Master's degree thesis

LOG950 Logistics

Shift towards Circular Economy in technical industries with the help of the product information system & standardization

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Abstract

Most organizations and companies are tending to be more sustainable and switching from linear model to circular model, but circular economy transition is hindered by barriers and its practice takes time. The main purpose of this research is to identify barriers facing by the technical industries regarding a shift towards a circular economy model. Another purpose of this study is to find solutions to overcome these barriers. The research is qualitative in nature; primary data is collected through unstructured interviews with companies within the technical industries. We focused on getting information on how companies understand the circular economy concept including sustainability, and what barriers they face towards circular economy implementation. The findings of the research revealed that the main barriers to the circular economy for technical industries are complexities in supply chain, coordination problems, quality issues, less attention to it in production and design, difficulties in disassembly of products and high startup or investment costs. To overcome some of these barriers the use of product information management systems could help. For such systems to work across the external supply chains, a standard for identifying product and sharing information must be followed. We developed a model using identification standards which overcome the complexities and coordination problems between companies and supply chain and their supply chain and also overcome the barrier of cost efficient dissembly of products in a circular economy.

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CHAPTER ONE. INTRODUCTION

1.1 Background of the study

The word that has affected almost everything in the world is “Globalization”. Globalization, have increased the opportunity for the manufacturers to enhance their customer base worldwide, while it has also increased the competition in the market. Globalization has also affected the companies` supply chains since they have become more complex and critical than they were ever before (Majta, 2012).

During the last century, the economic growth has increased tremendously due to the industrial and technological development causing increased global trade. The rate of worldwide consumption ratio has increased eight times over the last decades, and it is expected that the resource use globally would increase three times more until 2050 (Kok et al, 2013). The effect of growth in population and an increase in the consumption of material usage raise challenges to the environment, and the overall society, including the scarcity of resources. Scarcity not just refers to the shortage of resources, but it also affects geopolitical, economic and ecological development (Damen, 2012).

The recent model of resource consumption called the linear model, follow the philosophy of take-make-consume-dispose. This model is not sustainable as it uses scarce resources and it contributes to pollution of the environment. The cities are generating 1.3 billion tons of waste each year and it will surge to 2.2 billion tones by 2025(Masi et al., 2017). Waste and trash has a negative impact on our whole planet, our oceans are accumulated with plastics, marine life in endangered, animal kingdom and wildlife are affected by too many pollutants, persistent chemicals are causing various dieaseses, depletion of the ozone layer, global warming and landfill etc have concerned the humans to take serious action against waste (GreenLivingIdeas, 2014). The electronic waste is another kind of waste that is increasing fast. The electronic waste is estimated to be 40 million tons every year. It is expected that in coming years in some places the E-waste increase will be 500% (The World Counts, 2018).

If we talk about the businesses and supply chains, they are dealing with the problem of satisfying both its internal and external customers. The reason is due to the linear model in

which the increasing scarcity of resources contribute to an increase in the prices of the materials, which again affect the progress and profitability of the companies in a negative way. On the demand side, more and more pressure of environmental concern from customers towards firms and supply chains have seen, to produce more eco-friendly products. For handling all these issues, a new model is getting attention worldwide called the Circular Economy (CE). The Circular Economy model is based on the concept of changing the take-make-use-dispose pattern into closed-loops of material flows. Closed loops of materials are possible through different functions i.e. maintenance, repair, reusing, refurbishing, remanufacturing and recycling. It basically creates the synergy effect between the economic development and the environment (Masi et al., 2017). Supply chains are considered to be an important factor for implementation of the circular economy model because of the need for a joint effort of suppliers and manufacturers. The co-operation and co-ordination between supply chain upstream and downstream are partners are essential as upstream partners obtains eco-friendly inputs and with downstream partners to cooperate for environmental management practices such as product return, reuse and recycling (Zhu et al., 2010).

The transition to Circular Economy is not easy as is evident from several studies have outlined a lot of barriers and obstacles. Due to these barriers, firms are slow to make transition towards the circular economy (Masi et al., 2017). Some of these barriers are found to be the complexity of supply chains, high start-up costs, lack of availability of development models for the circular economy and co-operation risks between companies (Preston, 2012).

To compete in the global markets all the companies either they are in technical sector or consumer packaged goods sector, are required to be more agile and lean. This agility and lean is possible through the better management of information and informational flow. The information related to a product is "*all the information required in making decisions and taking actions in the whole life cycle of a product"*(Rosén, 2010). Information technology is considered a priority for managing the information flow across the supply chains. One particularly important technology is collaboration software systems which helps in changing the information into knowledge (Rosén, 2010). Standardization has also been helpful in providing rules and frameworks, which can help companies move towards the circular economy. These standards cover many different areas such as improving the energy efficiency of electrical products, being able to use the right and safe components in manufacturing, recycling & reusing the products for future use etc

(Kelemen, 2009). Technical industries such as high tech manufacturing companies, automotive, mining, energy etc. face a lot of problems in their supply chain. All companies have the challenges of tough price competition, dependent supply chains and a revolution of digitalization (GS1, 2018).

1.2 Justification of the Study

The world is being polluted each day as technology and facilities grow. With the increase in population and immense increase in industries affecting the environment in a negative way. Circular economy is nowadays very popular topic promoted by the EU, many governments and businesses all around the world. The focus of circular economy model is that nothing should be wasted. Everything after use must be recycled this will make the environment and the world more clean and safe for humans. Our research is based on new concept,as we will be targeting the barriers to circular economy in technical industries and the ways that these barriers would be overcome. The emerging digital technologies like Industry 4.0, represents new possibilities for handling the environmental challenges. A fundamental requirement for using digital technologies is the identification of each product. Identification is the logical link between the physical world and the virtual world. Therefore the main focus would be on the product identifiers to overcome the barriers of circular economy in technical industry.

This study would help the technical companies to realize why the unique identification of products is important and how standards can help the technical companies to implement more transparent supply chains, improve traceability, world recognition and ease in recycling.

In this study, we refer technical industries to the industries that use highly equipped machines and digital instruments that are helpful in their production. Examples of these kinds of industries are construction industry, automotive industry, defense and arms, energy industry (electrical & petroleum), computer industry and Aerospace industry etc. These considered industries work with tools such as massive machinery, heavy metals, digital and complex mechanical instruments, drills and cranes and other heavy transport equipment and appliances. It is crucial for these industries to have a secure method to recycle or dispose of metal and electronics waste that can have hazardous effects on our environment. There have been challenges in recycling and disposing of these types of machinery and metals as a single mobile phone may contain 40 various elements and products that cannot be extracted easily. Despite 400 million tons of metals are recycled

globally that is 30% of the overall metals in the world and 42% crude steel in the USA. (Leblanc, 2018)

Through this research the technical industries would be familiar with standards' of GS1 i.e. "identify" and the ways this identify the parts of a product would help in traceability, recycling the technical waste and decreasing environmental pollutants.

1.3 General Objective

The general objective of our study is to explore how the transition towards circular economy takes place in manufacturing industries. Another objective is how a product information system will help in the transition towards a circular economy in this sector.

1.3.1 Specific Objective

1) Explore what the circular economy cause regarding potential barriers in implementation.

2) Explore potential information systems for helping out in the circular economy transition.

1.4 Research Problem

Based on the discussion above, the following research questions are formulated.

RQ 1: What are the barriers to circular economy in technical industries supply chain?

RQ2: How product information management system could help in overcoming most of these barriers?

1.5 Purpose of the Study

The main purpose of this research is to identify the barriers facing by the technical companies regarding a shift towards circular economy model. The shift from linear towards circular economy is not easy though but huge benefits are expected in the long-run. The reason behind companies' slow move towards that shift is interesting to be explored. Another purpose of this study is to find solutions to overcome these barriers. To cope with these barriers we will introduce a new business model based on product identification standard and a product information system to assist the companies to better adopt the circular economy model.

1.6 Organization of the Study

Figure 1. 1: Organization of Study

Source: (Own Compilation)

Figure 1.1 shows organization of the study that is divided into eight chapters. The first chapter is an introduction in whichthe background of the study, research questions and justification and organization of the study are included. The second chapter is about the literature review in which the theoretical perspective of the research is explained. The third chapter is about the role of GS1 and its standards. The identification standard is the major focus of this research. The fourth chapter is regarding the research methodology, the data collection techniques, research design and research philosophy. The fifth chapter is about finding of primary data from companies' interview used in this research. The sixth chapter is about results and recommended model. The last paragraph consists of conclusion, limitations and further study and eighth chapter has references.

CHAPTER TWO: LITERATURE REVIEW

As companies are growing globally they are facing major problems in their logistics and supply chain networks due to the lack of transparency with having a focus on the environment-friendly actions that lead to a coordination problem among different supply chain areas. Technical industries also face a lot of problems in their supply chain.All companies either they are defense, engineering, energy, mass transit, mining or construction companies they all have the same challenges of tough price competition, dependent supply chains and a revolution of digitalization (GS1, 2018). In such industry they might have different subsectors but their problems related to supplier base are somehow same. We refer technical industries to the industries that use highly equipped machines and digital instruments that are helpful in their production. Examples of these kinds of industries are construction industry, automotive industry, defense and arms, energy industry (electrical & petroleum), computer industry and Aerospace industry etc. These considered industries work with tools such as massive machinery, heavy metals, digital and complex mechanical instruments, drills and cranes and other heavy transport equipment and appliances. It's crucial for these industries to have a secure method to recycle or dispose of metal and electronic waste that can have hazardous effects on our environment. There have been challenges in recycling and disposing these types of machinery and metals.Today each and every company is trying to adopt new business model and supply chain management solutions that add value to customers' services and a lower cost to get the edge over others. In addition, the shift from a traditional supply chain towards a green supply chain has seen to be evolved in last couple of decades. Environmental friendly production and consumption activities which reduce the negative effect on the environment are a major goal of green supply chain where the focus is not just on the reduction of negative consequences of production processes and residuals but also on the use of materials again and again through such systems where transformation is made through a relationship between ecological system and economic growth (Genovesea et al., 2017). Because of greater social, environmental and financial benefits, Circular Economy is new concept that is catching eyes of global companies like, Google, Unilever, Renault, etc. (Lewandowski, 2016).The shift from linear towards circular economy is not

easy there are many barriers associated with it which stops companies to adopt circular economy model.In addition, the product identification or wireless product identification is getting interest of every company for transparency of supply chain. Wireless identification basically means handling of a product or part of product automatically without physical work (Karkkainen & Holmstrom, 2002). There are most of the devices that are connected by one another with the help of internet. The internet-of-things (IOT) allows products to be remotely controlled, traced and tracked. This connectedness of devices makes the monitoring of products and transparency easy. But a specific hardware is required to integrate between product and Internet. This IOT makes the products more complex as many metal elements are attached to the products. The IOT significantly affect the circularity of economy i.e., it helps in recycling of products easier when the products have all the necessary information regarding what kind of material they are made of, who made them and what is the origin country and many other useful information. Hence, more the product is knowledge-intensive better would be the maintenance; traceability would be easier which leads to reducing material waste and delivery costs (Schoenmakere & Gillabel, 2017).

2.1 Circular Economy

According to Ellen MacArthur Foundations, Circular economyhas been a regenerative approach that substitutes the end-of-life concept with usage of renewable energy and removal of waste through restoration of design of materials, systems, products or business models (EMF, 2013). Circular economy mainly focuses on the 3R principal i.e. Reduce, Reuse and Recycle. Reduce mainly aims at lowering the amount of material in production and consumption process. Reuse aims at increasing the time strength of products and services and the last Recycling, which involves recreation of renewable resources after usage (Ying & Jun, 2012) in (Ghisellini et al., 2015).

There are two main parts of circular economy the first part focuses on reducing the impact on the environment and the second part is to create business models to implement the first part(Tortensson, 2016). The Ellen McArthur Foundation (2015) has given a model of circularity and showed the activities that can lower the impact on environment.

The figure 2.1 illustrates how technological and biological nutrient-based products and materials cycle minimize the waste and energy consumptionthrough maintaining and prolonging product lifespan, reusing and distributing products, refurbishing, manufacturing and recycling. The right blue side of the *figure 2.1* shows the industry and circles that are

inside are the more required ones because of more perspective to save energy (Tortensson, 2016).

