and papers are:

- Motivations (drivers) that push companies, operating in the EPS market, to move from a linear business model to a circular one. So positive outcomes and improvements that a firm could gain from this logistic, conceptual and operating change deriving from the CE transition.
- Barriers that a company would challenge in the implementation of this more sustainable business model.

3. RESEARCH QUESTIONS & THEORETICAL FRAMEWORK

As seen in the literature view chapter, and more specifically in the literature gap, the way, with all the challenges correlated, how an EPS manufacturer can transform its BM into a CBM is not properly treated. Indeed, almost none of the many CE academic compostitions has already tried to study the concepts and knowledge about the CBM transformation in the EPS sector, even though its positive economic trends and all the EPS characteristics mentioned above.

Indeed circular economy is an emerging object in this sector, that is taking more and more relevance among this industry actors, due to benefits and advantages that it could lead to, however it is still not considered in the literature, as shown in the literature review above.

Therefore, trying to cover the literature gap that has been found in the previous chapter, the research questions are:

- *What are the main drivers and barriers that a company has to address while trying to develop a circular business model in the EPS sector?*
- *What are the main changes that a firm should undertake from a organisational and logistic point of view to be able to perform a circular business model?*

Answering those two research questions should lead to a clear picture of why and how a company is able to perform this transition towards a cradle-to-cradle approach in EPS market nowadays, also discovering the real motivations that push a company to start this process. At the same time, the research questions could help finding a unique or several alternatives of improvement and understanding how much the EPS industry will push toward the circular concept.

Moreover, trying to be more precise and consistent, the project analysis and the answer of those two research questions are focused on the EPS packaging sector, omitting the other three expanded polystyrene applications.

Based on the previous literature review, the phase model for analysing circular economy transition in new product development by Franzò et al., has been taken as the 'model' to perform this project analysis (Franzò et al., 2021). The reasons are:

- It allows to emphasise the idea of transformation from a linear to a circular business model.
- It allows to consider the consequent changes that a firm has to implement to carry out this transition.
- It allows to divide into sequential stages those changes.
- It allows to understand if some companies are ahead than others towards CE.
- It allows to be specific to the EPS sector and relative products.

Therefore, the idea is to study how a company, that wants to become circular, operates through the three main phases of this product development model, spotting the drivers and barriers for each phase.

4. METHODOLOGY

First of all a literature review of the current studies and report about EPS has been performed to gain a base knowledge about this topic. The idea beyond that analysis was to show the current European EPS market trends and characteristics, while spotting the main doubts, processes and challenges of this plastic type. This work was extremely useful to create an overall general picture of the present EPS situation in Europe.

To define the already drivers and barriers that firms have addressed till now in their willingness and attempt to create a circular economy, a literature analysis of the CE barriers and drivers have been computed. This analysis resulted helpful in creating the companies interview model and in understanding if the EPS sector presents diverging enabler or hindering factors from the other researched realities.

Both geographical and product boundaries has been set with the aims of clearly defining the project outline and being more precise.
Geographically speaking, the EPS sector has been narrowed to the European zone. This decision has been made primarily because it is the market zone in which the interviewed companies and associations operate. Possible market connections outside the Europe, due to the complexity and internationalisation characteristic of this industry, are recognised and treated if it is considered necessary.
For what concerns the product, only EPS in the packaging application has been analysed, excluding the other three usages as mentioned in the previous literature view.

This 'horizontal cut' in the project boundaries has been made because EPS applications are deeply heterogenous, with specific sector characteristics and dynamics for each of them.
More precisely, the *component* and *product* applications (as defined in the literature analysis), represent a negligible percentage of the whole EPS sector, and so they have been drifted away from the analysis.
The EPS construction sector, that owns as many market shares as the packaging one, has not been taken into consideration due to its different features related to the market and supply chain, that would require a separate and individual analysis. Indeed, the main divergent dimensions between the packaging and construction markets are:

- Product lifespan: The EPS packages have a lifetime that varies from few days to about one year, instead the EPS for construction scope has a lifespan of some decades due to it lasts till the house is renovated or demolished. So the difference in the lifespan in relevant.
- Supply chain complexity: Due to the higher amount of actors involved in the packaging sector, its supply chain results more complex than the construction one. Indeed, starting from the EPS manufacturer, several customer's levels can be found for the packaging application (i.e. wholesalers, shops, final customer), while only few or no one (if the EPS manufacturer also performes the construction operation) in the building sector.
- Customer: The EPS idea and perception that the final customer owns about EPS is mainly caused by the EPS packaging, because it is the only EPS type the customer comes into contact. Moreover the collection activity of EPS packaging in the Business to Customer (B2C) market is still one of the main challenges.
- Legislation: Product certifications, like the possibility of using or not recycled EPS, varies a lot between these two markets. This difference becomes stronger if considering an EPS package for food purpose.

- EPS characteristics: The different scope of the two markets also influences the physical properties that an EPS product must have. For instance, the maximum percentage of recycled material that can be reached in the EPS for construction scope is higher than in EPS packages. This is mainly driven by the fact that EPS packages must have a perfect shape (i.e. perfect package corner) and higher resistance, both characteristics that cannot be reached with too high value of recycled EPS in the product.

4.1 Multiple case study

The empirical analysis, and so how to answer to the research questions, is based on multiple case studies. Case studies are rich, empirical descriptions of particular circumstances of a phenomenon that are typically based on a variety of data sources (Yin, 2003).

This approach has been chosen because is more appropriate to address complex organizational, managerial, and other business issues, which are difficult to study with quantitative methodologies (Ghauri & Gronhaug, 2010). Indeed, a circular economy development leads to multiple and complex changes in a company's business model that are extremely difficult to be quantify, especially if no one has already implemented it.

Therefore a qualitative approach has been carried out, because it allows higher flexibility in design and applications of knowledge, and it is consequently more suitable for shaping the complexities of a multidiscipline phenomenon like circular economy. The selection of the companies under investigation has been perform following criteria, which allows for easy accessibility and availability of information at a given time (Voss et al., 2002).

The criteria for the case selection are:

i. Companies' size, whereby companies are homogeneous from the point of view of the market share. Only companies operating in at the European level were taken into consideration in order to properly consider all the circular economy possibilities.

ii. Companies' country, as the thesis has been developed in Norway, only Norwegian firms have been selected in order to have the possibility to meet them personally.

iii. Companies' business model, as the selected companies started their activity with, and still have, a linear business model, but they have already explicitly considered the transition toward circular economy.

iv. Companies' Products, as the analysed companies have to manufacture EPS fish boxes, the main material studied.

We evaluated the presence of such conditions by checking secondary sources, with particular reference to websites, press releases, and news about the companies and their circular products, companies' market acquisition. Moreover, these information have been double checked during first contacts with companies.

4.1.1 Data collection

The data collection phase lasted approximately 60 days.

In order to gather information to answer the research questions, three different companies, compatible with the criteria above, have been interviewed.

BEWI and Sundolitt have been interviewed personally in their offices and production plants in Norway, while Vartdal has been reached through an online meeting.

A great opportunity, and an added value, was to contact and directly interview the key managers that are responsible for the circular transition in their respective companies.

Indeed here follow the firm, the person interviewed and the place of the meeting:

- BEWI, Director of Sustainability Camilla Bjerkli, BEWI offices in Trondheim
- BEWI, Plant Manager Johan Ølstørn, BEWI plant in Frøya
- Sundolitt, Plant Manager Frank Wilhelmsen & Sales Manager Rolf Fagervoll, Sundolitt building in Ålesund
- Vartdal Plast, Product Manager Mounir El'Mourabit, Online meeting

A structured interview model has been created and then applied during the interviews. This scheme (Appendix 1) is mainly focused on discovering the importance and the influence of the drivers and barriers in the EPS industry when moving towards CE, while trying to be as much conversational as possible during the meeting. In order to create the interview structure to collect the data, the list of the drivers and barriers that have been questioned is taken by the literature reviewed earlier made.

Interviewing those companies was extremely helpful to discover and understand the incentives and barriers that arise when a company wants to become circular. Moreover, thanks to the meeting with firms operating in the EPS market, also the degree of importance of each enabling or obstructive factor towards circular economy has been gathered. In the next chapters, the relevance of each driver or barrier is defined through one, two or three asterisks, with '*' meaning low relevance and '***' high relevance.
At the same time it allowed to know deeper and in detail the dynamics of the EPS market and the specific philosophy and way of acting of each firm. Several practical examples, possible projects and challenges that those firms are addressing nowadays have been valuable to reflect about future solutions to develop circular processes.

As transverse help in the data collection phase, three EPS associations that are link with the companies interviewed, were contacted in order to better understand the general dynamics in this wide market and the context in which EPS companies operate.

Here follow the association, the person interviewed and the place of the meeting:

- EPS Norwegian Association, Senior Advisor Bengt Bøyesen, Online meeting
- EUMEPS, Advisor Carlo Marzorati, Online meeting
- Grønt Punkt Norge, Project Manager Are Magnus Adolfsen, Online meeting

Having the possibility of meeting those important associations was useful to understand the EPS industry from a wider view, creating a kind of net with all information gathered with the companies interviews.
An overall picture of the current international and Norwegian EPS situation has been discussed, making more clear the main obstacles for the companies in this sector. As showed, all the associations know and have contact with the three Norwegian firms met to develop the empirical analysis. Indeed their participation to this project was extremely useful also to gather an external view and opinion of the different enterprises interviewed, allowing to better evaluate their willing to become circular that exhibited during the meetings.

Moreover other interviews with foreign firms, operating at their country or international level in the the EPS industry, have been made in order to better understand the principles of this wide and interconnected market and to try to spot some particularities and differences of the Norwegian market respect the other ones. Firms with different vertical integration degree and operating at different stages of the supply chain of the EPS sector have been chosen in order to understand how the logistic and processes management varies depending on each case study.