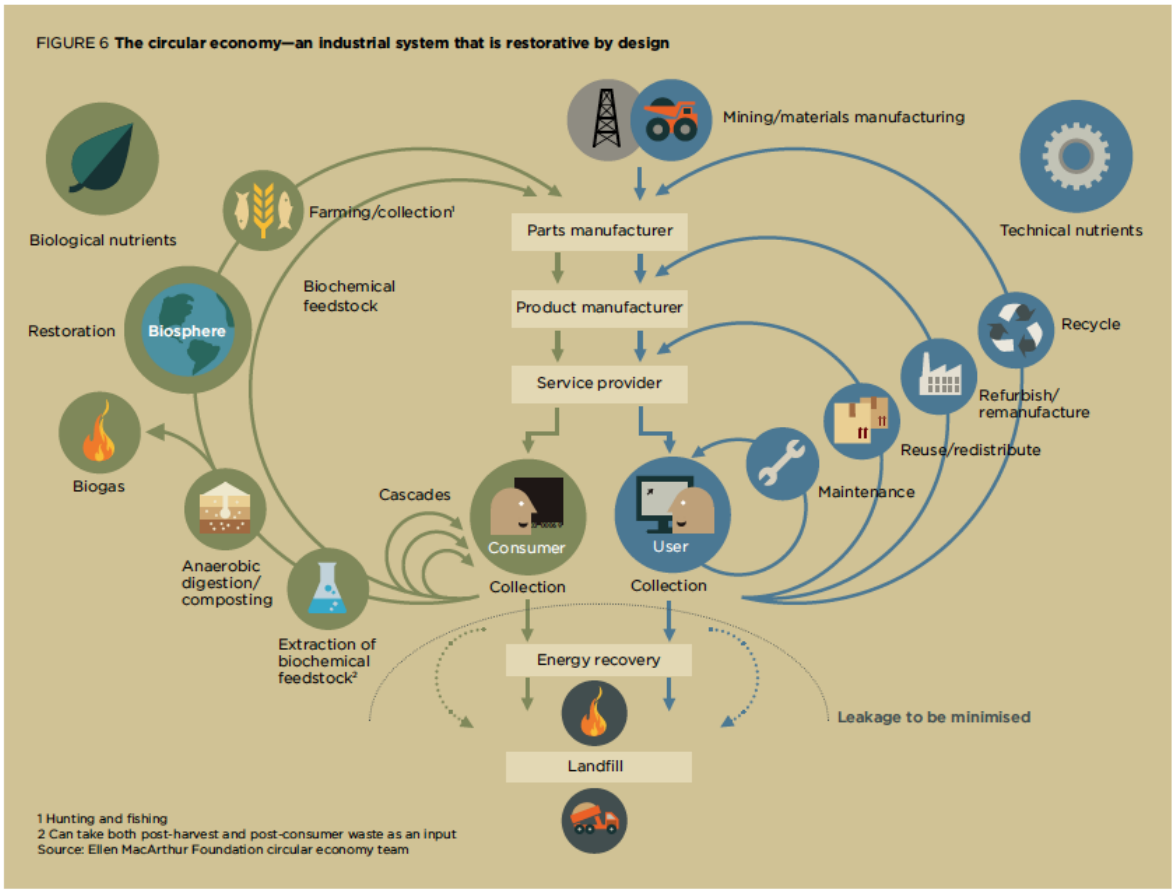

Figure 2. 1: Graphical description of circular economy

Source: (Ellen Macarthur Foundation, 2015)

According to Zhijun& Nailing (2007) shifting towards circular economy model requires a deep focus on the raw materials and energy. When producing a product the focus should be on decreasing the entire product life cycles negative effects on the environment from the very early stage of material extraction towards the product disposal. To make the circular economy activities possible, it is required to have new business models; circular business model is one type of business model (Tortensson, 2016). This means pursuing and creating the opportunities for a shift from an "end-of-life"concept to Cradle-to-Cradle, from using un-renewable energy towards using renewable, from usingtoxic chemicals to their elimination, from much waste to eliminating waste through the superior designof materials, products, systems, and also business models(EMF, 2013).

Different theories presented by many school of thoughts i.e.General system theory by (Von Bertanlaffy, 1950, 1968), Environmental economics by modified by pearce &

Turner (1989), and Industrial ecology presented by (FROSCH, 1992)(Ghisellini et al., 2015) all are the subfield of environmental management[1] and also the basis of the concept of circular economy. However, from all of the above theories the circular economy theory is mainly rooted on the idea of Industrial ecology theory (Ghisellini et al., 2015). Industrial ecology (IE) came up against the current view that the industrial systems and the environment should be handled separately that means "industrial system" and its impact on "the environment". The industrial ecology theory says that industrial system is kind of ecosystem where the materials are distributed, energy and information flow takes place through assistance of resources and services of the biosphere. Hence, IE argues that the industry and environment could not be separated from each other. Industrial ecology has three perspectives. The first perspective is about the detailed view of industrial economy and its connection with the biosphere. Second perspective covers the material and energy flow inside and outside the industry. Third perspective or pillar gives the proactive approach i.e. technological dynamics and shift of linear industrial system towards industrial ecosystem (Erkman, 1997). Reduction of wastes through closing of the open loop of material and energy flow is the concern of Industrial ecology (FROSCH, 1992).

2.2 Circular Supply chain VS Linear SC

Circular supply chain refers to the shift from a traditional pattern into a circular one i.e. *from raw material to waste towards raw materials to recycle/repair*. The world resources are finite therefore the supply chain of modern companies should have movement towards the circular supply chain. For becoming sustainable and growing in the same pace it requires the entire reverse logistics process(Robinson, 2016).Supply chain is a demanding concept in this era as the real competition is no longer company *vs.* company but SC *vs.* SC (Marquez, 2010). Supply Chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer (Christopher, 1992). Whereas, supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a specific organization and across businesses within the supply

[1] Environmental management is the management of people or human`s and their relationship with the environment and human`s effect on the environment. The Management of environment started in the 1960 and early 1970`s. minimizing pollution from the individual source were the early environment initiatives. Moreover, in later stages the environmental management started a systematic approach where the pollution was controlled at the source and entire ecosystems were managed(Nikbakhsh, 2009).

chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001). Moreover, effective transportation, customer management, marketing techniques and efficient distribution can enhance Supply chain performance.Information exchange is crucial allowing different parts of supply chain to coordinate with each other in order to maximize the efficiency. According to Moberg (2000), there are two kinds of logistical information. One is operational and other is strategic. Strategic information is the long-term plans and strategy that top management makes decision for. Examples are target markets, new product development, promotional strategies and product mix. Operational information is the daily business activities like inventory levels, point of sale information, shipping notices and orders. This information sharing either operational or strategic is essential for supply chain management. Technologies such are EDI (electronic data interchange) has fastened the information exchange. (Moberg, 2000).As companies are growing fast the supply chains are becoming complex in same trend. This complexity made the visibility of information and cooperation, among all the organizations` network a major ingredient for the future effectiveness of any supply network (Bartlett et al., 2007). Technical industries such as engineering, defense, mining, energy and mass transit face a lot of challenges to digitize their physical worlds and make their production much faster and efficient. Something that has merely changed the business industries and business segments is not other than the word digitalization. In this digitalized era the business world is constantly having the pressure of reshaping and reinventing themselves and their business models. Being digitalized has become the strong differentiator and a key element of many companies all around the world (Tieto, 2017).Topic that is taking attention of many countries is the green supply chains or in other words a transition from linear economy towards a circular economy.

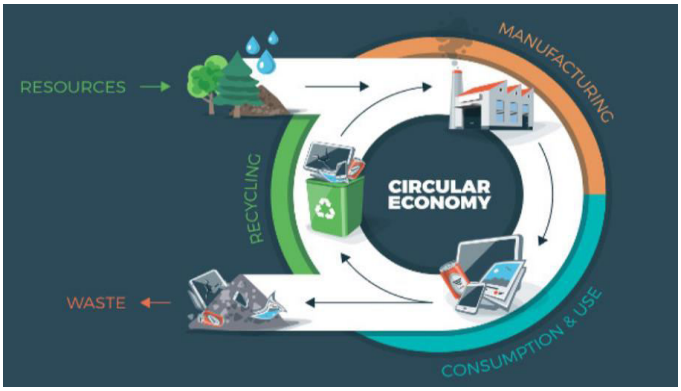

Figure 2. 2: Linear vs. Circular supply chain, Source: (Robinson, 2016)

Figure 2.2 shows the difference between linear vs circular supply chain.The linear economy model is based on the concept of producing a product, use it and dispose it after product`s life cycle finishes. However, the circular economy concept says that the use of completely new raw material would be minimized as well as all kind of wastage in material cycle with the focus of decreasing the negative consequences on the environment.Unlike traditional linear economy that involves of making, using and disposing resources, circular economy uses the resources to its maximum value. It is the recovery and regeneration of resources such as products or materials to recycle & use it again at the end of its durable life. The benefits of circular economy are vast as it reduces wastes, creates new opportunities for growth, help get rid of environmental impacts of manufacturing and gives vast resource productivity (Wrap, 2018). The various positive impacts of circular economy are the reason behind the dramatic attention towards this concept. This idea is gaining a momentum among the different organizations and policy makers as it is getting obvious that linear industrial model that we all are using recently, is no more compatible with the limited resources of our earth. The limited natural resources and high level of waste and pollution is not being helped by the linear industrial system(Mont et al., 2017). According to EMF (2013), the linear approach "take-make-dispose" is making the economy scarcer, volatile and high price levels. Although EU wastes management long-term policies aim to improve resource efficiency and reduce the environmental waste to achieve safe disposal and higher levels of recycling. 1n 2014, Europe alone generated 2503 million tons of waste as a result of economic activities and household wastes, that was the highest amount. This waste management leads to landfills, loss of resources, cause soil, air, and water pollution and ultimately may result in serious environmental issues (Eurostat, 2017). Moreover, this social & environmental costs of waste imposes costs to our resources that may be overused by inefficient producers who focuses on increasing productivity rather than efficient use of resources that is also the right of future generation, therefore taking account of finite resources and uncontrollable human-economic activities, there should be concept of circular flow of resources (Mont et al., 2017). There have been a lot of reports regarding this concept and how to transform the current economy towards the circular. Varieties of frameworks and strategies have been applied towards a circular economy transition. Different product chains need different forms of transition because there is a diverse property of products in terms of function, durability and composition. So, Circular Economy transition may differ product to product and with regard to the revenue model, technology and product design (PBL,

2017). Prioritizingrecycling of end-of-life products in circular economy is a very critical topic that needs to be addressed in different industries including technical industries that have complex products with mixture of materials. The products that have complex materials and what should get recycled first, identifying those materials and separation of materials that compose should be taken into consideration (Sultan & Eric Lou, 2016).

2.3 Transition towards Circular Economy

A circular economy is an industrial system that replaces the end-of-life concept with restoration, use of renewable energy, getting rid of the harmful and hazardous chemicals that hinder the reusing of materials and usage of materials, products and systems in order to reduce waste (EMF, 2013). Primarily, circular economy is designed in such a manner to reduce waste and purpose is to design out waste. In addition to reducing waste, it focuses on reuse of the consumables of the product that are biological ingredients or are non-hazardous to the environment, could be returned to the earth and can be a part of biosphere. Subsequently, energy used for recycling and reusing these materials should not be non-renewable sources such as fossil fuels, coal, natural gas that cannot be replenished easily. Rather it should be renewable such as winds, tides and sunlight to avoid dependency on the resources that are depleted.

Circular economy helps technical industries in such a manner that it changes the word consumer to users to recall that after usage of specific machinery product, it should be recycled and reuse (EMF, 2013). But the barriers faced by many companies are the quality issues, high start up cost and supply chain complexities. European union has initiated different projects; IMS2020 is one of them that is, roadmap towards the sustainable manufacturing project. Its main elements include sustainable manufacturing is enforced when the government and industries support the culture, production systems with value chains and eternal life-cycle solutions for manufacturing. Sustainability of manufacturing is influenced by lifecycle considerations (Design, Production, Use, Retirement and End-Of-Life of products). Manufacturing should be sustainable, but not only in terms of sustaining a certain level of environmental parameters. It must be sustainable in terms of performance and quality of both products and processes, safety of workers and other people affected by the manufacturing process. (Rolstadas, 2015).Every business needs to consider cost of transition towards any new system or concept. Therefore moving towards circular economy would incur transition cost i.e. Research and

development, asset investment, spending on enterprise infrastructure and subsidies would be the source of high investment cost (Mckinsey & Company, 2016).

2.4 Sustainability

Sustainability is a challenging concept that has been the element of many companies' code of conduct. The first inspiration came on the report of WCED (World Commission and Environmental Development 1987 also known as Brundtland Report that adopted the concept of sustainability. Sustainability thus is maintaining well-being of environment, social and economic resources (Kuhlman & Farrington, 2010). However, the term sustainability is still very vague, particularly in the business context where it has been used to describe everything from organic yogurt to petroleum production. But according to the LCSP, the creation of goods and services using processes and systems that are: non-polluting; conserving of energy and natural resources; economically viable; safe and healthful for workers, communities, and consumers; and, socially and creatively rewarding for all working people (V.Veleva et al., 2001). Sustainability development is setting up a vision for the economy to achieve the major challenges such as social and economic development, environmental protection (Vasam et al., 2015). Sustainability has also become a part of United Nations Organization's new goal known as "UN Sustainable development goals" as shown in the *figure 2.3;*

Figure 2. 3: Sustainable Development Goals

Source: (UN, 2015)

"The seventeen Sustainable Development Goals (SDGs) are our shared vision of humanity and a social contract between the world's leaders and the people," UN Secretary-

General Ban Ki-moon said of the 2030 Agenda for Sustainable Development adopted unanimously by 193 Heads of State and other top leaders at a summit at UN Headquarters in New York in September 2015. The seventeen goals are; to eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development (UN, 2015). According to the UN's Sustainable Development Goals 2018 report, Goal 9 and 12 are, Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation and ensuring sustainable consumption and production patterns. These two goals are evidence of sustainability and circular economy are in action and the need to have a sustainable manufacturing has come. Inclusive and sustainable industrialization, competitive economic, resource and energy efficiency, green production needs policies that can create global value chains and transformed business practices (SDG, 2018). Governments are legislating for the adoption of clean technologies, resource and energy efficiency, waste reduction, recycling initiatives and the reduction of harmful environmental impacts and consumers are searching for trusted data about the sustainability of the products they use (GS1, 2018).

2.5 Strategies of circular economy

Strategies or schemes of circular economy basically harmonize the supply chain actors such as producers, distributors, consumers and recyclers. The downstream actors' activities must coordinate to the decisions of upstream actors in the supply chain. The innovation in each and every stage of supply chain and not just focusing on the waste reduction at the later stage is admired(Vanner et al., 2014).

There are two pillars of circular economy if it goes beyond just focused on waste reduction presented by McDonough & Braungart, (2002) in (Vanner et al., 2014)

a. **Cardle to cardle principles** that is about

- Product design for durability, disassembly and refurbishment: This principle says that the principles of eco-designs should be applied in all of the products of businesses. The less usage of dangerous and toxic material should be use and finally the material should be such which could be recycled.
- Regenerative forms of consumption: This principle focuses on the way through which the waste from household consumption is transformed into new products.

b. Industrial Symbiosis

This principle is basically requires the coordination among different actors of supply chain i.e. from producer to distributor to customer and finally among recycler.

2.6 Materials in Circular economy Concept

The circular economy concept has divided the Materials into two different types. The first one is; Technical Material and other is Biological material.

Technical Materials: These materials are not biodegradable i.e. metals, polymers, minerals, alloys and plastic etc.

Biological Materials: These materials have biological origin i.e. goods from agriculture and forestry and are non-toxic in nature (Vanner et al., 2014).

Our research is basically based on the technical materials and the way they would be recycled with the help of unique product identification numbers provided by the GS1.

2.7 Barriers to CE

A shift from the circular economy model or any other business models for sustainability of economy requires a dramatic change that will move through the whole company including all the stakeholders. This shift is somewhat a disruptive in nature it is because current mode of working would also be changed due to the new solution to implement the model (Ritzéna & Sandström, 2017).

Following are the barriers in implementation of circular economy model.

Table 2. 1: Identified Barriers in Literature

(Preston, 2012)

Resource-Intensive development models	Traditional models are highly resource intensive; lack of less resource- intensive model is a trouble.
High start-up costs	In the long run Circular economy model would show a sustainable benefits and increase growth but in short run there are many risks for businesses and start-up costs
Supply chain complexities	As multiple companies around the world are engaged to make a particular product and customer base is global, the challenge for the supply chain in circular economy model

	could be the alignment; it means that from the early design stage to consumption the durability and reparability of materials should be the main strategy of companies.
Difficulty between companies coordination	To implement the Circular economy model another barrier is the coordination problem among companies because it needs multiple companies to adjust their daily operations.
Innovation	Another barrier in circular economy model implementation is the innovation. Supply chains in circular economy model requires smart infrastructure and such tracking and tracing technologies that could make the transparent logistics and supply chain activities to optimize their daily operations.

Liu & Bai (2013)

Structural	The innovation and flexibility is restricted by organizations` hierarchical patterns. Lack of budget towards circular economy model innovation Circular economy`s strategies are affected by the managers employment term restrictions.
Contextual	Competition in the market place restricts the movement towards circular economy
Cultural	Managers are risk averse

(Eijk, 2015)

Restrict supply chain	There is lack of the enablers to better the performance of cross cycle and cross sector Lack of the knowledge of exactly, the composition and the origin of material used

Lack of industrial symbiosis	Industrial symbiosis can be achieved by having a good knowledge of material/energy flow within an industrial sector and geographical area or in other words it is about an exchange of information regarding inputs and output to optimize the processes but this industrial symbiosis is a barrier towards circular economy because it's costly or difficult to obtain.
Logistics	Information exchange system is limited Cargo flows are handled by logistics, which also includes the reverse logistics, and supply chain management. For the circular economy transition network design is a barrier. The connection between network designs should be such that switching to different mode of transportation should be possible in case of any problem.
Product design and production	Removing of toxic material and separation of biological from technical substance is lacking. Shortage of information regarding green suppliers Current product design is given less attention towards the end phase of products
Recovery	Nowadays the products are more complex in nature; the recovery of such product is a big challenge.
Recycling	Recycled materials are some times more expensive than the new raw materials. Investing in recycling is seen to be risky on a larger scale

(Rizos et al., 2015)

Lack of technical skills	Another barrier towards implementation of circular economy is the lack of internal skills in small and medium size enterprises. They don't realize the benefit of implementing more advanced technical stuff that reduce the negative impacts on environment and would give them costs savings.

(Torstensson, 2016)

Quality Compromise	Companies' reluctant attitude towards circular economy is their concern regarding the quality of materials. The materials would be chosen based on the environmental aspects instead of performance
Disassembly of products is time consuming and expensive	The product is made of many different components which are attached in a way that their disassembly is hard and time consuming and it seems much better to produce a new product than to circulate the materials and also it would be very expensive to mould the components in a way they they could be available to use again.
No surety recycling, remanufacturing and reusing would help the environment and money saving	There is no surety to the companies that this process of circular economy would definitely save money or protect environment scarce resources or not. Companies are more concerned that it might be the case that producing a new product is

	less costly than reusing the old one
Quality Assurance	Another barrier is that it is difficult to know what has exactly done with the material and the recycled material are good with respect to quality so all these things requires cost

(Berchicci and Bodewes, 2005) in (Mont et al., 2017)

Design of products irrespective to circular economy	The products that are produced lacking the circular design this is the reason that the reusing, disassembly, remanufacturing etc is hard
Hygienic issues	It is also a thinking that the recycled or reused materials are not safe and hygienic

2.8 What is product?

According to (Stark, 2005) the most important feature that a business has is its "Product". It consists of the goods and services that are sold to end customers. This product can be a single or from a batch of multiple product or product line. He also explained that it can be a single spare part which combined with others to make an entity. It is not necessary that a product should be a physical form it could be digital i.e. software.

2.8.1 What is information?

Information has its roots from data which is about symbols, raw data, facts etc and when this data is structured and analyzed it becomes information. This information is accessed by the availability of some software or information systems' through which the data is analyzed and transformed into the information (Otto et al 2013 cited in Mattila, 2018)

2.8.2 Product Information

Product information is all about product attributes and product relations (Lee et al, 2006). Product information is an essential part in this era. Information systems are used to manage this information to provide available data for all the partners (Kim et al., 2001).

In today`s era where industries make hundred or thousands of products with a lot of spare parts and components use the standards or digital systems for identification and naming as a physical product, a service or a spare part(Sääksvuori & Immonen, 2002) in (Mattila, 2018). There are three different types of product information.

a) Product specification information

b) product lifecycle information

c) mata data.

***a) Prodct specification information*:** This type deals with the characteristics of a product both physical and functional also it is technically detailed version of a product.

***b) Product life cycle information*:** this type is associated with the all the procesess and stages through which a product has gone in its whole life cycle i.e. engeenering and design, manufacturing, production, use, disposal or recycle.

***c) Product mata data*:** this is the product information which have the details about format, location, creator, editor etc.

Product information is necessary for all the business operations and international tradewhen it comes to industrial manufacturing, spare parts and e-commerce.

2.9 Product information Management System

As markets become global it is very important to have good collaboration between retailers and the suppliers and with all the partners in the supply chain for efficiency and business growth. This global market created a need for product information and content management for the successful business operations. PIMS or product information system helps companies in this matter. The product Information management systems basically assist in collecting, managing and distributing product information among all the partners. In Product information management system the Products can be classified into the product hierarchies, sales organizations and also into the international classification standard i.e. GS1 standards. With GS1 standards a product contains all the necessary data which the consumer needs to know (Vijverberg, 2017).

2.9.1 Standards and Value Creation:

Computer based information is necessary when the companies implement the agility with coordination among all the partners in the supply chain. Information can be used in many ways i.e. it is a strategic resource and can be a source of value creation. The ehole information can be accessed by representing it independently by how and what it is used in

the business processes and in value creation. The way through which the information can be made independent of the business processes is by means of object orientation or standardization of the information. By making the information independent of how and by what it is being used and created would help in re-structuring the information when it is required to use in other business processes. Information should be flexible for the efficient control and support of value creation process. *Figure 2.4* demonstrates the flexibility of information and value creation.

For the purpose of removing point to point suppliers` specific solutions, one should use the product data technology standards. These product data technology standards would serve *(a) a standardized ontology of product and information models, (b) a standardized language (or languages) to represent the information models and (c) standard implementation of standardized information models*(Rosén, 2010).

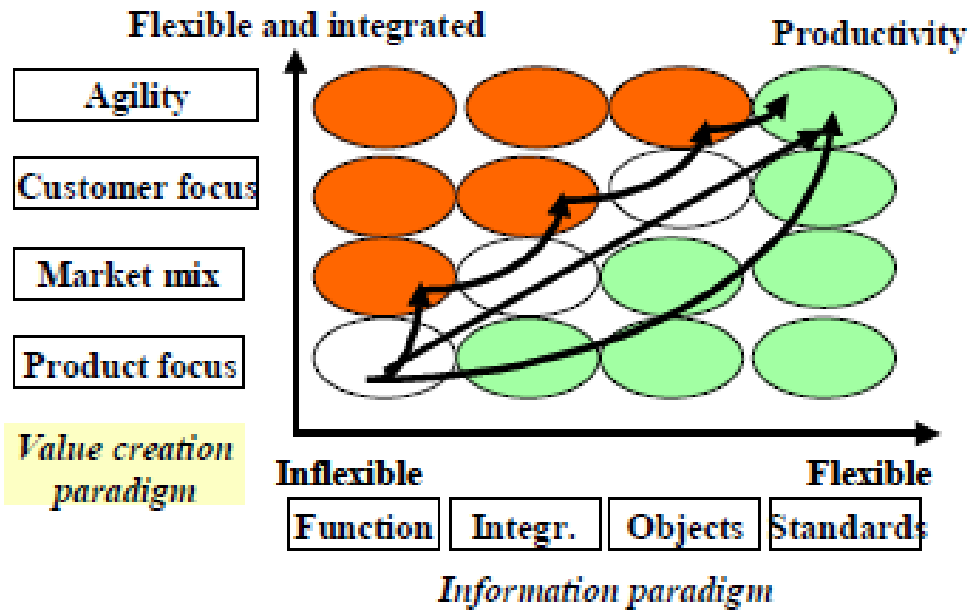

Figure 2. 4*: Standards and value creation*

Source: (Rosén, 2010)

Due to lack of product information standards companies face challenges in Product information management system. It has seen that through standards companies could better govern the product information. Standardization is such a crucial element that without it no one can access the information accurately as well as the improvement and management of product information is difficult(Mattila, 2018).

2.9.2 International Standardization in European Union

EU (European union) has seen to be the leader when it comes to the international environmental politics. The leadership has started when EU endorse many different agreements for environmental protection for introducing the issues such as climate change, trade in toxic wastes, POP (persistent organic pollutants) and many others. The European Standardization has provided such rules and framework, which help companies to protect the environment. These standards covers many different areas such as improving the energy efficiency of electrical products, recycling the products for future use etc (Kelemen, 2009).

2.9.2.1 Standardization in EU

"Standards are tools for the sharing of technical knowledge".Product standards basically provide certain criteria about the product i.e. integral safety, wastage and incorrect interfacing of components as well as products` impact on environment on the whole life cycle of a product. . There are almost 13,500 European standards for products. The ISO (International organization for standardization) is the federation of national standards bodies. In technical committees of ISO the preparation of standards is taking place. The ISO standardization

The products and services impact on environment can be seen from slight to significant at any point in the life cycle. The best strategy is early identification and planned accordingly decreases the chances of affecting environment (EUR-LEX, 2004).

ISO 9000:2000: *This ISO standard covers the design and development of a product i.e. transformation of requirements into specification of product, process or system.*

IS0 14001:1996, 3.2: *It includes all the surroundings in which organization operates i.e. air, water, land, natural resources, humans and their interaction.*

ISO 14001: 1996, 3.3*: Elements of Organization`s activities, products or services that can have environmental impact.*

ISO 14001: 1996, 3.4: *Whole or partial effect to the environment due to the organizations` activities products or services.*

ISO 14040: 1997, 3.8: *Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal* (ISO, 2002).

2.9.2.2 Waste Electrical and Electronic Equipment (WEEE) Standard

Waste Electrical and electronic equipment (WEEE) standard has introduced by European Union (EU) in 2002. This standard requires that the Electronic products must be dispose separately. A cross out wheeled bin symbol is used to label any electric and electronic equipment.

This equipment can contain such substances which could be dangerous for the human health if do not dispose or recycled carefully. Due to the scarcity of natural resources the WEEE should be recycled instead of dispose. The equipment is the source of 80% to 90% of reusable material if collected and recycled carefully (EU, 2002).