Finally comapnies not operating in the EPS context, but in market related with that (i.e. recycling processes or waste management), have been contacted in order to go deeper in instrumental operations of the reverse supply chain.

4.2 Data Analysis

After each interview, the data came out from the survey have been analysed and studied in order to verify their reliability.

Most of the information were qualitative, so their reliability was considered thinking their conceptual linearity with the data collected in the previous interviews and to perform the introductive part.

The EPS associations interviewed played a crucial role in this analysis step because they allow to verify the credibility of the information gathered.

For what regards quantitative information gathered, they were evaluated by checking secondary sources like companies' website, companies' financial papers and always asking to EPS associations.

Moreover in case of doubt, companies were contacted again by email in order to solve the information uncertainty out.

5. DISCUSSION AND RESULTS

In this chapter, the information and considerations gained from the several interviews are expressed. They are exposed trying to follow a logic evolution to clearly define EPS drivers and barriers within the current industry context, also mentioning specific correlated factors gathered thanks to the experience of the people interviewed. Before analysing drivers and barriers for each phase of the product development process, each study case is described individually in order to give to the reader a clear picture of the actors involved in the following discussion.

5.1 RESULTS – Presentation of the case studies

5.1.1 BEWI

BEWI is a leading international provider of packaging, components and insulation solutions.

In 1980 BEWI was founded by the Bekken family on Frøya in Norway. Since its outset on the island Frøya off the coast of central Norway, the dedication to create value to its customers, the society and its owners has established BEWI as a driving market force by offering sustainable solutions in innovative and efficient ways, focus on the packaging and building insulation products.

Since 2014, the Group increased its size and strength acquiring around 30 companies in Europe.

The acquisition has resulted in an established European presence. The exchange of experiences among existing and new subsidiaries have created competitiveness, and synergies have been realized in sourcing, integration of raw materials operations and mergers of Group units.

Even though its dimension, BEWI strongly believes that business activity must be aligned also with ethical and environmental principles, dimostrating a strong commitment in integrating the concept of sustainability through its whole supply chain, from production of raw materials and end goods to recycling of used products.

Moreover the Group knows the instrumental role of product and design development, production processes, use and re-use activities for the realization of its vision, combining technology and innovation with production and operational know-how in order to lead the change towards a circular economy in the market.

BEWI is confident that managing the entire value chain is the unique way to close the loop and operate the transformation towards a circular business model, but at the same time it understands that it won't be easy. Trying to be as fast as possible, it is has already set new targets by 2030, based on three main concepts:

Figur 5.1 - BEWI Production plant in Frøya, Norway

- Lean: it is about classic economic efficiency. Focusing on making more of less, using renewable energy.
- Keep: it is about keeping the resources in the economy for as long as possible.
- Close: it is company's vision to close the product loop, with all the necessary transformations in the BM.

5.1.2 VARTDAL PLAST

Vartdal Plast was founded by Jan Vartdal in 1961, and it was the first company in the world to produce fish packaging from expandable polystyrene (EPS) in 1965. It is a company strongly based on and managed by Vartdal family. More precisely the 3rd family generation took over the helm in 1997, still keeping on supervising the firm with the same starting values and the same vision, that is the "Customer Always First!".

As the other study cases, Vartdal Plast is decidedly dedicated to minimise its environmental impact. It has strict environmental management procedures for production, ensuring efficient use of natural resources.

As first attempt of closing the loop, Vartdal also takes responsibility for its products being able to take part in other cycles after use through its membership in Grønt Punkt Norge AS.

Together with BEWI, Vartdal Plast strongly believes in the relevance of the concept of circularity due to the envirmental improvements and benefits it could lead to and it is sure that it is a transition that will happen sooner or later. For this reason and especially for its dominant environmental vision, Vartdal Plast is working hard to make it real as soon as possible.

5.1.3 SUNDELITT

Sundelitt was established in 1917 in Aalesund. The company developed rapidly from the production of fishing tackle products of polystyrene. With over 50 years experience in the production of polystyrene, Sundelitt is the Scandinavia's leading provider of expandable polystyrene (EPS) and finished products of expanded polystyrene (EPS). The Group produces and distributes its products from 7 countries in Europe. Corporate headquarters are located in Oslo.

Differently from the previous two study cases, Sundolitt seems to be more sensitive on economic aspects than environmental ones, not doing so much to develop a CBM transition, but just performing the basic environmnetall-friendly activities that are necessary to compete with the other actors of the market.

Figur 5.2 - Sundolitt Headquarter In Ålesund, Norway

This Sundolitt's strategic position is mainly driven by the combination of the actual low economic profitability of closing the loop for the EPS products and its low desire of sperimenting and low faith in the circular economy.

5.2 DISCUSSION

Based on the previous analysis about the EPS market and characteristics, the EPS risk of becoming environmental litter has been defined as the first problem for the utilisation of this plastic type in the current literature. Indeed the potential EPS impact on the environment, and more specifically on the marine ecosystem, if mistakenly realised and the possible EPS losses, that could happen along the supply chain, have been completely studied by several researchers.

However, the EPS industry is addressing other sustainability challenges nowadays, that are partially or not mentioned in the current state of art, but that represent an instrumental factor for companies and associations within the EPS industry to start the implementation of a circular economy.

To explain in a more structured way and with a wide sustainability view these existing EPS issues and to create a background of the following discussion, the social, environmental and economic perspectives are initially discussed..

Environmental Perspective

- Environmental impact: Although EPS, thanks to its lightweight nature, insulating properties and other characteristics, is one of the best materials in its applications from an environmental point of view, there is stil a room of improvement to further decrease its negative environmental externalities.

So a cradle-to-cradle approach in this industry could further reduce the current environmental impacts generated by EPS supply chain, making more clear the advantages of the EPS utilisation in its applications. Moreover, these environmental improvements could be easily studied thanks to a Life Cycle Assessment analysis of the new theoretical circular economy with a following comparison with an existing LCA on an EPS linear production. Indeed, nowadays organisations and institutions have already computed several LCAs of their EPS products, to keep track of the environmental externalities of the supply chain process and to demonstrate the already advantages of EPS usage.

Social Perspective

- Customers' perception: Being white and composed by small balls, EPS is one of the most recognisable plastic types. Moreover, the polystyrene concept is known by many. It is for these reasons that the social sphere impacts a lot on the EPS market. People's perception about EPS is wrong and misleading nowadays, being considered as one of the most damaging material for the environment.
- Wrong consideration from associations: Several associations wrongly define EPS as non-recyclable, although it is 100% recyclable in theory. Moreover, Ellen McArthur Foundation (2021) puts the replacement of EPS packaging with other materials as a priority.

Therefore creating a circular economy, especially for the B2C market, could lead to positively change this wrong EPS perception by both people and institutions. Indeed, closing the loop would require an active role by the final customer that could see personally the recyclability process of this material. However, making customer aware of the correct EPS disposal and making it act correctly are two of the biggest challenges, as it will be mentioned above in the report.

Economic Perspective

- High value waste: Differently from other materials, waste of EPS still maintains an high market value, about € 700 per ton of compacted used EPS. This value, as the overall EPS market, is performing a positive trend.

Circular economy, also from the economic perspective, is required in order not to loose such a high valuable material.

These main challenges, that have to be solved out, make it evident why circular economy is becoming a more and more relevant concept in the EPS industry. Indeed developing such a cradle-to-cradle approach would lead companies to gain big advantages, especially against competitors. It is for these reasons that several companies are trying to understand how to perform this transition toward CE.

Now, as mentioned in the methodology, drivers and barriers, that a company has to address trying to become more circular, are exposed utilizing the product development by Franzò (Franzò et al., 2021). That process is composed by three main phases, that are:

- Idea generation phase.
- Development phase.
- Commercialisation phase.

5.2.1 Idea Generation Phase

This first phase typically requires the identification of partners along the supply chain to acquire the technical competences required to develop circular products, with particular reference to the raw materials and production processes. Such managerial practice refers to the value creation dimension of the business model (Franzò et al., 2021).

In this chapter the distinction between the B2B and the B2C market is not discusssed, because it treats only the operations from the product design to the product manufacturing. For this reason, looking primarily inside the company boundaries, this market specification does not influence this product development phase.

One of the principal characteristics of the EPS industry is the homogeneity in the production processes for EPS products. Indeed, the technologies used to manufacture such packaging products are established since long ago, and they consist of the following steps (EUMEPS, August 2002):

- Pre-expansion: Polystyrene granules are expanded by free exposure to steam to form larger beads, each consisting of a series of non-interconnecting cells. Upon contact with steam the pre-foaming agent found within the polystyrene beads (usually a hydrocarbon such as pentane) starts to boil and the beads are expanded to between 40 to 50 times their original volume.

Figur 5.4 - Virgin Beads Before Expansion

Figur 5.3 - Virgin Beads After Expansion

- Conditioning: After expansion, the beads still contain small quantities of both condensed steam and pentane gas. As they cool, air gradually diffuses into the pores, replacing, in part, the other components. So the beads undergo a maturing period in order to reach an equilibrium temperature and pressure.

- Moulding: The beads are moulded to form boards, blocks or customised products. The mould serves to shape and retain the pre-foam, and steam is again used to promote expansion. During moulding, the steam causes fusion of each bead to its neighbours, thus forming a homogeneous product. When mould- ed, nearly all the volume of the EPS (~98%) is air.

The final product is a rigid foam with a density of between 10 – 100 kg/m3, good shock absorbency and thermal insulation properties, and impermeability to water and air (Lassen, February 2019).

Visiting the BEWI plant in Frøya, it seemed clear the consolidated feature of the production technologies. The factory is an old BEWI plant, working with the same process since a long time, producing a big amount of EPS packages per day.

Indeed the object of the plant is to be as efficient as possible in both time and economic perspectives, so aiming at optimising the operations.