2.9.2.3 CE marking Standard

CE marking is an indicator which tells that the producer has completed all the legal requirements to be sold throughout the European Union. The CE marking ensure that the business know that products having this mark can be traded in EEA with no restrictions at the same time consumers` get to know that the product is meeting all the standards related to health, environmental protection and safety (European Commision, 2018).

2.9.2.4 GS1 Global standard

GS1 is a global organization that works with specific standards for particular product. GS1 standards help products in identifying, capturing and sharing the data that is stored in the particular products through use of barcodes and RFID technology.

CHAPTER THREE. ROLE OF GS1

3.1 Global Standards

Due to the technological development the supply chain of companies has changed. The development of new business models such as e-business and e-services has emerged. A standard platform would provide better results to the e-procurement, e-commerce and e-communication. Global standard is basically the rules and methods through which the industries improve the communication and improve their processes by following the globally agreed standards (Thota, 2016).

3.2 Why Global standards are needed?

Global standards improve the communication or information sharing as mentioned above. For the information sharing there should be good relationships between all the partners and also a good information technology is required. This would increase the supply chain transparency and improve all the processes (Thota, 2016).

Transport items of any composition such as a single carton, a pallet (with multiple cartons) or a steel bundle, the re-labeling freight along all the supply chains would not be needed due to one identification standard. This one identifier would give a multi-leg supply chain journey visibility with reduction of waste and cost (Ryan, 2015).Therefore, supply chain visibility is an important tool for the overall companies' performance. The lack of information within supply chain creates many problems. Major problem is the bullwhip effect which is about the huge variations in the order quantity, weak product forecast, uncertain production planning, excess capacity and high cost for correcting all these errors (Adielsson & Gustavsson, 2011). Hence Global standards make sure the visibility of supply chain through sharing of information along all the partners. *Figure 3.1.* is representing the visibility of supply chain through standards.

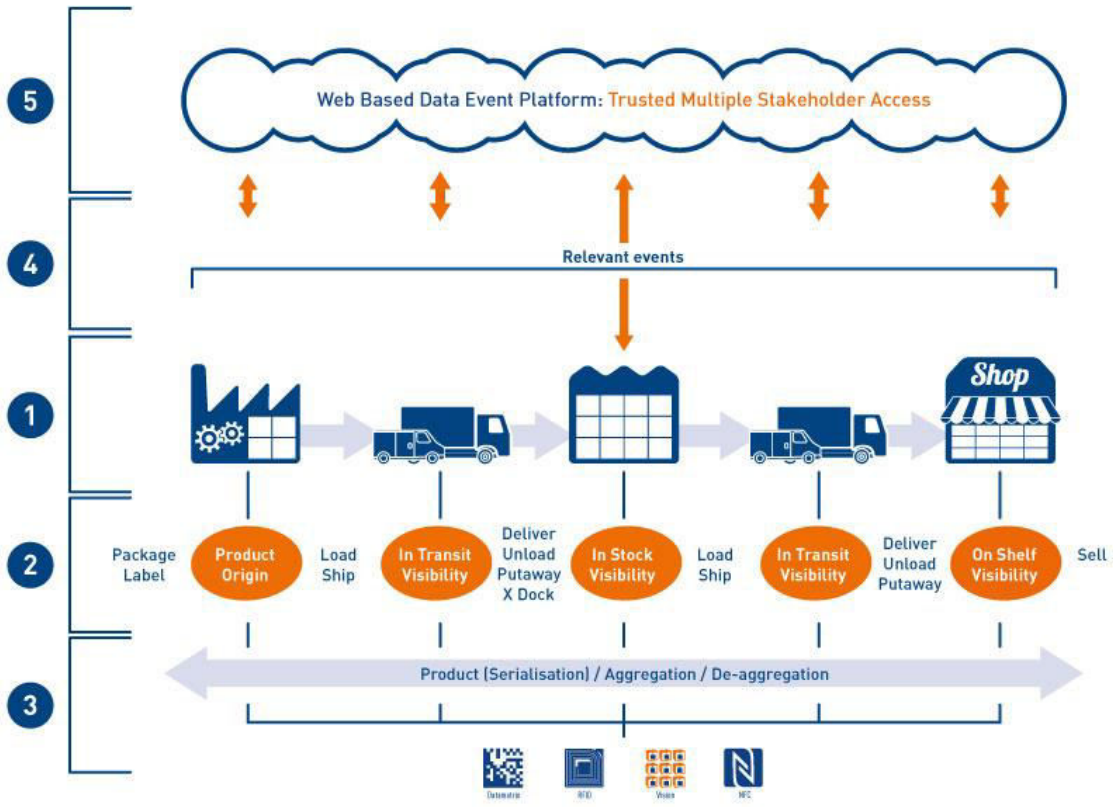

Figure 3. 1*: Visibility of Supply chain*

Source: (Zetes, 2018)

3.3 Introduction to GS1

GS1 started their journey by putting a barcode on a packet of chewing gum to be recognized globally in 1974 and it recently has standards in all industries such as healthcare, retail, Foodservice, technical, transport and logistics. GS1 had started working with barcodes but they are now working with more technologies like RFID (Radio-frequency Identification) (GS1, 2017). It is a non-profit, neutral, user-driven both global and local organization that is creating a common foundation for businesses around the world by uniquely identifying, capturing and sharing the essential data about products and systems. They enable visibility through exchange of authentic data and enable organizations to improve safety, sustainability, efficiency and security. GS1 serves as a community that is inclusive and collaborative in nature. In addition, GS1 is known as a global standards body offering a system of unique numbers to identify goods, assets, services and locations. The 4.0 industry concept has been important in the digitalizing the

value chains, business models and products. International competition has dramatically increased that every organization has to differentiate its product globally. Industry 4.0 is the fourth industrial revolution in manufacturing and other industries. The automation, data exchanges, cloud, cyber-physical systems, robots, Big Data, Artificial Intelligence, Internet of things coupled with (semi-)autonomous industrial techniques has shaped our industries into world of digitalization. It is a vast vision with vast technological aspects that has currently transformed our industries. Some of the important technologies of fourth industry revolution are Internet of Things, Big Data analytics, advanced robotics, digital simulation models and consistent engineering across the supply chain (i-scoop, 2016). Industries are coping up to take action against forging, cut process costs and create such alignment to meet customers' ultimate needs. GS1 is a non-profit organization that has been supporting the companies from last 40 years to implement solutions to 4.0 industrial problems such as data security issues, counterfeiting, cyber crimes and other technical problems. The distribution of consumer goods and groceries sectors are the largest user group of GS1 and its standards were originally created for retailers and producing companies but as time passed other industries also felt the need of integrated supply chain to compete in this challenging environment. Technical industries also urged the need for optimization and standard developments for instance clear identification of products, traceability, Trademark protection, Maintenance and life cycle management (GS1, 2018). GS1 improves the consumer transparency, speed, and trustin supplier by achieving efficient and visible supply chain (GS1, 2017).

Figure 3. 2: GS1 power of Standards

Source: (GS1 Annual Report, 2016-17)

In today's world of technology and innovation, every product needs a unique identification and GS1 helps companies by providing a single language to identify, capture and share the data along the supply chain to make sure the necessary information is available and distinguishable.

GS1 provides a globally unique identification keys (ID keys) to capture the necessary information hidden inside the product so that it can be used to share and improve the overall informational flow of supply chain. It provides a framework that will enable products to get secure information throughout the supply chain as standards has great importance in daily operation and decrease the costs associated with the implementation and maintenance. Standards in supply chain has significant place in supply chain as it makes the alliance of the partners much smoother to exchange information and improves the efficiency. Standards are such agreements set of numbers that gives a pattern to a particular industry. Standards can be set of rules or set of measures through which products of the company can be organized or assembled (Thota, 2016). There are varieties of standards within the organization, sector of industry or even a country. Different organization has different standards to identify or classify their products that can match their industry and type of data they use. However, GS1 has system of standard that is global and multi-sector. GS1 system of standards has been built upon two elements i.e. GS1 automatic Identification and GS1 communication standards *(figure 3.3)*.

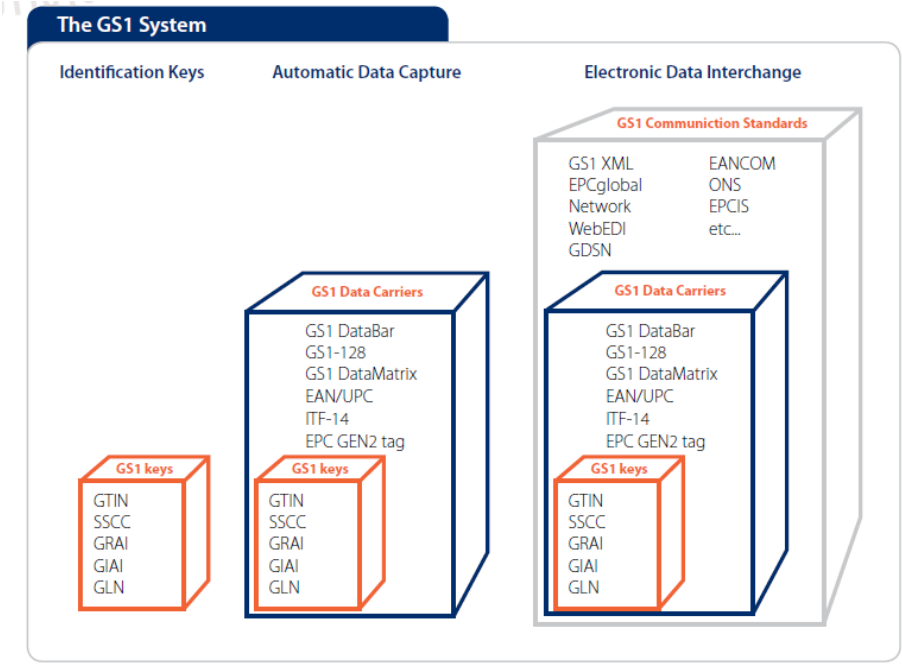

Figure 3. 3: GS1 system

Source: (GS1, 2018)

- *GS1 Automatic Identification* standards consist of GS1 identification keys & Application Identifiers, GS1 Data Carriers and EPC Identifier. GS1 Data Carriers (Barcodes or EPC/RFID tags) are used with the GS1 Id keys and Application Identifiers.

- *GS1 Communication Standards* copes with the transactional data that is used between the trading partners to increase the visibility among the supply chain using the Global Data Synchronization Network (GDSN). This kind of system is used in EPCIS for instance, item loaded onto ship, items at customs etc.

3.3.1 GS1 Standards

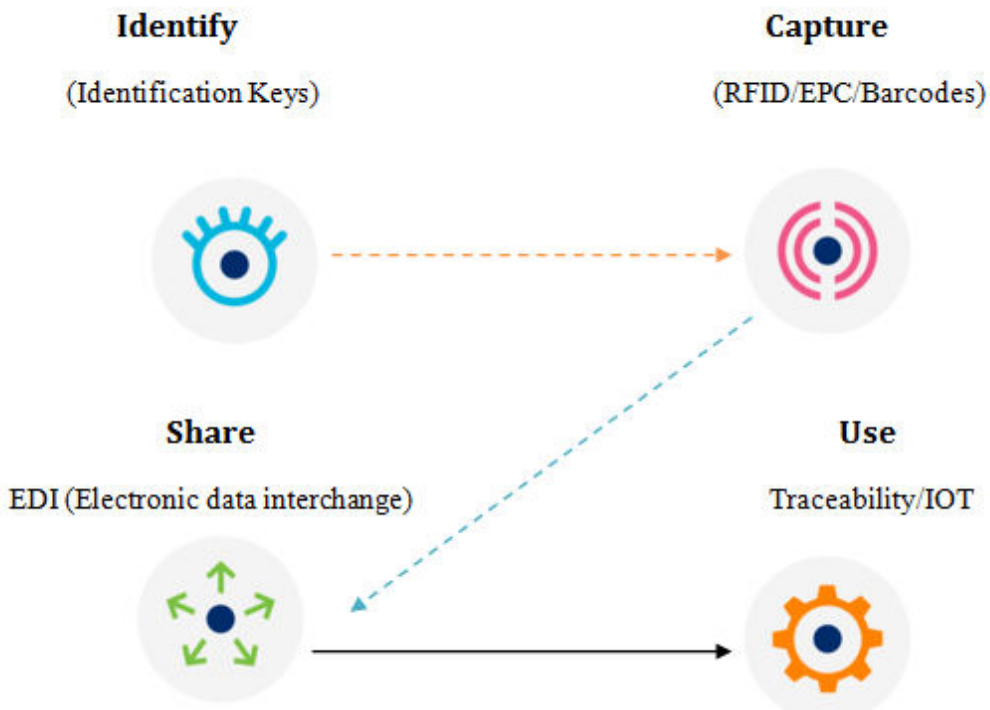

Figure 3. 4: GS1 standards

Source: (Own compilation)

There are basically three different standards of GS1 as shown in *figure 3.4*. The first one is **Identify** where GS1 provides the uniquely identification codes or number to particular real world entity it can be a trade item, logistics unit, physical location, document etc. The second standard is the **Capture**; it includes the Barcodes, and RFID tags. The GS1

identification keys are attached on an object because of the bar codes and RFID data carriers. Through these RFID tags and Bar codes the data can be retrieved regarding a particular object when attached with readers, printers and other applications. The third standard is **Share;** this includes the master data, business transaction data and physical event data and communication data standards. This allows sharing data among all the partners in the supply chain and applications. The **Use** is not a standard but sometimes companies combine different standards to properly run the function of business.