The timing factor, especially when the plant serves aquaculture companies every day, is extremely relevant, in order to deliver the EPS packages during the right time in which the fish is sliced, ready to be sold. Instead in economic terms, the product design process is extremely relevant, because it has to balance the trade off between the packaging thickness and the product quality depending on its service type. In other words, producing thinner packages means reducing the costs due to the lower amount of EPS beats included. However, the lower the thickness is, the lower the packaging resistance is, reducing the service quality that the company offers. It is for this reason that this trade off has to be properly balanced and it depends on the firm's experience and know-how about the product.

Moreover, the packaging thickness depends also on the service to which the EPS box is designed. For instance boxes used for the pharmaceutical sector, fish boxes that travel by plane and fish boxes that only travel by truck or ship, all require different physical characteristics.

As mentioned above, although the package design of the several EPS products is generally consolidated to maximise the plant production efficiency, the design phase is still instrumental and active in this sector, always seeking of new product configurations.

Indeed, there are three main research areas of product improvements:

- EPS beads production: this interesting area of research regards the processes used to produce the EPS beads. The production of virgin beads, from fossil fuels, is a well established process, while the several recycling process seen in the literature review, present a fertile area of research and improvement.
- Product composition: Nowadays, especially for the food packaging, the majority of used beads are virgin ones. However, with the CE transition, the percentage of mechanically recycled beats inside a product will increase more and more, leading inevitably to study the physical effects of the recycle components in the final package. So the design phase, for this area, will become more relevant to find the right composition between virgin and extruded beads that maximises the previously mentioned trade off between production costs and service quality.
- Product shape and functionality: the development of new packages shapes to solve some technical issues. A practical example by a company is the creation of a fish box that does not realise liquids when the fish is transported. Indeed one of the issue when transporting fish by truck is the realise of liquids in the roads, that freeze in the winter season, creating possible dangers to drivers. From this example, the product design can be also pulled by the market, trying to solve some needs out. However, as it will deeper explained in the commercialisation chapter, new products configuration with higher costs, are usually not sold by manufacturers. Getting back to the previous point, the product shape design may play an important role in the future with the increasing introduction of mechanically recycled beats inside the final product. Indeed possible changes in the package shapes or thickness may be necessary to maintain good profits, guaranteeing the expected quality, with the higher amount of recycled beats.

Moving on from the design phase to the manufacturing, productive technologies are consolidated for a long time, and this characteristic leads to two main considerations:

- The real game changer is before those processes, so how EPS beads are produced before entering in the production plants.

Indeed nowadays virgin EPS beads are produced starting from fossil fuels, inevitably impacting on the environment. However, in the EPS sector an high number of researches are already started to create beads without the utilisation of fossil fuels. A greater challenge is the product of recycled beads that could fit with food contact regulations. Indeed, one great obstacle of the EPS packages are the tight regulations that allow to use only certified EPS when the packaging product has to come into contact with a food, like for fish boxes.

Therefore the challenge of this first stage of the supply chain is to discover processes and certified them in order to produce recycled beads that could fully used for the food packaging application.

Nowadays, several technologies are being implemented with this aim, among those there are two that are able to produce styrene, the base material of the EPS beads, without the utilisation of fossil fuels:

- Production of beads by biogas.

- Production of beads by pyrolysis oil. This oil type can be produced by generic plastic wastes, allowing to increase the plastic recycling rate. More precisely, this process is more energy intensive than mechanical one, but it allows to manufacture 80 kg of EPS beadas starting from 200 kg of plastic waste. A practical example of the utilisation of pyrolysis oil to produce fish boxes is the Vartdal Airbox Loop produced by Vartdal Plast, that is approved for direct contact with food by the Packaging Convention's EK certificate issued by Nofima. Moreover its content of recycled plastic is certified by Ecoloop (Vartdal Plast).

These two processes are able to produce beads equal to the virgin ones in terms of chemical composition, but without starting from fossil fuels.

Looking at the three sustainability dimensions, the environmental, economic and social one, some considerations arise.

The 'green' advantages are the reduction of the environmental footprint (about 15%) due to the non utilisation of fossil fuel and the usage of plastic wastes, that otherwise would be incinerated or landfilled.

The obstacles instead are the higher costs that they require nowadays, that are caused by the low scale of operations. This economic factor, that will be treated more in detail in the commercialisation part, is influencing the sell and the expansion of these opportunities.

Looking at this part of supply chain more from a social and culture point view, several factors could hinder or enable those different recycling and bio processes.

The acknowledgement of different recycling opportunities, in addition to the mechanical one, could foster their diffusion and improvements.

However this acknowledgement is not so easy to be achieved. First of all there is a kind of sector inertia to the mechanical recycling (extrusion operation), that is the most diffused nowadays due to it is an easy and low energy intensive process. For this reason, some companies prefer to be stuck on this typology of recycling, without researching or trying something else. It is true that the mechanical process is a well established technology but, as any other operations, it has its own pros and cons. For instance extrusion deteriorates a little bit the material and it does not eliminate all the bacteria. Due to this lower quality PS generation, some operations of control are needed.

It seems that mechanical recycling is pushed too much, especially by the operators of this technology, that are trying to exaggerate the negative environmental impact of all the others recycling methods.

Therefore, both internal and external enabling factors could results instrumental for the adoption of new recycling technologies. Inside the company the management awareness about the environmental problem first and about new opportunities to try to solve it then, is a key component toward a circular transition. However, the management acknowledgement must be coupled with the willingness to act in favour of an environmental improvement, and its intensity depend on the company's philosophy. Interviewing several firms, their different ways of thinking were revealed clearly, especially when speaking about the reasons of improving circular economy aspects on the EPS sector. Firms with an higher environmental friendly philosophy are moving toward circular economy because they truly want to improve the current environmental situation and so they believe the positive consequences that this change could bring. Moreover, companies with this view are more inclined to put the environmental concept first against the economic perspective, in order to start this transformation process. Indeed, attempts to try new technical and organisational possibilities requires expenses that not anyone is willing to bear.

Looking outside the company boundaries, a critical role is played by legislations and politicians, that should support companies to invest and not obstacle them. As before, also for this aspect, the function of knowledge is extremely relevant to allow the government to make the right supportive decision.

Companies operating in the EPS sector, more specifically in the manufacturing stage of the supply chain, hardly own the knowledge to compute researches about new processes to produce beads. Indeed, these competences usually reside in chemical sectors or enterprises.

For this reason partnerships with or acquisitions of firms that have the right know-how to develop more sustainable solutions are instrumental to allow this CE transition.

For instance Vartdal Plast that is collaborating with BASF, or BEWI that is carrying out ongoing initiatives for the depolymerisation of PS with companies like Amsty, Ineos or Indaver.

The typology of partnership is a long-term one and it requires tight collaborations among the actors, due to the high costs of research that are invested and the knowledge of EPS manufacturers about the right physical EPS characteristics required. Moreover acquiring the right competencies nowadays, whatever through acquisition or collaboration, leads to have a competitive advantage in the future that can be hardly copied by the same sector competitors in a short time. Firms that have already started this CE transition for a couple of years are much ahead their competitors in this run nowadays. The reason why they started so early is their firm's philosophy and awareness about the possible improvements in terms of environment footprint of their operations, without giving too much importance at that negative economic perspective at that time. So, in terms of innovativeness degree due to knowledge acquisition, in additions to the advantages above mentioned, the management support to environmental problems and willingness to change plays a key role. As a consequence, a relevant competitive advantage in the short term future is expected to be gained.

- Knowledge and technologies to produce EPS packages are consolidated by all EPS producers, meaning that once having discovered and certified the utilisation of non fossil fuel-based beads, the existing plants are suitable, avoiding high capital expenditures. This factor could result instrumental in the implementation of circular economy in the EPS sector.

Table 5.1 - Barriers in the Idea Generation Phase

Idea Generation Barriers		
Barrier	**Definition**	**Relevance**
Low knowledge of recycling processes	A low knowledge of recycling processes could neglet the utilisation of them by a company. From an economic point of view, in order to gain the necessary knowledge, acquisition or investments are needed.	***
Low productive volumes of new recycling processes for beads	Volumes used in new recycling processes are low. For this reason scale economies are not reached, negatevely impacting on production costs and on the willing of EPS manufacturer to use them.	***
Market inertia toward mechanical recycling	Mechanical recycling is the most established recycling process and being chepear than the other processes is usually preferred.	**
Company's economic focused philosphy	A company's philosophy centred only on the economic perspective could neglet the managment awarness and willingness toward environemntal friendly aspects due to the investments needed	**
High production costs of new recycling processes for beads	New processes to recycle beads are still emerging and expensive, creating an economic barrier for EPS manufacturer	**
Strict certification for food contact packages	Tight regulation that certifies the process used to produce EPS food boxes, not allowing some recycing processes. For this reason companies has to invest in order to create and certify processes for the manufacturer of recycled food boxes.	**

Table 5.2 - Drivers in the Idea Generation Phase

Idea Generation Drivers		
Driver	**Definition**	**Relevance**
Well established EPS production processes	Production processes to manufacture EPS packages are well established since a long ago	***
Partnreships to gain knowledge	Partnerships are extremely relevant to gain knowledge about supply chain phases that are not the core of company but necessary to foster environemntal improvements.	***
Creation of competitive advantage	Due to the growing environmental interests, a company moving toward CE concepts will gain competitive advatange	***
Large company size	A large company has the necessary resources to acquire knowledge and make changes that a smaller could not	***
Management awarness of environmental impact	Knowledge about the current environmental performances of EPS production is the base to perform environmental improvements	**
Company's environmental friendly philosphy	A company's philosophy centred on environmental issues fosters environemntal improvements	**
Knowdlege of politicians	Politicians' knowledge about ongoing researches and environemtal solutions is instrumental to favour them through right incentive schemes	**

Acknowledgement of different recycling opportunities	The knoledge function plays a key role in the adoption of more environmental friendly opportunities	**
Management support toward environmental issues	Management support to make decisions in favour of more enviromental friendly practices	**
Further reduction of environmental footprint	New recycling processes could further reduce the environmental impact of the EPS production	*

5.2.2 Product Development Phase

The second phase (development phase) usually consist of modifications in the companies' production operations, which must be changed in accordance with the new and more circular products. These managerial practice refers to the value creation dimension of the business model (Franzò et al., 2021).