3.3.1.1 GS1 Automatic Identification Standards

GS1 Identification Keys (GS1 ID Keys) are applied to any product, asset, location, logistical unit for naming & differentiating them among other products so that the specific customers or suppliers should identify that product. Table 3.1 shows some important ID keys;

Table 3. 1: GS1 Identification Standards

Source: (GS1, 2018)

GTIN	Global Trade Item Number
GLN	Global Location Number
SSCC	Serial Shipping Container Code
GRAI	Global Returnable Asset Identifier
GIAI	Global Individual Asset Identifier
GSRN	Global Service Relation Number
GDTI	Global Document Type Identifier
GSIN	Global Shipment Identification Number
GINC	Global Identification Number for consignment

3.4 How does GS1 Identification standard works?

GS1's Identification standards provide companies the ID keys through which companies can retrieve information about their items moving in the supply chain. These ID keys help sharing all the information with the partners in an efficient way.

These Identification keys can be applied over the products, physical locations, containers, documents and on many other entities. These ID keys are unique in nature and a perfect source of visibility of supply chain.

3.4.1 GTIN (Global Trade Item Number)

Global trade items number is unique identification of trading goods such as chocolate bar, bottle of shampoo or an album. In other words everything which is priced, procured or invoiced can have a GTIN. This GTIN can be encoded in a barcode or RFID tag. When these barcodes or RFID tags are scanned anyone can get accurate information about a particular item or product.

3.4.1.1 GTIN Data structure

GTIN is available in 4 different formats as shown in *figure 3.5* i.e. GTIN-8, GTIN-12, GTIN-13 and GTIN-14.

GTIN-12 (UPC-12) is used in North America while GTIN-8 (EAN/UCC-8) and GTIN-13 (EAN/UCC-13) is most commonly used outside of North America and GTIN-14 (GS1-128 or ITF 14) is used for identification of products and services at different packaging levels (Bar Code Graphics, Inc, 2018).

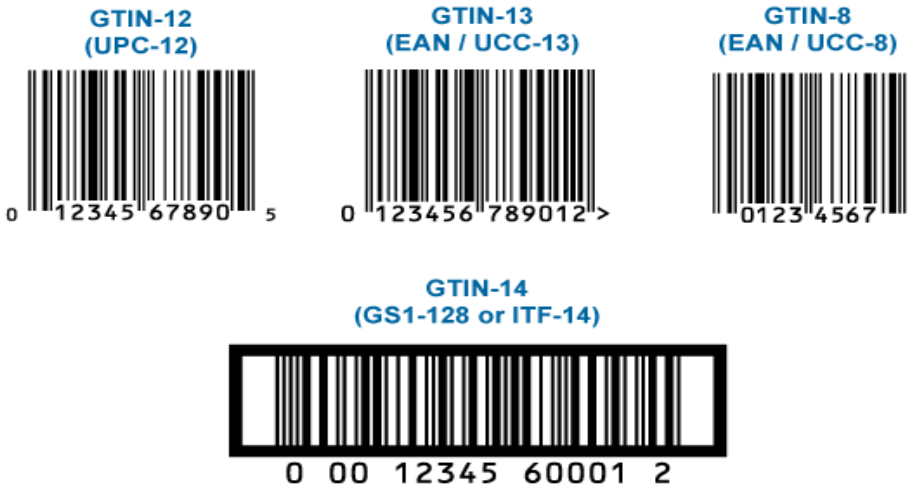

Figure 3. 5: Barcode Formats

Source: (Bar Code Graphics, Inc, 2018)

3.4.1.2 What does GTIN contains?

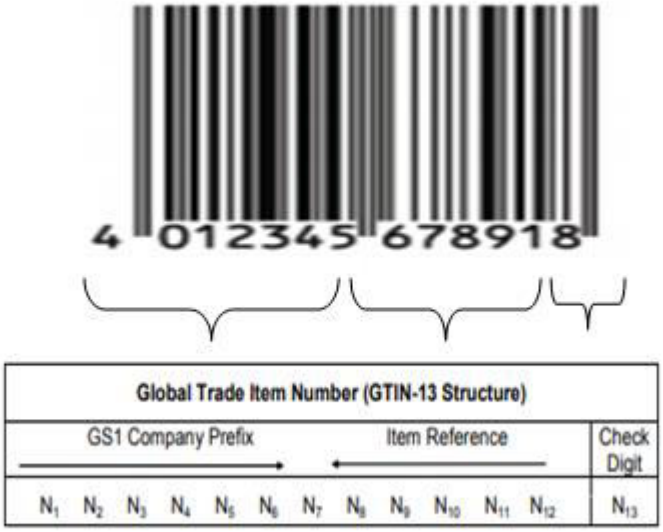

Figure 3. 6: *GTIN number Specification*

Source: (GS1 , 2009)

Company Prefix:

GTIN number has three different specification in identifier as mentioned in *figure 3.6*. The company prefix is the number assigned to the member companies based on their location. This prefix number is issued by the GS1 member office or GS1 Global office (GS1 AISBL, 2018)

Item Reference:

Item reference refers to the item number which is assigned by the subscriber/member company to each of its trade item (GS1 , 2009).

Check digit:

Check digit is a number used to check the data integrity(GS1 , 2009).

3.4.2 Global Location Number

GS1 provide companies unique Global Location Number for identification of any kind and level of physical and operational location. It can be a store, a warehouse, a port and many others. Like GTIN, GLN is also encoded in a barcode or RFID tag and with this GLN identifier anyone can get information about the warehouse, product origin company or all master data about a product as shown in *figure 3.7*.

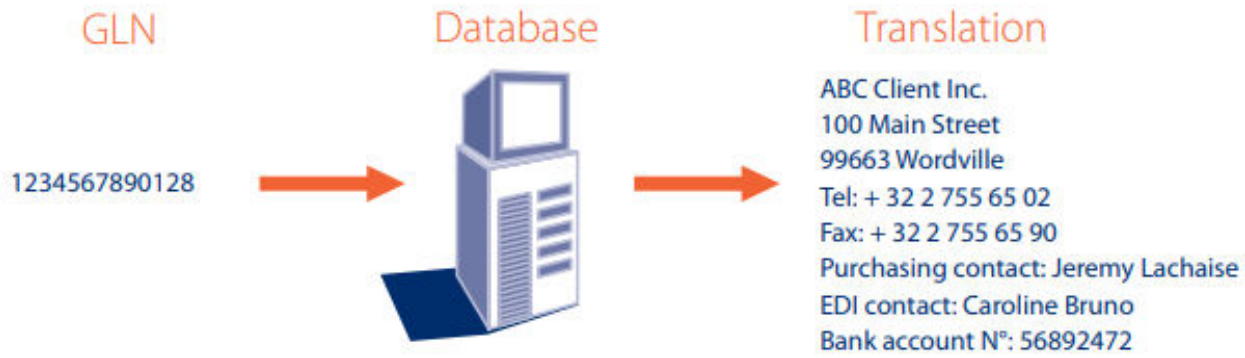

Figure 3. 7: Information retrieved through Global Location Number

Source: (GS1 AISBL, 2018)

3.4.2.1 What does GLN contains?

Global Location number has a company prefix, a location reference and a check digit as shown in *figure 3.8*.

Company Prefix:

The company prefix is the number assigned to the member companies based on their location. This prefix number is issued by the GS1 member office or GS1 Global office (GS1 AISBL, 2018)

Location Reference:

This refers to a specific location mentioned by the member companies.

Check digit:

Check digit is a number used to check the data integrity (GS1 , 2009)

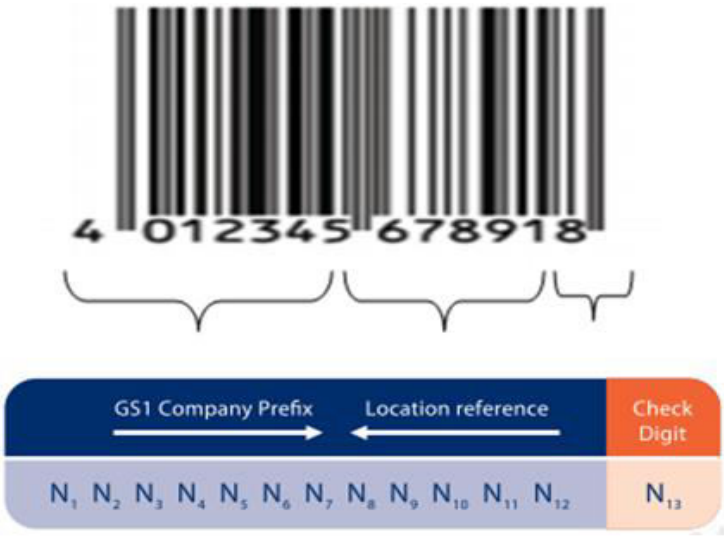

Figure 3. 8:GLN number Specification

Source: (GS1 , 2009)

3.4.3 Serial Shipping Container Code (SSCC)

Serial shipping container code of GS1 is used to identify the logistics unit. This logistic unit can be in the form of Pallet, parcel or anything which tie together for the purpose of transportation or storage.

This code is an important key for the track and trace of any logistic unit in the supply chain. This SSCC code is encoded in a bar code or EPC/RFID tag which helps identify any logistics unit where ever it would be around the world and also gives information about what the logistic unit contains shown in *figure 3.9*.

Figure 3. 9: GS1 SSCC

Source: (Google, 2018)

3.4.3.1 How Does SSCC works?

The SSCC identifier has five different kind of specifications as shown in *figure 3.10*.

Application identifier:

The application identifier (00) basically indicates the Serialized Shipping container code.

Company Prefix:

GS1 company prefix is given to the GS1 member companies and is unique in nature and varies in length. Some companies have license U.P.C prefix. For the purpose of using SSCC the company must be converted into the GS1 company prefix.

Serial Preferences:

This is basically the number which is given to any logistic unit for identification purposes in a supply chain. This number is given by the holder of GS1 company prefix.

Check digit:

Check digit is used to check any error in the data.

Extension digit:

Extension digit is used to increase the capacity of serial references in the SSCC and the range is from 0-9(GS1 US, 2014)

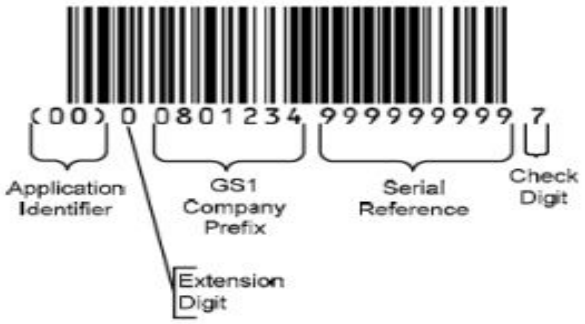

Figure 3. 10: SSCC number Specifications

Source: (GS1 US, 2014)

3.5 Global Data Synchronization Network (GDSN)

The Global Data Synchronization Network (GDSN) is a part of GS1 as shown in figure. It is a network of interoperable data pools enabling collaborating users to securely synchronize master data based on GS1 standards. GDSN supports accurate, real-time data sharing and trade item updates among subscribed trading partners (GS1, 2018).

Every organization who wants to exchange product data with its suppliers and distributors, they must join the data pool that is a certified, tested and meet the GS1 global standards. In order to connect, company should connect to the GS1 Global Registry a central directory that will keep tract and record of connections as shown in *figure 3.11*, it always guarantees that the data would be unique and would comply with shared GS1 standards (GS1, 2018).

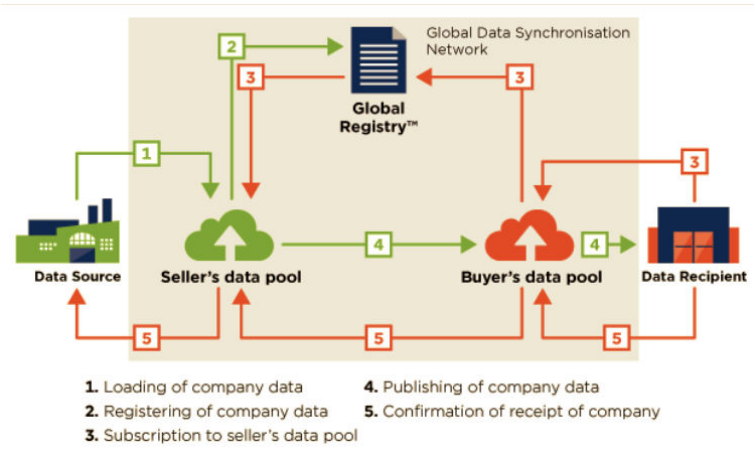

Figure 3. 11: GS1 Global synchronization Network, Source: (GS1 2018)

3.6 Electronic Product Code (EPC)

Electronic product code is a unique number and universal identifier, which identifies a particular item in the supply chain and can be related with the emergence of the product and date of production. EPCs are encoded through RFID technology and track all the objects through RFID tags.

3.6.1 Electronic Product Code Information Service (EPCIS)

The aim of EPCIS (Electronic Product Code Information Services) is to authorize application to create and share visibility event data. It eases the sharing of information across enterprises and businesses. It helps to make a standard data-sharing interface between applications that captures the event data and allows them to access it. EPCIS helps to get the details about the physical or digital activity in the supply chain of products and other assets, identified by keys.

3.7 GS1 Sectors

GS1 has served almost all the important industries i.e. Retail; Consumers packaged goods and merchandise, Apparel and general merchandise, healthcare, Transport & logistics, Foodservice, Humanitarian Logistics and Technical Industries.

Retail: As world is becoming more digitalized there is a need for the brand owners and retailers to have connection with the customers. The transparency of supply chain and processes through identification of the products, shipments, location and sharing the accurate information to all the partners is very important. GS1 has provided the Global trade item numbers (GTIN) for solution of product assortment issues). The second contribution of GS1 in Retail sector is the GS1 smart search. This feature helps the web developers to put the information regarding products on web pages.

Consumers packaged goods and merchandise: The earliest adopters of the GS1 standard are the brands of consumer packaged goods and fresh food providers. Consumers used to go to physical store for grocery and household merchandise; they use the mobile search to check the content/ingredient of a product and allergy stuff or the country of origin of that product.GS1 barcode attached to the packaged goods helps consumers to get to know whatever they want to. Also GS1 helps the companies in improvement of their online image and their speed to market function. (GS1 Annual Report, 2016-17)

Apparel & General Merchandise: In Apparel & General Merchandise industry GS1 has provided the EDI and EPC/RFID standards, which automate the production, packaging etc. It has also contributed towards inventory management through RFID technology in this sector.

Healthcare: In Healthcare industry GS1 is providing the unique device identification (UDI) system, which helps all the healthcare stakeholders in identification of any medical device in case of need. It also increased the accuracy of the medical records and helped in transparency of hospital supply chains and pharmaceutical companies.

Transport & Logistics: Transport and logistics is a very important part of supply chains and its transparency matters a lot. GS1 standards have huge contribution towards transport and logistics sector. These standards are SSCC, GSIN etc.

Foodservice: Food service sector is becoming huge and the complexities regarding the consumers demand and efficiency of supply chains are also demanding. GS1 through Global Location Number and Electronic data interchange helps such companies to make their purchase in less time (GS1 Annual Report, 2016-17).

Humanitarian Logistics: GS1 has also engaged to improve the supply chain or humanitarian sector. GS1 is working with UN high commission of refugees and many other organizations to improve the supply chain.

Technical Industries: GS1 contribution in Technical industry is huge. The complexities of technical industry`s (Defense, engineering, energy, mass transit and mining) supply chain and different challenges such as competition, cost pressures and with the time advancement in digitalization and automation increases the need of getting solution to these challenges. These companies requires to identify their parts and components with the identifiers which should be unique in nature from the very early stage i.e. design phase. GS1 has solved many of the problems of such companies. They provided such standards from which companies can identify parts and components with the unique number identification. These identifiers are such useful that the information regarding materials life cycle can be accessed whenever required.It is also giving solution to the challenges of industry 4.0 providing such standards where the communication devices uniquely identify each other and are also connected to the main infrastructure with accuracy and quickly (GS1 Annual Report, 2016-17).

3.8 Success stories of GS1 in Tech Sector:

The case of Schaeffler Group: Schaeffler Group manufactures the components, engines systems, bearing solutions, transmitters and chassis. Scaeffler is the world's leading automotive Group. This Group is using the GS1`s GTIN (Global trade item number) programmed in a barcode. This standard has ensure the authenticity of schaeffler products and made traceability of each bearing possible (GS1 a, 2018).

The case of ATE Continental: This Company provides the high quality automobile spare parts i.e. brakes, hydraulic components, brake fluids and electronic components. This company used Global trade item number (GTIN) and serial numbering programmed in a barcode. And these codes were attached to each and every spare part. This helped the customers to authenticate the spare part by scanning it through Smartphone apps or other means (GS1 b, 2018).

The case of Contitech: Contitech is the famous company in providing rubber and plastic technology. Automotive, rail, mining, machine and plant engineering and many other industries are the customers of contitech. They make a customized system for their customers and ensures that each and every system is being shipped or transferred to authentic customer. They have used SGTI (Serialised global trade item) standard which is encode in a bar code and this bar code is attached to each and every system and also on the components of the system for better traceability (GS1 c, 2018).

3.9 GS1 and Circular economy:

As products are produced, packaged, sold and shipped after reaching to the customers they consume it and the consumed products are either thrown away, disposed or recycled. The movement of consumed material requires many different actions that needs a lot of paper work and is expensive also there are risks to environment and human health. GS1 helping this out by providing solution for each type of waste i.e. traceability of waste is possible and partners are able to share the information. In other words it is engaged in changing the make-use-dispose thinking towards make-use-recycle. The GS1 Finland is an important member in the *Finland National waste management Plan* named as *CIRCWASTE* and its motive is to direct Finland towards circular economy. The main function of GS1 is to

digitalize the logistics and provide such solutions' which could help in recycling the waste also to provide such mobile cloud solution through which the losses of SMEs in the supply chain management could be reduced (The Finnish Environment Institute (SYKE), 2017).

Chapter Four: Research Methodology

This chapter is about the research methodology of the study. Research Methodology is the method of data collection and research designs that help in analyzing the overall data and information that is essential for solving the research problem by means of scientific methods. As Saunders et al., (2009), referred the term "methodology" the theory of how research should be undertaken.

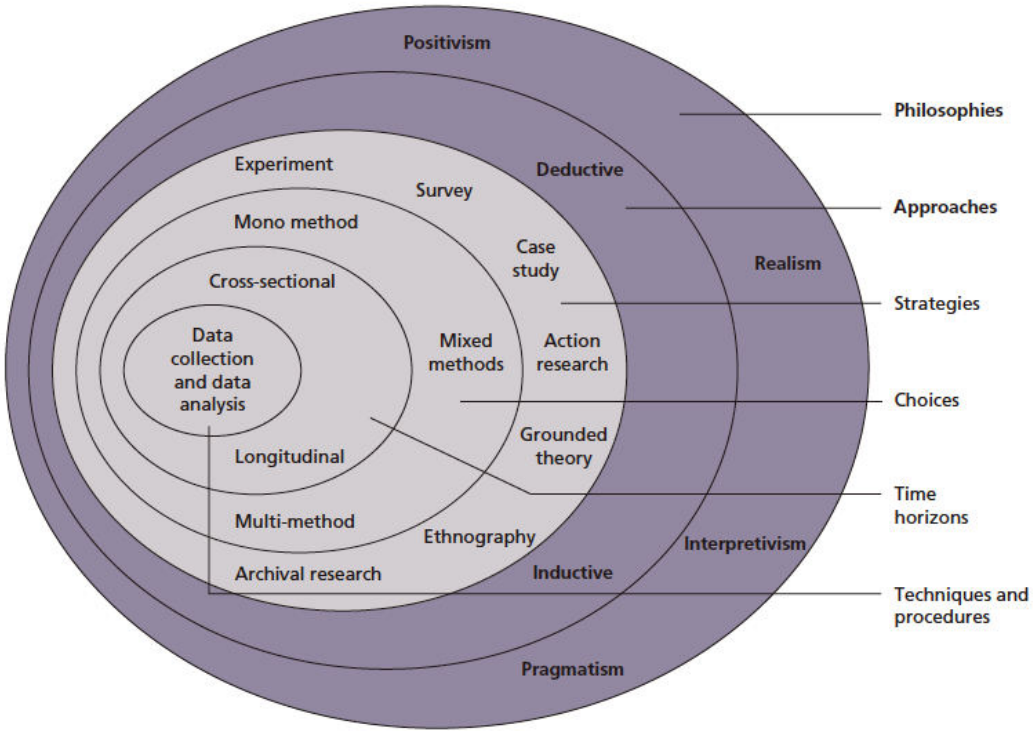

Figure 4. 1: "The research onion"

Source: (Saunders et al., 2009)

4.1 Research Philosophy:

A research philosophy is a belief about the way in which a data should be gathered, analyzed and used. The research philosophy you adopt contains important assumptions about the way in which you view the world. These assumptions will underpin your research strategy and the methods you choose as part of that strategy (Saunders et al., 2009) As shown in the *figure 4.1*, research can be like onion that need to peel away as we go through each phase. According to Saunders, there are three main dimensions of research philosophies:

- Ontology
- Epistemology
- Axiology

Ontology refers to the branch of philosophy that is based on nature of reality and structure of the world, directing to specify the form and nature of reality and question what the reality is (Wand & Weber, 1993).

Ontology is classified on the basis of:

- Objectivism
- Subjectivism

Objectivism portrays the position that social entities exist in reality external to social actors concerned with their existence. For instance, a large organization wants to change all the managers in any particular department, in this example the management is an objective entity and they decide to make an objectivist stance to the study of specific organization. The second aspect is *subjectivism*; it holds that social phenomena are created from the perceptions and consequent actions of those social actors concerned with their existence (Saunders et al., 2009).

Epistemology is based on the nature of human knowledge and understanding that can be acquired through different kinds of inquiry and alternative methods of investigation (Hirschheim et al., 1995). It concerns what constitutes acceptable knowledge in a field of study. It can be divided into two aspects; resources researcher and feeling researcher. The 'resource researcher' deals with the data from the perspective of natural scientist. On the other hand, the 'feeling researcher' is concerned about the feelings and attitudes of the workers towards their managers. So the 'resource researcher' is involves developing positivist philosophy whereas the 'feeling researcher' is focus on interpretivist philosophy(GuhuThakurta, 2015). In the domain of research philosophy, Epistemology is therefore classified as:

- Positivism
- Realism
- Interpretivism

The philosophical approach of natural scientist is observed in *Positivism* is like the work of natural scientist is based on observable social entity. A positivist works with an observable social reality and that the end product of such research can be law-like generalizations similar to those produced by the physical and natural scientists (Remenyi et al., 1998). The

strategy of this dimension is based on data collection and hypothesis development. These hypotheses will be tested and confirmed that can be used for further research. The positivist researcher follows highly structured methodology in order to facilitate the hypothesis. Moreover, positivism works on quantifiable observations and accordingly statistical analysis (GuhuThakurta, 2015).

Realism is another philosophical position which relates to scientific enquiry. The essence of realism is that what the senses show us as reality is the truth: that objects have an existence independent of the human mind. The philosophy of realism is that there is a reality quite independent of the mind. The two kind of realism is direct realism and critical realism. Direct realism portrays the world through personal human senses. Critical realism is the experiences and the images of things not the direct things (Saunders et al., 2009). *Interpretivism* also known as contructivism is the worldview in which the researcher believes that individuals seek understanding of the world in which they live and work. The purpose of the research is to depend on the participants' views, ideas and experiences (Creswell, 2014). It advocates that it is necessary for the researcher to understand differences between humans in our role as social actors. This emphasizes the difference between conducting research among people rather than objects such as trucks and computers. Taking the example of actors who play a part or role in movie or theatre act out their part in accordance with this interpretation. In the same way we interpret our everyday social roles in accordance with the meaning we give to these roles (Saunders et al., 2009).

Axiology is a branch of philosophy that studies judgements about value. It is the process of social enquiry with which we are concerned. The role that ones values play in all stages of the research process are of great importance if one wants their research results to be credible or reliable (Saunders et al., 2009).

4.2 Research Paradigm

As a researcher, its one responsibility & essential part of research methodology to choose a specific research philosophy for one's paper. This will help other who will be studying particular or comparable context in future and who might encounter those real-life obstacles. Research philosophy or Research paradigm termed by Guba, holds utmost and important belief system that guides the investigation (Guba & Lincoln, 1982). "A research paradigm inherently reflects the researcher's beliefs about the world that s/he lives in and

wants to live in. It constitutes the abstract beliefs and principles that shape how a researcher sees the world, and how s/he interprets and acts within that world"(Lather, 1986). Paradigms are thus important because they provide beliefs and dictates, which, for scholars in a particular discipline, influence what should be studied, how it should be studied, and how the results of the study should be interpreted. The paradigm defines a researcher's philosophical orientation and, as we shall see in the conclusion to this paper, this has significant implications for every decision made in the research process, including choice of methodology and methods. And so a paradigm explains how meaning will be constructed from the data one gathers, based on their individual experiences, i.e. where they are coming from. It is therefore very important, that while writing one's thesis, one should clearly write down the research paradigm. (Kuyini & Kivunja, 2017). Several other researchers have suggested two primary taxonomies for paradigms namely, Positivist, Interpretivist. A positivistic paradigm typically assumes a quantitative methodology, while a constructivist or interpretative paradigm typically uses a qualitative methodology. This cannot be true for every scenario; there are examples in which one may pursue an interpretative study using a quantitative methodology (Chilisa & Kawulich, 2012). Research paradigm used in this study isinterpretivism. In interpretive research there are no predefined dependent and independent variables and purpose is to examine the subjective perceptions and reflections underpinning the social action (Kaplan & Maxwell, 2005). This study focuses on the circular economy and product identification that is a qualitative study. A circular economy is an industrial system that restores the use of materials over and over again to get the maximum usage of the materials and products. Its based on reuse, repair, refurbish, re-manufacture, recycle and recover materials, products and systems of different industrial like plastic industry, electrical equipment, home appliances and many more (PBL, 2017). This concept can be applied on different organizations according to their capacities and long-term vision. Different countries and government organizations like Europe Union, UNO, Dutch government and other international organizations work vigorously towards greener supply chain, sustainability and economy that promotes more renewable resources. As this interpretive research, can be viewed as a social reality and we can interpret through sense-making process.