Indeed the main practice that is performed by companies in this phase is *the intervention on key activities*.

So, in this chapter the structural changes in the different supply chain stages, that a company has to undergo in order to close the loop, are analysed.
Most of those interventions needed to create a CE regards the reverse supply chain, more precisely how to structure and organise it.
The reverse supply chain main operations are:

- Collection: it consists of collecting the used EPS. By many companies is the most critical and difficult activity and so the one to which new ideas and opportunities has to be developed.

  In Norway, according to Grønt Punkt Norge, the collection phase complexity diverges depending on fish boxes and technical products (i.e. non-food packages). For fish boxes the collection activity is easier due to the presence of bigger players and higher volumes. Instead for technical products, some issues and challenges arise. Indeed, communities do not know how to handle EPS waste due to high space occupied and possible high transportations costs. In order to try to solve those collecting obstacles, EPS producers and importers pay a fee to Grønt Punk Norge, thanks to which it establishes two possible incentive schemes:

  I. Grønt Punk Norge pays a fee to EPS collectors for each ton of EPS waste that is sent to be recycled. EPS collectors send to Grønt Punk Norge monthly report about quantities collected to receive the incentive

II. In some cases, Grønt Punk Norge pays a compactor to be installed in EPS collection points, to facilitate this operation and reduce the space.

- Compacting process: The compacting operation, after the EPS collection, is performed because, economically and environmentally speaking, it does not make sense to transport a material that consists of 98% air. Thanks to this operation, each EPS cubic meter, when compacted passed from a density of 10-100 kg/m3 to 300-400 kg/m3, allowing to transport about 23/24 tons of compacted EPS per truck, according to the Norwegian EPS Association.
- Transport: This activity is performed to move the compacted EPS to the recycling plant and then to the final user. As mentioned below in the chapter, the transportation is one of the most critical activities to develop a circular economy.
- Recycling processes: They are those processes, as seen in the introduction, that allow to recycle compacted EPS mechanically or chemically.

In order to properly analyse what are the challenges that arise when developing a reverse supply chain, a first distinction between the B2B and B2C market has to be made. Indeed these two configurations present diverging aspects that has to be taken into consideration, that are:

- Level of complexity: The B2B market is more organised than the B2C one, due to the product is usually sold to the company that directly uses it, without any intermediaries. So the EPS manufacturer knows exactly where the EPS sold is, in which quantity and for what scope it is used, understanding if there could be some contaminations or not. All these aspects reduce several organisational uncertainties, making more easy the study of recycling projects. The B2C market instead, due to the higher heterogeneity of final customers and delivery places is by definition more complex.

- Level of awareness: The B2B market presents a higher awareness level about EPS products. This characteristic is mainly driven by legislative and 'business' factors that influence a company and make it inevitably more conscious on how to treat EPS after it is used. From the legislative perspective, due to the tighter waste normative, a firm has to show which are its wastes and how it treats them. So, in order to be compliant with the law, an organisation has to inform itself about what are the possibilities of how to handle an EPS used product. From a business point of view, due to the increasing environmental interests by final customers, some companies are on the front line to find sustainable waste treatments to gain competitive advantages. The B2C market instead, characterised by a lower knowledge and interest by customers, presents several gaps about EPS products and how to treat them.

These distinctive factors leads to find different incentives and barriers depending on each market configuration.

Therefore this chapter, for the part related to the reverse supply chain, expect for the recycling phase, will be divided into B2B and B2C.

5.2.2.1 B2B

Due to the high level of awareness and low level of complexity, in this market typology the recycling rate for EPS packaging products is quite high, for both food and non-food boxes.

Indeed, according to EUMEPS, for fish boxes (the main utilisation of EPS package in Norway) the collection rate is about 90%, while for non-food packages the percentage is similar. These high values, differently from B2C market, are more specifically driven by:

- Large volumes: In the B2B market the volumes handled are much higher than in the B2C market, may lead to reach scale economies. Therefore the probability of organising un efficient supply chain is higher due to higher quantities that could make the project and investments needed profitable.
- Knowing in advance quantity and typology of EPS waste: This advantage leads to the possibility to forecast quite precisely the infrastructure needed to the EPS treatment, clearly understanding the feasibility of an investment.

However, although the B2B market presents these favourable aspects in contrast to the B2C one, the implementation of real circular economy results still difficult to be made.

As mentioned in the introduction, almost all the Norwegian EPS packages are fish boxes that are exported abroad to several countries, leading to a high geographical dispersion that also reduces the quantity for each delivery location.

Following the several steps of the reverse supply chain, the first step is the collection activity.

Collecting used EPS is one of the key challenges that an EPS manufacturer has to address, due to four main reasons:

- Costs of compacting: Nowadays an EPS compactor costs around 30’000 - 40’000 €, and so companies install it only when there are enough quantities of EPS waste to reach an economic profitability. Moreover, a firm with a strictly economic philosophy and less environmentally friendly one, perceives even bigger this economic obstacle, because it could think that a compactor purchase is a too high expensive for a machine that treats waste. So also in this aspect, the ideological view of a company deeply influences its choices and willing of implementing a reverse supply chain operation.

- Need of high volumes: As written above in this chapter, to make a recycling plant investment economically profitable, in order to extend the high initial capital expenditure on high volumes and to run the recycling process efficiently, big quantities of EPS waste have to be collected. As well, precisely on the collecting point, high volumes are also required to justify the expensive purchase of an EPS compactor.

- Increasing price of used EPS: The price of compacted EPS briquette grew from 150-200 € per ton one year ago, to 700 - 750 € per ton today. This fast growth that has been happening since last year is caused as a consequence of the increased of the virgin material price from 1,5 €/kg to 2-2,3 €/kg. This really high price of the EPS waste, due to the high profitability opportunities, could lead some firms, not operating in the EPS sector but using EPS packages, to compact and sell by themselves the EPS waste that they create, making the collection of EPS waste, and so the achievement of high volumes, more difficult for EPS companies. It is more likely that this possibility does not occur in industries in which the EPS packaging waste is seen as a problem to be treated where companies have to pay in order to dispose it (i.e. fish industry), and so in those sector partnerships with EPS manufacturer to collect EPS waste are usually established. However, a big Norwegian company operating in the aquaculture industry has already started compacting and selling by themselves the used EPS fish boxes, that it produces, since the beginning of 2021. In this case, the size, the experience and contacts of this firm have allowed to buy a compactor and gain profits out of it.

- Key role of partnerships and synergies: Partnerships and synergies, between the EPS manufacturer and companies producing EPS waste, are instrumental to collect as much EPS waste as possible. Creating synergies means that the EPS manufacturer has the advantage of collecting EPS waste, while helping the other actor to get rid of the used EPS, also sponsoring the purchase of machines needed (i.e. compactor). So it is a clear win-win situation. An added advantage that a synergy leads to the EPS user is the creation of a good environment inside the workplace. Indeed, especially in harbors where they are full of used EPS fish boxes at the end of the day, those packages are seen only as an obstacle by workers, because they occupy a lot of space and they are difficult to be disposed during the working hours. For this reason, creating a partnership with an EPS manufacturer is extremely useful because it allows to keep the workplace clean thanks to the compactor given and it helps to take the compacted EPS waste away. This better waste organisation in the workplace increases the working environment quality due to it facilitates job to workers and it completely changes the workers' idea about the EPS, that stopes to be considered as a problem. However, in order to create a synergy like the one just mentioned, some aspects must be taken into consideration:

- Workers training: The EPS manufacturer has to train workers that are responsible for compacting the EPS waste, otherwise some inconveniences could happen. Indeed, as already occurred to a Norwegian company, workers started putting unconditionally in the compactor every type of waste, damaging the machine and creating an compacted EPS briquette without value because too contaminated by other materials. Therefore teaching workers how to use the machine is required, otherwise profit losses would occur.
- Feasible workplace for infrastructure: The workplace has to be in a good position to install the infrastructure needed to collect and to take the EPS briquette away.
- Level of EPS waste: Synergy are created when they are economically profitable. In other words, the volumes of EPS waste collected has to cover the investment made by the EPS manufacturer for the infrastructure.

Speaking about partnerships in general, they are instrumental to guarantee high volumes collected in the long-term. Partnerships can be international, for instance in Portugal an Norwegian EPS company, to feed a recycling plant in Lisbon in order to make it run always efficiently, buys compacted EPS briquette from non European countries at the market value. This situation makes even more clear the high need, and so the relevance, of large volumes of EPS waste, that are bought at more than 600 €/ton plus the transportation costs, rather than having nothing. Moreover it makes evident that synergies, when feasible, leads to a big advantage.
A possible threat about partnership is the quality of the compacted EPS waste. As mentioned by a company interviewed, the quality of EPS bought within Europe is good, while some quality problems could arise when dealing with non European actors. This factors impacts a lot with the mechanical recycling, in which, differently from the chemical one, the feedstock has to be with a low level of contamination.
For instance, an EPS manufacturer, trying to mitigate the quality factor relevance, uses different compactors depending on the application to which the compacted EPS has to be used. In this way, lower quality EPS waste, suitable for specific applications, will not contaminate the feedstock for applications that require an higher quality.

After the collecting phase, two main possibilities of recycling, from the infrastructure perspective, arise:

- Investment for several recycling plants near each usage phase location: This solution consists of a creation of a plant close to the point in which the EPS becomes waste, in order to minimise the distances and so the costs of transportation, while having some issue with production efficiency.

- Centralised recycling plant: This possibility is based on the construction of a central recycling plant that takes EPS waste from several European points. In contrast to the previous alternative, this solution would gain advantages from the realisation of scale economies, while having high transportations costs to reach the plant.

Looking deeper at these two different configurations of reverse supply chain, some considerations rise, especially thanks to the help of the companies interviewed.

The biggest economic barriers that have to be overcome by a company in the implementation of CE is the high initial investment that is required to build the recycling plant and the high transportation costs. Speaking with companies, the already mentioned issue of collecting high volume of used EPS, makes the first alternative absolutely economically unfeasible. Indeed, in order to cover the initial capital investment for a plant, a big amount of processing material is needed, and with a low plant this is not possible.

So a unique big plant is the solution preferred by companies nowadays, as the plant in Lisbon that is the only one in Portugal. However, even with this unique recycling plant, collecting enough EPS is such a critical operation, that wastes are also taken from extra European countries.

This fact means that the more difficult it is to find EPS wastes, the more they are struggling with high expenses for transportation. Indeed, today developing a reverse supply chain is not worthy from an economic point of view due to the too high transportations expenses that companies have to bear to move the compacted EPS from the collection point to the plant.

It is for these reasons that the location of the plant becomes a critical factor for the realisation of a feasible reverse supply chain. Now, it is more clear why Norway does not have any recycling factory, because, as a small nation quantities would be too low to cover an investment, and the transportation costs would be too high to take EPS waste from abroad due to its geographical position. For instance a Norwegian EPS company is near to open a recycling plant in Denmark. This decision about the plant location has been made due to the more central position of Denmark, rather than Norway, in the Scandinavian peninsula that can facilitate and reduce the transportation costs towards the recycling factory.

Therefore the transportation logistic plays a critical role, and nowadays it is the biggest barrier to be solved.

Although these economic barriers, companies understand that today is the right time to act in order not loose market shares in the future. Indeed, the EPS market is growing, and the utilisation of recycled EPS is going to take off in a short time, enlarging the competitive positions among actors that have invested and believed in sustainability goals and the others that did not.

Perceiving this situation, some firms are investing in infrastructures, taking a huge risk from a financial point of view. To decrease this risk, strong partnerships for guaranteeing the collection of enough EPS waste in the future are need, however companies, understanding this sustainable trend by the market, are still investing without exactly knowing the right quantity of plant feedstock. Therefore the financial risk is high, but the EPS sector behaviour and the risk of loosing competitive positions are so strong, that firms decide to move toward recycling, even though they do not believe too much.

Another way to address and develop new CE solutions is through acquisition of established firms with already existing factory. Indeed some EPS companies are acquiring other smaller firms operating in the same market to expand their business and to gain instrumental knowledge and know-how to perform the cradle-to-cradle approach.

Acquisitions by big companies leads to several considerations, that are:

- As said by different companies, acquisitions are also needed to guarantee EPS volumes. So, even in this case, the need of managing high EPS quantities to allow recycling solutions that otherwise would be unfeasible with low volumes is set as a primary object. The strategy of companies is to gain the market shares (so quantities) of the selling companies in order to start performing CE activities, in an economic feasibility, creating a competitive advantage against the other firm that cannot do that.

- The second reflection is about the difference in risk generation between investing in a plant and acquiring a company. The acquisition leads to directly have volumes, contacts and partners of the selling company, having a lower risk than opening a new recycling plant from the scratches.

- The last consideration regards the future market structure as a consequence of the current trends. Today the European EPS market is already a quite concentrated market, viewing big companies, like Synthos, BASF, Ravago, Sunpor and BEWI, owning relevant market shares. These firms, although their important size, are struggling in the implementation of CE operations due to the mentioned factors above. So for smaller companies that operates in one or two European countries, it is already unfeasible to make investments toward CE as the bigger firms are doing. So these several acquisitions that are occurring in the market will reinforce this market characteristic, further increasing the gap between small and big companies. So, looking at the current situation and at this particular trend, the EPS market seems to become more concentrated in the next future, with high power kept by few companies.

5.2.2.2 B2C

In the B2C market, due to its higher complexity, the CE operations are under developed than the B2B one. Indeed, most of the EPS companies are focusing mainly on the B2B market, on how to overcome its barriers, partially omitting the retail sector.

The main cause is the higher profitability opportunity of the B2B market due to its higher volumes treated.
As for the B2B market, the collecting activity is the most critical operation of the reverse supply chain, however in the B2C is a far more difficult. The main obstacles that arise in this phase of the reverse supply chain are:

- Low customers' awareness: Final customers wrongly know EPS as a plastic material that is not recyclable. This incorrect perception mainly comes from few and misleading information of some organisations that still declare the non recyclability of EPS, although it is 100% recyclable. Moreover, differently from B2B market in which companies are pushed to be informed about this material, customers are not willing to search and learn about EPS, only viewing this packaging material as a problem because it is a lot and cumbersome. The main issue that is driven by the low awareness is the customer's choice of how to dispose EPS. Indeed, if EPS is thrown it away in the wrong bin, it will not be surely recycled, not being able to close the loop. Therefore in the B2C market, although the reverse supply chain is structured and organised by a company, each final customer is in charge of the final product responsibility, allowing or not the implementation of the CE. In other words, a firm does not have the control on the customer's choice, and this factor increases the uncertainties about the efficiency and efficacy of the reverse supply chain, making the EPS collection more complicated. The unique solution that could mitigate this barrier are marketing or informative campaigns to increase the customers' awareness and change their wrong perception about EPS, allowing them to make the right choice during the waste sorting activity. However this knowledge obstacle cannot be overcome by an action of a single company, but the movement of the whole EPS sector, thanks to national and international EPS associations, is instrumental. Indeed nowadays EPS associations are trying to find several solutions for the collection in B2C market.

- Low volumes: In the EPS sector quantities play a critical role, from an economic point of view, to perform and make CE operations profitable. In the B2C market the primary EPS packaging type is for non food application (i.e. product protection packages), so an application that does not produce EPS waste everyday, like fish boxes in the B2B market. This fact leads to the generation of low waste volumes, making extremely difficult to economically justify a reverse supply chain or an investment for this sector. For this reason, when general waste arrives to the municipal collection point it directly goes to the incinerator because it is not profitable at all to sort EPS from the other waste material due to the low volumes. Looking at a wider view, two new sorting plants have been opened in Norway to separate the different waste materials to increase their recyclability. However, due to the too low waste volumes, they are working at inefficiently conditions.

- Contamination problem: A relevant issue about the EPS collection in the B2C market is the high level of EPS waste contamination. This factor is caused by the non-existence of a specific bin for EPS waste in the households, leading to throw EPS away with other wastes. Contamination arises when waste are compacted to be transported, crumbling the EPS in smaller parties and making it more difficult to be sorted. For these issues, the Norwegian EPS Association, with the help of the waste municipality organisation, tried to create a separate bin specific for EPS in he households, but without any success. Indeed nowadays in Norway, EPS from households is directly incinerated because it is not separated by the other wastes.

In order to overcome these relevant barriers, the collaboration and partnership with municipal authorities is the biggest possibility. On one hand because it is impossible to privately act on the households bins, meaning that the unique action space for a company is the collection point that is handle by the municipality, in which wastes are already brought together. On the other hand because municipality could give a great help to increase the awareness of customers about EPS.

Therefore, also in this market, partnerships play a huge role to develop a feasible reserve supply chain. Nowadays EPS associations and municipalities are collaborating to find feasible solutions not to incinerate or landfill EPS waste, however, due to the problems mentioned above, the way to them is still long. A concrete example of partnership to improve the collection rate in the B2C market, that is occurring in Norway, is between a Norwegian EPS manufacturer and Grønt Punk Norge, to collect households EPS waste in the west and south-east part of Norway. Thanks to this collaboration, municipalities have agreed to be part, and an increase in the EPS volumes collected has been showed.

After the previously mentioned collecting phase to the municipal collection point, the problems that arise are the same of the B2B market. Indeed, hypothetically thinking to be able to sort EPS waste, the main barriers would be the low volumes that could hardly economically justify the purchase of a compactor to create compacted EPS briquette. After the compacting phase, the high cost transportation to move the waste from the collection point to the recycling plant is another relevant issue.

5.2.2.3 Recycling

Speaking about recycling, unconditionally for B2B and B2C because the plants are unique for both markets, as already highlighted in this chapter, the most relevant economic factor that could restrain the recyclability rate, focusing only on the recycling phase, is the lack of enough volumes to guarantee an efficient production by the recycling plant.

Instead speaking about recycling opportunity, the main issues are the ones already analysed in the idea generation phase. This stage of the reverse supply chain is full of ongoing researches that try to find more sustainable end economic solutions to recycle EPS. Nowadays the main obstacles that could neglect recycling improvements could be the lack of knowledge that has to be developed or gained through partnerships or acquisition, the lack of awareness and support by the company management and a close mindset towards several recycling opportunity that could lead to remain stuck only on the mechanical recycling.

Looking at factors that could help the development and consolidation of new recycling processes, the creation of a market demand for recycled products, pushed by both customers and legislation, will be instrumental in order to increase the required volumes and reduce the operating costs thanks to the achievement of scale economies. This enabler factor is deeply analysed in the following chapter, within the commercialisation phase. Moreover, also governmental decisions, driven by a good knowledge of the several processes, could incentive the research and utilisation of different recycling processes than the mechanical one.