4.3 Research Design

"Research design is a plan that describes how, when and where data are to be collected and analyzed" (Parahoo, 1997). According to (Kerlinger, 1986) research design is "the plan

and structure of investigation so conceived as to obtain answers to research questions". It is a systematic master plan for scientific study that can have several approaches such as qualitative, quantitative or mixed methods (Creswell, 2014).

4.3.1 Qualitative Research

Qualitative research is an approach that is used for understanding and examining the problems of any individual or group of people. This kind of approach can be questions, interviews and methods that are basically conducted for the targeted participants. The style of method is usually inductive style, has flexible structure and the data analysis is done through interpreting the data analysis inductively and pay attention towards the complexity of a situation (Creswell, 2014). Five strategies have been identified as qualitative research methods. They include ethnographies, grounded theory, case studies, phenomenological research and narrative research (Campbell, 2014).

4.3.1.1 Types of Qualitative Research

"Ethnography is a qualitative strategy in which the researcher studies an intact cultural group in a natural setting over a prolonged period of time by collecting primarily observational and interview data" (Creswell, 2014).

Grounded theory is another method of qualitative approach that allows a researcher to generate a theory that offers and explains about the main concern of the population or how the concern is settled down (Scott, 2009). According to (Charmaz, 2006), "Grounded theory is a design of inquiry from sociology in which the researcher derives a general, abstract theory of a process, action or interaction grounded in the views of participants". The process of grounded theory can use several stages of data collection and refinement and interrelationship of information (Strauss & Corbin, 2007).

Case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real world context when the boundaries between phenomenon and context may not be clearly evident (Yin, 2014).

Another form of qualitative research is narrative and phenomenological research. Narrative is defined broadly as an account of an experience that is told in a sequenced way, indicating a flow of related events that, taken together, are significant for the narrator and which convey meaning to the researcher (Coffey & Atkinson, 1996). According to (Musson, 2004), phenomenological researches are based on individual's accounts of their

experiences and the ways in which they elaborate their interpretations and connecting them to the outer world and the society they live in.

4.3.2 Quantitative Research

Quantitative research is the analyzing of a variety of numbered data through statistical procedures, testing of variables and studying the relationships between those variables. It involves assumptions that can be tested deductively, explaining the findings that can prove the results and has a structure form of report. Survey research and experimental design are two main quantitative forms of research (Creswell, 2014).

4.3.3 Mixed Method Approach

Mixed method approach study has combination of both quantitative and qualitative forms of data. This kind of method is used to double-check the accuracy of the information so that no biasness should influence the database; it can be useful to aid one database to examine another or researcher can have alternate ways to extract the data. (Creswell, 2014)

4.4 Data Collection

This study is conducted as qualitative approach method using data from semi-structured interviews. Our primary data are obtained through the use of unstructured interviews from technical companies. Qualitative semi-structured interviews are one of the most dominant and widely used methods of data collection within the social sciences (Bradford & Cullin, 2012). Interviewing the specific companies who work with technical parts of machinery and focus on the idea of green supply chain and sustainability, has given an idea about the internal capacities, internal problems and barrier that they encounter each day by handling those products. The ideas and views given by the company are observed and analyzed through an interpretive measure and inferences depend on the subjective perceptions of the employees working in the higher hierarchy. In order to obtain the answers to the research questions more in depth, an exploratory review of existing literature was done. The academic databases such as Google Scholar, ProQuest, ScienceDirect and Academia were used. Keywords such as “Circular Economy, Product Identification, Sustainability, and Barriers to Circular Economy” were used. Mostly White papers, Reports, Governmental publications and Journals were used as secondary data.

4.5 Interview execution

Two of the interviews were taken face to face that seems to be a traditional method in qualitative research. One of the Interviews was through sending the interview guide via email the reason is that the person was not reachable to conduct face to face interview. During the interview Notes were taken to remove the chances of forgetting some important stuff. The Interview guide was changed little bit based on the company i.e. some questions were added for GS1 Company and the context of one interview guide was somehow different than the other.

4.6 How Qualitative Data Analysis is done

For the detail analysis of primary data a general analytical procedure was conducted. For the purpose of qualitative analysis and getting a true picture of the interviews they are transcribed. In this transcription a special attention has been taken on the accuracy by focusing on the shortening of sentences that means, authors tried to eliminate the words which were repeating (Thomas, 2006).

Chapter Five: Finding of Primary Data

This section of the paper provides the findings and based on the unstructured interviews conducted by the authors, the observations and the secondary data. The aim of this section is to provide information that enable us to answer the research questions. The research is qualitative in nature; the data is collected from the interviews with respondents in company A, company B and GS1. We are not mentioning the names of the two manufacturing companies since we have a non-disclosure aggreement with them, but we describe the type of companies and their objectives.

5.1 Company A

Company A is a technology-based company that delivers competitive solutions to meet the power needs of its customers. It works within the marine and automotive industry. Its products and services include power systems, nuclear and many more. Being into a technological industry the company tries to have a reputable rule to minimize the risk of climate change, low carbon global economy, reduction of environmental impacts from production as well as improving environmental performance of its products. Furthermore they are strongly committed to health, safety and environmental management.
The respondent said that we don't exactly use the term circular economy but we have all the focus towards environmental protection.
We have the program called Revert which is about minimizing the demand for the new materials in which the metals are being recycled. This also helps in lowering the cost and reusing of finite resources i.e. rhenium, hafnium, nickel and titanium.
The authors asked the question regarding to circular economy, the respondent said that almost 95% of the engine parts and equipments are recycled and have high quality but the main barrier is the cost of recycling.
Through the Revert program tons of carbon dioxide are saved compared to using new materials. In addition to the cost of recycling, another barrier the respondent mentioned was the disassembly of the products.

C*ompany A* uses the Baan system for its product identification. The Baan system is an ERP system, which gives the opportunity to make labels for each item in a warehouse, work-in-process parts and final products. For identification of products internally, their products and parts follow three main standards;

- Unique item number on parts of products
- Permanent marking on manufacturing parts
- Material melting number
- LOT number

The *unique item number* is defined by the engineering and physically labels are put the parts. It is a marking method to identify the material with a unique ID or number in the system.

Furthermore, *permanent marking* is provided for manufactured parts with *3.2 Certification (GN local rule)*. 3.2 Certification is a part of the EN 10204:2004 standard for delivery of metallic products. There has been a need for manufacturers to prove the materials used in their products have safety-critical pressure equipment to meet the required properties. The EN 10204:2004 standard has two types, 3.1 and 3.2. 3.1 is issued by the manufacturer that proclaims that the products supplied are in compliance with the requirements of the order and it is assisted by evidence of the manufacturer's test results. 3.2 EN is prepared by both the manufacturer and an independent third-party in which they declare that the products supplied are in compliance with the requirements of the order and the test results are supplied. The independent third-party ensures material conformity across the upstream supply chain to steel manufacturer (Thompson, 2016).

Material melting number is stamped manually on the part to give information and control the quality of a particular product in production.
By this, each part and component has its own item number.Critical components are requested by Class Society to be traced from component level to product. Therefore, engineering ,define critical components, in the Product Data Management System and set up a *LOT control number* to enable to track traceability as demonstrated in the *figure 5.1* below.

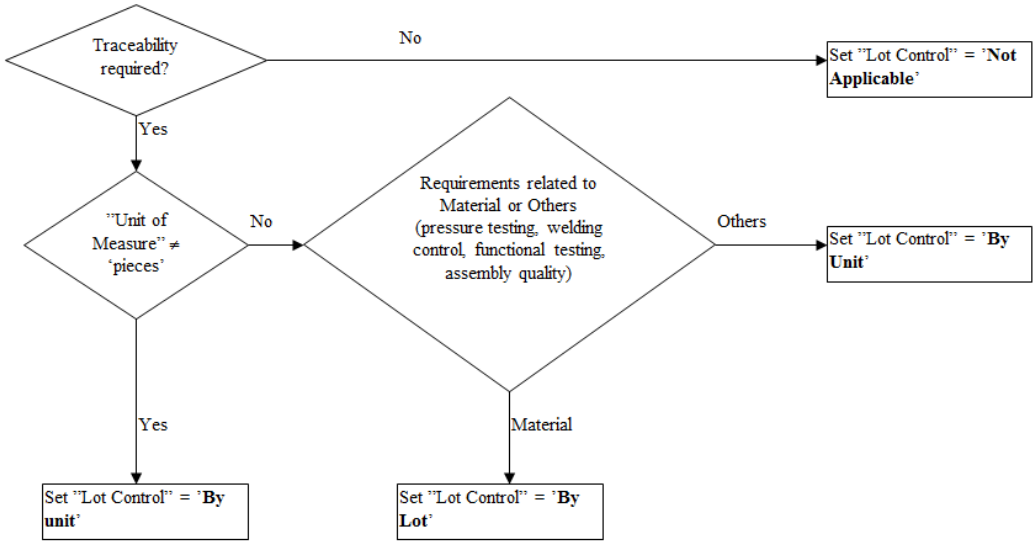

Figure 5. 1: Internal system of company A

Source: (Company A)

LOT control in the ERP Baan system connects the customer's product back to the supplier's material deliveries. Everything is stored in Baan so they can track the items backward and forward through the supply chain after the items are delivered. When they Release Production Orders the LOT number is generated and will appear on the Covering note (Production Routing).

Figure 5. 2: Barcodes Formats

Source: (Company A)

The operator or supervisor uses the LOT Allocation Report *(figure 5.3)* to report which Main LOT the sub LOTs are consumed by using Baan or Bridgelogix.

LOT controls are mandatory for Critical Items. The engineers are responsible to set the correct LOT number to the items.The logistic (production and warehouse) has the duty and responsibility that the LOT linking is correct from supplier to customer.

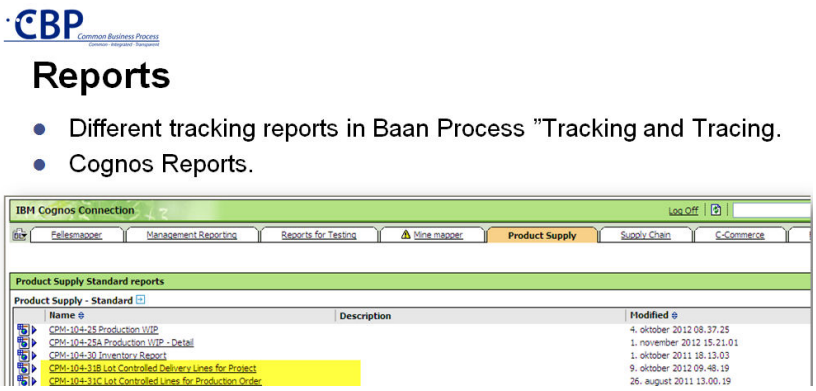

Figure 5. 3: Internal systems (tracking Reports)

Source: (Company A)

In addition to this, the company's customers can also identify their products by International Maritime Organization (IMO) Ship Number for Customer's vessel and an ERP project number from the Baan System. The suppliers of the company can use Purchase Order number, 3.2 certificate number, drawing and item number/batch, material melting number on the products. Suppliers LOT is linked to the Company's LOT in the LOT in the Table in Baan System. All materials and components certificate are linked by LOT in Baan and the documents are stored in ECM (Enterprise Content Manager).
The numbering schemes used by Company A are:

- Unique item number on parts of products
- Permanent marking on manufacturing parts
- Material melting number
- LOT number
- IMO Ship Numberfor Customer's vessel
- ERP project number
- Purchase Order number to supplier
- 3.2 certificate number
- Drawing and item number/batch

5.2 Company B:

Company B is a Norwegian company that manufactures professional lighting solutions for global markets. Their goal towards a sustainable environment is,

'*The total products that come to at end, do not end but they are used again to make something new'.*

'The main objectives of the company are; reducing wastes, diminishing energy utilization, expanding reuse of product, efficient environment transport solution and prohibit emissions.'

The company is abided by law to follow the local and global standards and environmental policies, which is reflected in one of the answers of the employee:

'Our company's products also satisfy the WEEE Directives (Waste Electrical and Electronic Equipments), has ISO 14001 environmental certification and policy for corporate Social Responsibility (CSR) to support a precautionary approach to environmental challenges, undertake initiative to promote greater environmental responsibility and support the development of environmental friendly technologies.'