Table 5.3 - Barriers in the Product Development Phase, B2B Market

Product Development Barriers - B2B		
Barrier	**Definition**	**Relevance**
High geographical dispersion of customers	An ESP manufacturer sells its products to several consumers all over the Europe, making the reverse supply chain more complex	***
High capital investment for a recycling plant	Investment in a new recycling plant is relevant	***
Difficulty to reach high EPS waste volumes	The company's struggle to find enough EPS waste. This challenge impacts on the economic profitability of the recycling plants	***
Transportation costs	Transportation costs to move EPS waste from the collection point to the recycling plant. This economic barrier increases with the higher dispersion of EPS consumers	***
Company's economic focused philosphy	A company's philosophy centred only on the economic perspective could neglet the managment awarness and willingness toward environemntal friendly aspects due to investments needed	**
Increasing of EPS waste price	The high market value of EPS waste could make more difficult its acquisition by EPS manufacturer to recycle it	**
High market concentration	High concentration means high competitiveness among few nand powerful companies	**
High financial risk	High financial risk due to the investements that companies are making although uncertain conditions of profitability	**
Quality problems of collected EPS	Uncertain EPS waste quality from sellers	*
Workers training	A company has to teach how to properly collect and compact EPS waste, otherwise some issues could arise	*

Feasible workplace for infastructure	Position and place of an EPS consumer are instrumental to make it a collection point	*
Cost of EPS compacting	Compactor pruchase is expensive and it needs economic motivations to justify it	*

Table 5.4 - Drivers in the Product Development Phase, B2B Market

Product Development Drivers - B2B		
Driver	**Definition**	**Relevance**
Partnerhips	Partnerships are extremly important to ensure quantities of EPS waste in the long-term	***
Synergies	Synergies are relevant to ensure quantities of EPS waste in the long-term	***
Large company size	A large company has the necessary resources to acquire knowledge and make changes that a smaller could not	***
Creation of competitive advantage	Due to the growing environmental interests, a company moving toward CE concepts will gain competitive advatange	**
Acceptable complexity level	B2B market presents a lower supply chain complexity than B2C, facilitating the adoption of CE practices	**
Awarness by customers	B2B market presents an higher customers' awarness about EPS than B2C, facilitating the adoption of CE practices	*

Table 5.5 - Barriers in the Product Development Phase, B2C Market

Product Development Barriers - B2C		
Barrier	**Definition**	**Relevance**
Low customers' awarness	The low customers' awarness about EPS directly impact on the correct sorting of EPS	***
High uncertainty of reverse supply chain reverse volumes	The EPS waste volumes that are correctly sorted only depend on the final customers and not by the company	***
Low volumes	Extremely low volumes of EPS waste	***
Contaminated EPS	The non-existance of a specific bin for EPS waste, make it go in contact with other waste materials	***
Transportation costs	Transportation costs to move EPS waste from the collection point to the recycling plant. This economic barrier increases with the higher dispersion of EPS consumers	***
High capital investment for a recycling plant	Investment in a new recycling plant is relevant	***
High supply chain complexity	The heterogeneity of final customers, in terms of position and awarness, makes the B2C supply chain extremely complex	**
Market inertia	All the EPS waste from B2C market is still incinerated, making more difficult to start the changes	**

Company's economic focused philosphy	A company's philosophy centred only on the economic perspective could neglet the managment awarness and willingness toward environemntal friendly aspects due to investments needed	**
Cost of EPS compacting	Compactor pruchase is expensive and it needs economic motivations to justify it	*
Workers training	A company has to teach how to properly collect and compact EPS waste, otherwise some issues could arise	*

Table 5.6 - Drivers in the Product Development Phase, B2C Market

Product Development Drivers - B2C		
Driver	**Definition**	**Relevance**
Marketing and informative campaigns	Increase final customers' awarness could reduce some CE barriers	***
Partnerships with municipalties	Partnerships with municipalities is the unique way to properly manage the EPS waste from households	***
Creation of competitive advantage	Due to the growing environmental interests, a company moving toward CE concepts will gain competitive advatange	**
Large company size	A large company has the necessary resources to acquire knowledge and make changes that a smaller could not	**

5.2.3 Commercialisation Phase

Finally, the third phase (commercialization phase) is mainly focused on customers' involvement to establish the company's new circular practices. On the one hand, customers are instrumental to take the used products back, ensuring the supply of raw materials required to produce circular products. On the other hand, companies communicate to customers the new value of circular products, converting it into economic profit (Franzò et al., 2021).

Customers, both in the B2B and B2C markets, are fundamental to pull the demand of recycled EPS and to guarantee the supply of used EPS to be recycled. However, as seen the in previous two chapters, some actions and incentive factors are needed in order to make them help the realisation of a circular economy in the EPS sector.

The greatest challenge that the EPS market is addressing nowadays is how to create the demand of recycled EPS, so how to convince customers to buy recycled material instead of virgin one. Indeed, the economic factor is the first barrier that stops buyers from purchasing recycled product. At the beginning of the negotiation, customers seem willing to buy products made by recycled EPS, however, when the decision has to be made, they quite always prefer virgin EPS because cheaper than recycled one.

Recycled EPS is more expensive due to the high costly operations that the reverse supply chain requires and due to the still low volumes of EPS collected.

It is kind of a circle, in which the recycled EPS is more expensive than virgin one because companies are struggling to collected EPS waste, not reaching scale economies. These low EPS waste quantities are in turn caused by the low market demand.

Companies have already developed some EPS products made by recycled material, however they are quite all unsold due to the higher price.

So it becomes clear how an incentive scheme by authorities, that could foster the selling of recycled EPS product, is needed.
There could be two alternatives of incentive scheme:

- Taxation on virgin products.
- Incentives to favour the purchase of recycled material.

One of these two schemes is needed in order to balance the two product typologies, giving the same possibilities to recycled products to be sold.

Moreover, as mentioned previously, a possible game changer in future could be some environmental tighter normative that would oblige firms to obtain certain certifications, like a certain amount of recycled EPS inside each product. In this case, those restrictions would increase the market shares of recycled products.
This possibility seems to be more likely for two main reasons:

- The European Commission environmental targets, especially with the Green Deal by 2050, that aims at reducing as mush as possible environmental impacts. Indeed nowadays with the growing interest, researches and incentive schemes to encourage CE practices and the strong attention on the plastic sector, the EPS market could be deeply influence by new environmental rules.

- Some companies operating in the EPS market have already started moving towards CE concept also in view of tighter environmental restrictions. In this way, even though today their CE operations are quite economically unfeasible, they expect to gain a great competitive advantage when narrower environmental normative will come.

Focusing more on the fish boxes sector, the main barrier for the implementation of recycled EPS boxes is the tight food contact normative, that does not certificate the utilisation of extruded recycled EPS, so by mechanical recycling. Indeed, this regulation is one of the main challenge that EPS manufacture are trying to overcome thanks to researches on the different recycling processes, in order to obtain certification to produce fish boxes by recycled EPS.

Looking at the EPS package used to protect products, a threatening trend for the EPS sector that is increasing among several companies, is the one that consists in replacing the packaging material from EPS to paper based. This relevant choice computed by firms is driven by the wrong conception that final customers have about EPS, and plastic more in general. Indeed, due to recently aggressive campaign against the plastic environmental impacts and the high EPS recognisability, people have created a wrong perception about this material, considering it an environmental damaging material that can easily substituted or removed from its applications. However, EPS, thanks to the existing LCAs made by company operating in the sector, is demonstrated to be one of the best materials, from both environmental and economic perspective, in order to reach the needed scope in the used applications. This statement is even more true for the realisation of fish and food boxes, in which the EPS physical and insulation characteristics make it the best packaging material.
Unfortunately, the customers' incorrect idea is hard to be changed.
Therefore some companies, instead of trying to change the conception about EPS, decided to directly replace it with another material.
This fact further proves the customers' relevance in pulling the market offer of companies.

Also in this development process phase, partnerships are instrumental to start innovative trends. An example is the collaborations between a Norwegian EPS company and furniture and wines sellers through which 100% recycled EPS packages are used to protect their products.

Table 5.7 - Barriers in the Commercialisation Phase

Commercialisation Barriers		
Barrier	**Definition**	**Relevance**
Higher price of recycled EPS	The higher price of recycled EPS package, than virgin one, inibhits its sales	***
Strict certification for food contact packages	Tight regulation that certifies the process used to produce EPS food boxes, not allowing some recycing processes. For this reason companies has to invest in order to create and certify processes for the manufacturer of recycled food boxes.	**
Misleading customer awarness	Customers perceive EPS wrongly. Their low awarness about this product leads them to think EPS too environmentally impactful, pulling the market demand away from EPS package.	**
Replacement of EPS packging	Some companies started replacing EPS package with other paper based materials. This choice could become a strong threat for EPS sector	**

Table 5.8 - Drivers in the Commercialisation Phase

Commercialisation Drivers		
Driver	**Definition**	**Relevance**
Incentive schemes	National or international incentive schemes are needed to foster the market demand of the recycled EPS	***
Thighter environmental normatives	National or international environemntal normatives to oblige companies to use a certain minimum percentage of recycled EPS in their products	***
Parterhisps	Partnerships are fundamental to develop new ideas that could increase the recycled EPS sales.	***

6. CONCLUSION

From a wide view, thanks to the results and considerations achieved, the EPS sector has already started its transition towards circular economy. Indeed, in all three process development phases, companies have implemented (or they are trying to) circular practices. As seen, the main drivers that pushed firms to start this CE transformation were economic and competitive factors, even if a relevant environmental company's philosophy is becoming more and more important nowadays to develop innovative circular solutions. This process has started and it is still carried out by firms despite the unfavourable factors, mentioned in the previous chapter, that slow this sustainable transition down.

Companies operating in the EPS sectors are trying to reach higher circular performances because they understand the great opportunity and potential that they could create from both environmental and economic perspectives. However, in doing that, every EPS manufacturing is adopting personal and different solutions from the market competitors, allowing to understand the high degree of uncertainty about the 'best' practice and risk that each company is taking. For sure, the process phase in which companies are struggling the most is the commercialisation, especially when speaking about the sales of recycled, and so momentarily more expensive, products. Indeed, as gathered from the study cases, customers in the EPS sector are still caring more about the economic aspect rather than the environmental dimension of the product that they buy. It is for this reason that a key activity by EPS manufacturing is to create a space in the current market for recycled products, being able to effectively communicate and transform the new product value into a profitable revenues stream. Solutions in both generation and logistic phases are being developed today, such as the new recycling processes or new collecting synergies, trying to create new more environmental friendly processes and make them economically feasible from a logistic view.

Incentives schemes or new normative to foster new recycling process and to help companies from an economic point of view are needed to allow the EPS sector to finally take off, in order to create a stable and high market demand for the recycled EPS products.

Moreover, as a consequence, the establishment of durable circular practices will help changing the misleading perception of final customers about EPS, making the expanded polystyrene to be considered as fully recycled, as it is actually. This social transformation could then further foster the sector to new circular opportunities.

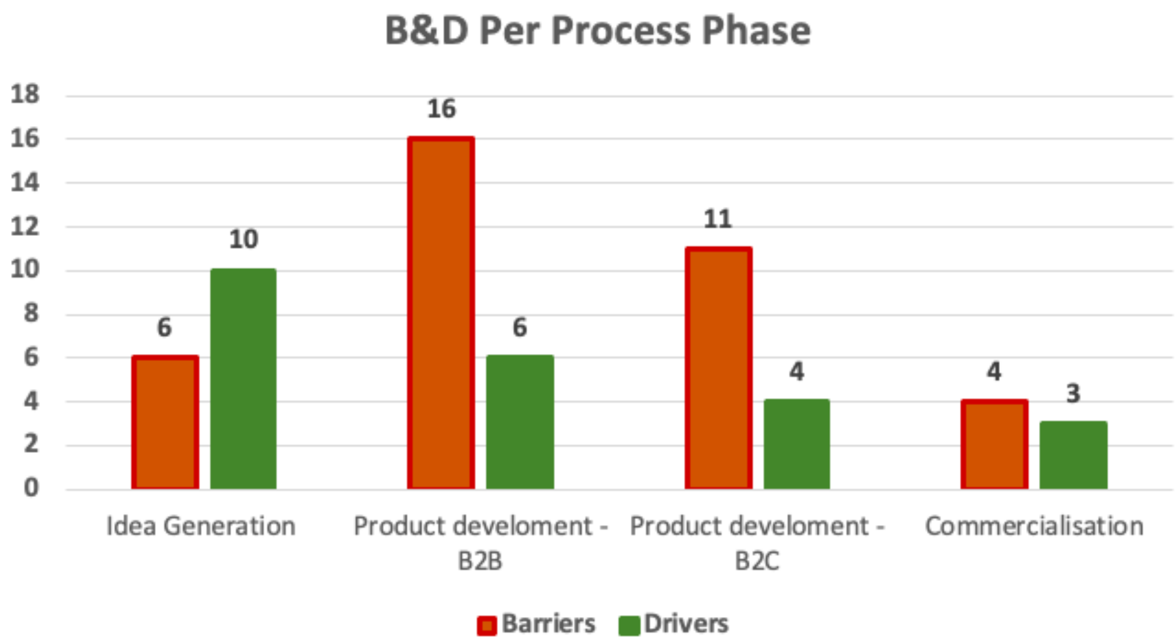
A relevant aspect that is influenced by the CE practices and that has to be taken into consideration is the market structure. Indeed, the run towards the collection of high volumes of EPS and the gain of more circular knowledge about EPS, makes big companies buy smaller organisations, further increasing the concentration of the EPS market at the European level. Therefore, the economic company's potential, that deeply characterises the possibility to implement or not a circular practice, is impacting on the sector structure, penalising small size firms. In the future, the role of the policymaker will play a critical role, due to it will have to balance market dynamics without compromising the companies' capability to implement new circular solutions.

At the end, studies and data about the environmental improvements that CE practices create, will be instrumental in the future to recognise and make clear the lower environmental impact that has been reached. As seen, the process through which companies pass to create and implement CE solutions is extremely long and complex, in which each factor plays a decisive role for the final implementation.

6.1 Theoretical Implication

The academic contribution of this thesis is the study of the application of the circular economy practices into the EPS sector, analsing their economic feasibility while considering their environmental and social impacts. Indeed, as seen in the literature review, the circular operations are deeply treated theoretically but hardly in practice in the EPS market. For this reason, the added value of this work is that answering to the research questions, that cover the literature gap, a first attempt of classification of the activities to close the loop for EPS products, while considering the correlated barriers and drivers, is performed.

Looking at the complete picture, the Graph 6.1 shows the numer of drivers and barriers for each step of the circular product process. From this simple osservation, the first thing that stands out is the diversity, in terms of quantity, of barriers and drivers among the three development phases.



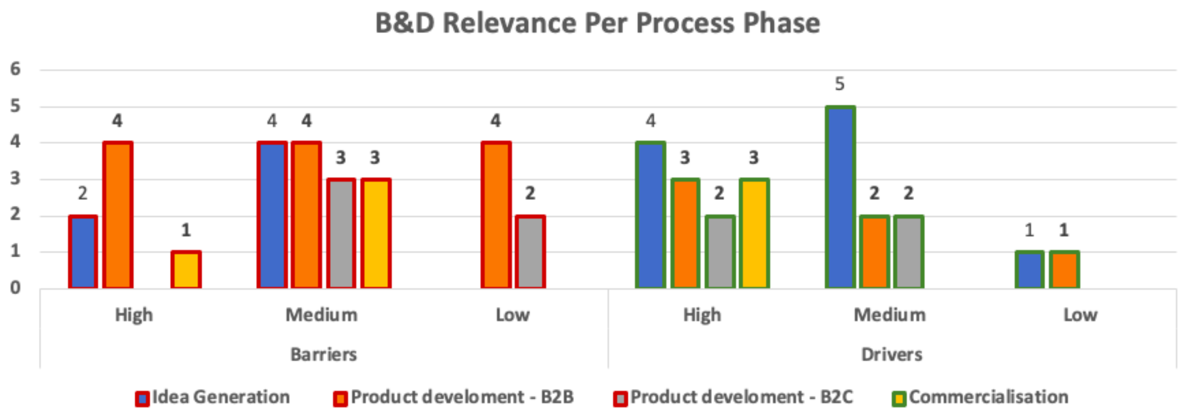
Graph 6.1 – B&D Per Process Phase

Indeed, the product development phase is the stage in which we find the highest number of hinder and foster factors. These great values are driven by two main reasons:

- The product development phase is the stage in which the highest number of actors are involved, leading the company to challenge with many variables, that could obstacle it but at the same time represents a great opportunity of improvements
- In this part of the process, the firm's departments, business units and operating offices involved are almost all, meaning a huge organsational complexity and so an high number of factors.

Instead, the commeracialisation phase is characterized by low volumes of factors. This detail is caused by the characteristics of the activity and by th low level of awareness, that is present even now among the EPS manufactuers, on possible solutions to close the loop also in the B2C market. Therefore this uncertainty and difficulty on understanding how to procede in this phase leads not to have clear also the barriers for the implementation of solutions.

Another aspect, that is useful to cite, is the correlation between the relevance of barriers and drivers and product development phase, as represented in the Graph 6.2.



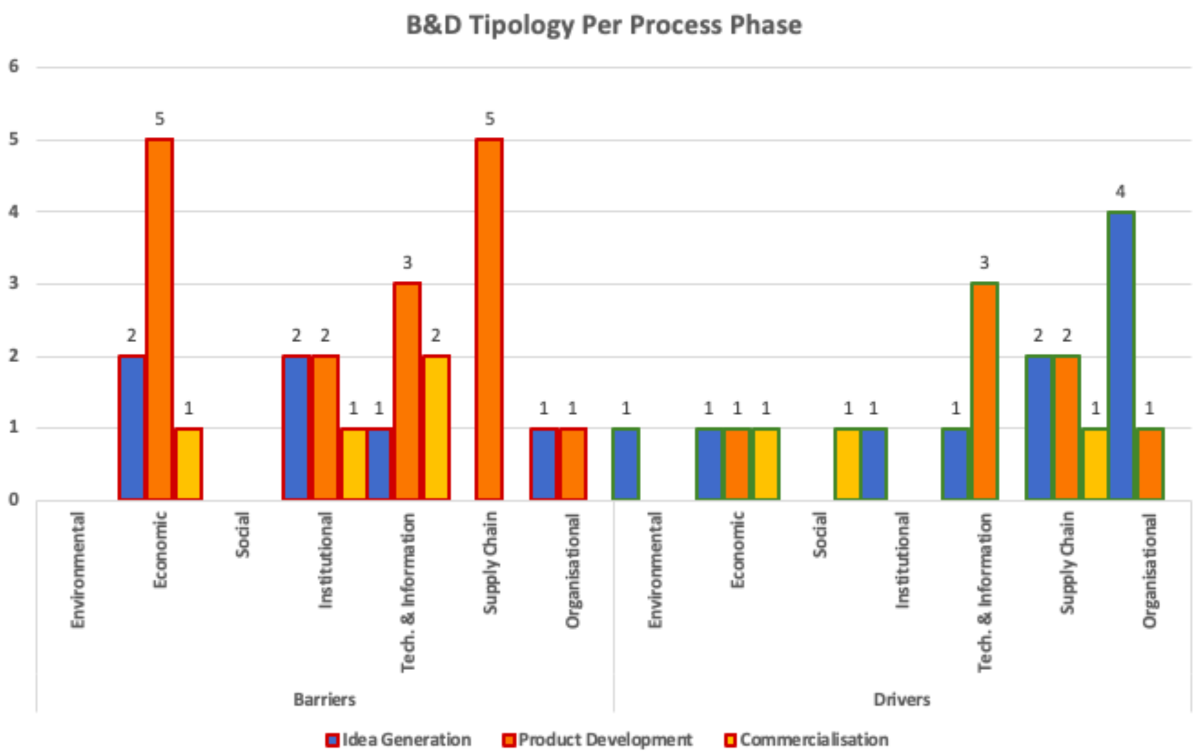
Graph 6.2 - B&D Relevance Per Process Phase

In the idea generation stage the drivers are more relevant than barriers. This result means that companies should be pushed on investing in this initial stage, due to the greter number of positive results that coul be achieved in comparison to the lower number of hindering elements. Moreover this outcome, as seen in the previous chapter, is also led by the already advance research level, that facilitates the implementations of new recycling methods.

An opposite result instead arises in the product development phase, due to the drastic complexity level that is charactersied by and the economic disadvantages that still play a dramatic role for the realization of the circular business model practices.

The three commeracialisation drivers have all the highest level of relevance because they could guarantee a first starting point from the actual complex situation.

Overlooking the numbers and the relevance, another important dimension to have a clear picture is the barriers and drivers typologies for each phase.



Graph 6.3 - B&D Typology Per Process Phase

Indeed, the graph 6.3 shows in the first stage of the process, the organizational factors play a big role, meaning that a good company's managers knowledge and spirt toward environmental is necessary to start the trasnitions for more circular practices.

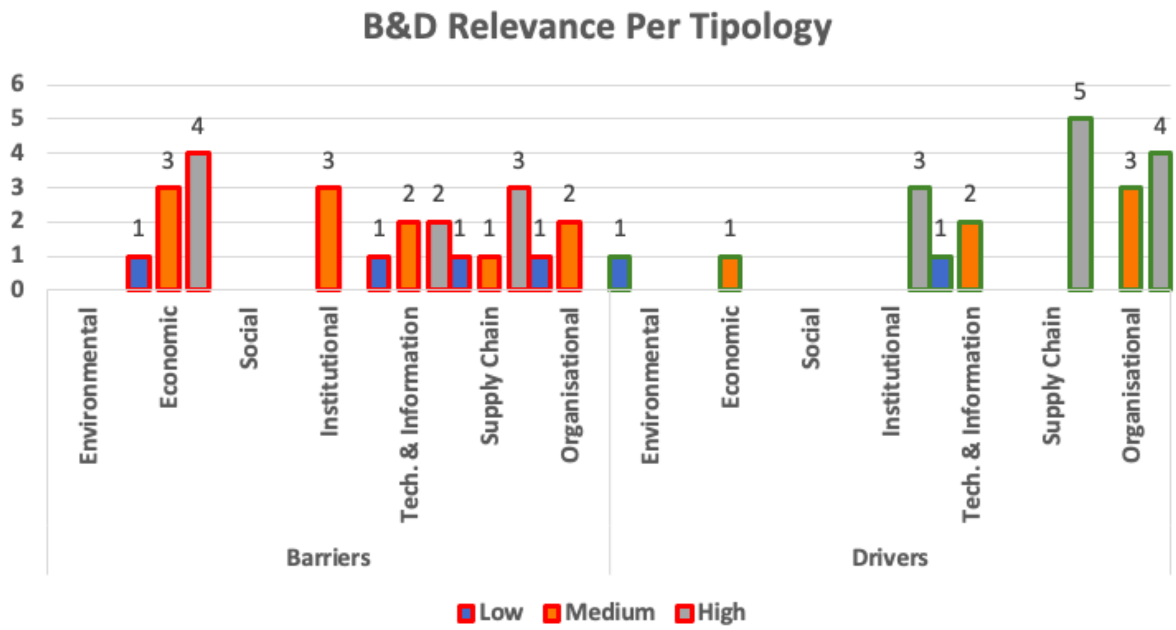
Moreover this graph demonstrates once again the fundamental importance of the economic and logistic aspect in the product development phase.While the commercialization phase is clearly influenced by final users and institutions, the principal participants acting in this stage.

Combining the graph of the relevance with the graph of the typologies, the Graph 6.4 explains which typologies of barriers and drivers are considered more revelant for the study cases.

Coerently with what written in the previous chapter, the more majestic barriers are the economic ones, both in terms of number and relevance. At the same time, the supply chain barriers, that are linked with the complexity of incrementing a circular logistic full of several actors, are the second typology that hinder the realization of a CBM.

Looking at the drivers, the organizational ones, in terms of management awareness and willingeness in developing more sustainable practices, play an instrumental role in the realisation of the CBM transformation.

At the same time institutional drivers are extremely relevant to help companies, from an economic point of view, overcoming the correlated barriers.



Graph 6.4 - Relevance Per Typology

6.2 Managerial implication

The manager implication plays an instrumental role in this thesis. Indeed the initial idea of this work was developed together with Camilla Bjerkli, the BEWI Director of Sustainability, with the aim of increasing the awareness of whole EPS sector about the challenges that a company operating in the same market has to tackle to close the loop.

Thanks to the thesis correlator Simone Franzò, the division of the structure into the three main process phases increases the clearness of the process that a firm has to pass through. Moreover in this way it results useful for all EPS companies that are at different stages of CE practices implementations, because it allows managers to understand in which phase of the CBM transformation their enterprise is, helping them to spot the main positive and negative factors they could tackle.

Therefore the main goal of this thesis is to discover the current level of the CBM transformation at which the EPS sector actually is at European level, spotting the several problematics, environmental strategies and spirits, that are pushing or obstacling companies.

At the same time, possible ideas are expressed to give mangers some tips that could help them developing new solutions to going on and conclude their circular economy transformation. Moreover this work could be useful to increase the awarnes of the final and intermediate users, about the EPS product and market dynamics that are often hid. Thereofer it could change the classic people's view about EPS, indirectly helping EPS manufactuer on valorising EPS products and on spreading the true that EPS is 100% recyclable.

6.3 Limitations and avenue for future research

Limitations of this work is predominant qualitative characteristic in comparison to a quantitative one. Indeed, the main dynamics, barriers and drivers within the EPS has been spotted, considering both causes and possible consequences. However specific and more technical studies could improve the value added of this thesis, introducing more practical number, futher helping the decision-making process of mangers in the EPS market.

Another important aspect that has to be taken into consideration are the geographical boundaries that has been introduced in order not to have a too high level of complexity. At the same time, due to the international feature of the EPS market, especially in the last years, a value added improvement could be to consider also non European market actors, discovering new dynamics and sector factors.

As seen in the previous chapter, the company size is a relevant influencing factor that could penalize or dramatically help an organization, consequently modifying the market structure. Therefore a useful improvement of this thesis could be the inclusion of smaller zise companies, in comparison to the three ones interwied, in order to understand their specific market situation, discovering new sector elements peculiar of that firm typology.

Suggestions to continue this project are the creation of a survey to deeply understand the final customers' conception about EPS in the B2C market, in order to constitute a knowledge base upon which project may be developed with the aim of increasing people awareness, reducing the EPS return rate volatility, to raise the recycled quantities. Moreover, interviews and meetings with municipalities could be useful to spot solutions to facilitate the EPS sorting and so decreasing the volumes of waste incinerated. Indeed, the B2C market is more underdeveloped than the B2B one in terms of CE performances, and studies could be relevant to help companies creating feasible projects.

Looking at the B2B market, interviewing companies that have changed packaging material from EPS to paper based one, can be important to discover their reasons and so possible problems and challenges that have not already been addressed by the EPS market.

In addition, an analysis of national incentives scheme that are in place nowadays in the European countries could be valuable to see if one plan is more helpful than the others for the EPS circular implementations and if it could be applied at the European level.

Finally, although the high complexity, a LCA for a circular EPS product, based on a theoretical circular supply chain could be developed, in order to show the real environmental improvements that could be reach.

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8. APPENDIX

8.1 Appendix 1

Company structured interview

Name

…………………………………………………………..

Surname

…………………………………………………………..

Company/Association

…………………………………………………………..

Company country

…………………………………………………………..

Role

…………………………………………………………..

Part I – Company Level - Enablers

1. What are the supply chain stages covered by your company?

2. Has your company already implemented Circular Economy practices?
   A. Yes
   B. No, but we intend to implement them in the future
   C. No, and as of today there is no intention to implement them in the future

3. Which practices have your company already implemented?

4. For each of these CE drivers, please declare its relevance:
   - Reduction of raw materials constraints
   - High price of input resources' price
   - Reduction of the volatility of input resources' price
   - Opportunity to reduce environmental impact
   - Company's image enhancement
   - Management environmental awareness
   - Competitive advantage
   - Improvement of the value capture (cost reduction, new revenues streams,..)
   - Potential to increase the customers' awareness about the product recyclability
   - Potential for improving existing operations
   - Strong partnerships along the supply chain
   - Geographical proximity of supply chain partners/customers
   - Supportive funds, taxation and subsidy policies

5. Are some enablers more relevant for specific company's CE practices? If yes, which ones for what practice?

Part II – Company Level – Barriers

6. For each of these CE barriers, please declare its relevance:
   - Lack of financial capability and support
   - High investments costs ad high time needed for breakeven
   - Lack of tools and methods to measure long-term benefits of CE
   - Complex and overlapping regulationS
   - Lack of social awarness (or misleading)
   - Lack of governmental support
   - Lack of information and knowledge to perform transition toward CE
   - Lack of internal technologies and technical skills
   - Uncertainty about quantity and quality of products from the reverse supply chain
   - High product complexity
   - Lack of partnerships and collaboration along the supply chain
   - Supply chain complexity in terms of geographical boundaries and number of partnerships
   - Fear of risk
   - High organizational inertia from both managerial and operational perspectives

- Lack of top management support
- Incompatibility with existing linear company's operations and CE targets

7. Are some barriers more relevant for specific company’s CE practices? If yes, which ones for what practice?

8. How much do you think the transportation costs obstacle the adoption of CE practices?

9. How much is relevant the role of customer in the EPS sector in the transition toward CE to collect used EPS?

10. How much is the customer’s interest to buy recycled EPS products against pure EPS ones? Is there an increasing trend?