In addition to sustainability, barriers of Circular Economy were discussed, technological barriers is an issue in implementing the CE in organizations. These include; less attention towards end-phase of product, separation of biological substance from technical products lacking due to less information, difficulty in reusing the products due to complex nature of products, recycled materials being more expensive than the real/virgin materials, consuming more time, quality issue and supply chain complexities. Quality issue and disassembly of products were the main barrier that they may face because the reused products may not be as good as the products with the new and high standard virgin product. To produce more quality product it needs to be more accurate and precise in extracting those parts while recycling.

As shown in *Figure 5.4*, article number[2](C51SL4560) and batch number [3] (PE8000342) at the top, are stored in their info system gives them information about the product details such as components information, type or date of the production etc. These numbers (article number, batch number) are usually used to identify specific manufacturing of the product

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[2]The International Article Number (also known as European Article Number or EAN) is a standard describing a barcode symbology and numbering system used in global trade to identify a specific retail product type, in a specific packaging configuration, from a specific manufacturer.

[3] A batch number is a designation that is printed on the drug label that allows the history of its production to be traced. This includes not only identification of the specific batch produced, but all relevant issues of control and manufacturing particulars should also be traceable from the batch number.

in any supply chain of the company. The information given on the particular product will be in the database of the company for twenty years.

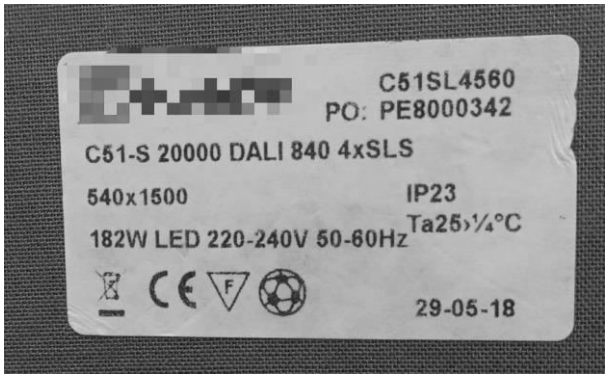

Figure 5. 4: Product identity label

Source: (Company B)

All the European companies including the company that we have interviewed, by the law have to recycle the used products and none of the technical products goes to landfills as they contain hazardous material and may impact the environment harshly.

The products are labelled with a "crossed-out wheelie-bin' symbol to show that this products must not be thrown away. This symbol is called Cisco product symbol. It is important to dispose of waste equipment separately from the municipal waste stream. (WEEE Directive)

The Company claims to have product identification number for the parts and components for outbound delivery that is for transferring the products and parts through their supply chain from suppliers and to the customers. The systems they usually use internally are, 'info system' and 'Baan system'. For recycling part, they consult another two main organizations to recycle for them as taking producer responsibility to dispose waste in accordance to the law. A small amount of the fee is charged to the customer to ensure the proper treatment of disposable at end-of-life products.

In regard of using GS1 as global standard for identifiers, the company would prefer to have this standard for all its products in their different branches that are located in Denmark, Netherland or Estonia. It would ease maintainance of one major database to connect throughout different systems present in different countries. Using global standards for their internal parts (for example the GS1 standard), could help the company tackle the problems with standardization of products while recycling but it could impose issue of security and problems in regard with their competitors.

5.3 GS1 Interview:

GS1 Norway has fifteen team members. In the administration department there is one managing director. Two persons are managing the consultancy services and providing helps if some member company needs support i.e. operating consultant users' support and operating consultant support. Department of market and business development consists of six people, i) Chief operating officer, ii) Development manager, iii) Senior industry development manager, iv) Industry development manager in public sector and digital market places v)Product manager GLN (Global Location Number), and vi) Marketing manager. The department of delivery and standards consist of three people i)Senior Advisor ii) Senior advisor Data Capture and iii) Senior advisor EDI (Electronic data Interchange). Department of sales support, smart center and partner program consists of three persons, i) Manager smart center and partner program/senior advisor, ii)Management consultant course management and sales support, and iii)Audiovisual Designer. This interview was conducted in the department of delivery and standards from Terje Menkerud, a senior advisor in AIDC (Automatic identification and data capture). GS1 Norway has more than 6300 users all over the country. It also offers the GS1 smart center, through which the companies get the advisory services and training for effective trade and logistics, in addition partners learn and exchange different ideas.

5.3.1 GS1`s Efforts towards Sustainability:

This section would present a picture about GS1`s work towards sustainability. This would give us an insight about the company`s efforts and mindset regarding sustainability and these efforts would depict their thinking about circular economy.

The respondent stated that company`s efforts towards sustainability are a deep concern. GS1 offers a globally standardized way of doing business by cutting down costs and improving efficiency through for example reduction of transport by decreasing the rate of air with in the packages called "case fill rate". This means having more goods and less air in the parcels resulting in more packages are being transported on fewer lorries supporting sustainability and environmental friendly way of doing transport. This is a key element that GS1 system has when it comes to supporting a sustainably way of doing transport. The Mix- Move- Match concept states that the deliveries of customers are arranged very close to the location of customers and that logistic units are combined to get the optimum utilization of transportation .The consolidation of different logistics unit into one a single

customer delivery decrease the amount of lorries needed for transporting the deliveries. GS1 provides a unique identification of the logistic units named as SSCC (Serial Shipping Container Code). This GS1 SSCC is encoded in a barcode and attached to the entire logistics unit. The Mix-Move-Match concept with the identifiers of GS1 has reduced the logistics cost by 35% and the consumption of vehicles has doubled which ultimately decreased the CO2 emission.

In response to the question about challenges to the company with respect to sustainability the respondent said.

GS1 is not a logistics company, it came from the retail sector and not many companies see us as a logistics company. This is the biggest challenge to get the actors and the players in the field of logistics to know who we are and get aware our system and get to know how we could we help them in daily business by reducing the cost and solution towards environmental friendly transportation.

He further explained that since a lot of players in the market have their own systems, they don't interact effectively. If you get some material from other market you have to re-label it. To get the entire community in to the same global standardized way of trace and track with unique identification is a big challenge in a way of sustainability. The reason is that if there are global standardized system all the information about a particular product would be shared which is not the case in most of the countries.

5.3.2 Circular economy:

This section describes the discussion with the interviewee about "Circular Economy". As a fact that CE concept is neither known by many companies nor implemented so much. Hence, the discussion will give a perception about their knowledge about CE.

The respondent explained that "Circular economy" as

"*A way of reuse of resource"* and

"Is the reuse of pallets reuse of containers reuse of what the transport is done with".

We don't focus on circular economy per se but everything we do is based on sustainability and environmental friendly way of doing things and GS1 has focus on carbon footprints. GS1 would not accept that our system is used in a way that is not for the better good. Everything we do focus on the circular economy thought. Everything we do is based on sustainability, efficiency and environmental friendly way of doing things not just in transport and logistics, but in everything we do from healthcare sector, retail, and apparel sector to logistics sector.

Logistics and transportation doesn't do anything with reducing wastes but the way we do things make the difference. GS1 will help to identify various parts in recycling e.g. Plastic pallets should be used instead of using wood pallets for delivering of materials and components. Plastic pallets have life span of 10 years and wood pallets have life span of may be 5 years so plastic pallet can be used again and again. Different ways of using pallets and crates means being able to supply the market with a system to handle such logistics as GS1 can do, but GS1 has no program for recycling and minimizing waste outside of food sector i.e. in technical products.

Product attribute in the GDSN of GS1 supports recycling to be registering what the product contists of, and how these products to be treated in a special way and how to recycle them. All the labels related to environmental sustainability put on the products such as CE or others, are all have in the GDSN. You would be able to make a choice to use a sustainable products or not a sustainable product. Not all these attributes are mandatory so not all producers are using it.

5.3.3 Efficiency of Different companies` information system through GS1:

This section gives the contribution of GS1 in different companies` information systems and databases.

GS1, neither sell software nor sell hardware we are a globally standardization company with our standards, frame work, and with our collaboration in different sectors if the producer and the seller and the retailer everybody uses GS1 system one would be able to do efficient, economical and more sustainable way of doing business.

SAP has implemented all the parts of GS1 system in the SAP system. They are using the GLN for location identification GTIN for trade item identification and SSCC for containers and logistics units. Also most of the BMS or ERP providers are using parts or the whole GS1 system within their own programs.

5.3.4 Barriers to Circular Economy:

This section provides the discussion about barriers to circular economy with respect to technical products and the barriers in general relative to supply chain.

The respondent says that, *quality could be an issue in the recycled products.* He also mentioned that, *recycling is more expensive than the virgin materials but it depends on the price of the material itself. Further, if you see it in an environment perspective it would not*

be because this is the whole idea of recycling, but if you have a sustainable mind you would probably prefer recycled material over virgin. Companies give less attention to end-phase of product because there are new products available and they just replace them with the new one. Their thinking about recycling is normal but not that much as it should be.
Transition towards circular economy is expensive and time consuming and there are possible complexities in the supply chain as well. He thinks that, *moving towards circular supply chain needs a lot of investment.*
Regarding the hygienic issues in the recycled materials he thinks that, *it depends on the country system i.e. how the products are being handled and recycled so in his perspective economy matters a lot. Coordination among companies in transition towards CE varies from company to company. Some companies have more focus on environmental friendly thinking of doing business and some have not.*

5.3.5 Ways GS1 could Help Technical Sector in Circular economy:

This section provides the discussion with respondents about the way GS1 could help out technical sector in circular supply chain because GS1 has not so much contributed in this sector.
GS1 could probably be used for identification of what the substances of product are if they have access to a database with such information but the problem with all the databases and repositories is that they don't say anything about what product contains, it just tell what product is.
Even If you are connected to the database of the producer, you could probably not get the information on what the product is made of because in technical products producers are not obligated to say this product contains this much led or this much copper etc. Due to the unavailability of information or information not being shared regarding what the product consists of since it is just available in producers' database, it's difficult for GS1 to help the companies in recycling process because the information is not available.

The GS1 system has started GS Cloud global database it has seven attributes i.e. image, target market, GPC (product classification code) etc., and any product from any industry can upload these attributes. Information on 80 million products can be uploaded in the cloud, but the responsibility is doing so lies in the manufacturer if he wants to upload it or not. This GS Cloud global data base haven't been used in the technical industry yet.

However, BAAN, SAP, ERP systems have, close collaboration and coordination with GS1 and it will improve the operation of manufacturers. If companies are using our external identification standards they can use the same standards internally and efficiently run their internal processes but the problem in the technical industry is that many technical companies are not using GS1 standards in production even if they are using it in logistics and transportation.

The GS1 system can be used both in close loop supply chain and in open loop supply chains. Using GS1 standards in closed looped supply chain would be more efficient because information sharing is easy in closed loop supply chain than the open loop supply chain.Technical installation has to be treated in special way. Having access to track and trace systems following the GS1 standard both in logistics and in recycling processes, would be really useful.

Chapter Six: Analysis and Recommendations

This chapter focuses on the data collected in the unstructured interviews of the three companies. Based on our analysis, we have identified barriers for moving towards circular economy. We provide recommendations to the companies in technical industries that are in need of any new strategies to develop new opportunities to go green, more sustainable, introduce new concepts and systems that minimize waste and comply with all international laws.

6.1 Answer to Research to R1

RQ 1: What are the barriers to circular economy in technical industries supply chain?

Table 6. 1; Barriers identified in literature/ companies

Source: (own compilation)

Barriers identified in Literature	***Company A***	***Company B***	***GS1 Organization***
Resource-Intensive development models			
High start-up costs	✓		✓
Supply chain complexities			✓
Difficulty between companies coordination			✓
Innovation			
Structural			
Contextual			
Cultural			
Restrict supply chain			
Lack of industrial symbiosis			

Logistics			
Product design and production			✓
Recovery			
Recycling			
Lack of technical skills			
Quality Compromise		✓	✓
Disassembly of products is time consuming and expensive	✓	✓	✓
No surety recycling, remanufacturing and reusing would help the environment and money saving			
Hygienic issues			

Norwegian companies in technical industries all know the concept of "circular economy" with a high focus on environmental sustainability. Even if don`t use exactly the word of "Circular Economy", all their efforts towards environmental protection have the base in this concept. Large Norwegian technical companies have special attention towards regeneration of resources and they have special programs to implement such thought as illustrated by the "Revert project", the "sunshine program" etc. Mentioned by the respondents.

Company B's move goal towards a sustainable environment is pushed added by charging their customers a small recycling fee that is transferred to the recycling funds to handle recycling. Company B has a membership in an association of recycling companies that make sure the electronic product waste are handled carefully and that products are reused instead of new raw materials. By doing this energy consumption is saved, and envrionmental-friendly products are produced by reducing the global waste. The company is also certified with ISO 14001:2004. This makes the company comply with the rules and regulations of environmental management system thereby reducing the negative effects on the environment. There are a lot of different barriers mentioned into the literature review chapter. Some are general barriers and some are related to the supply chain. There are

different barriers identified by the companies whom we have interviewed. Most of the barriers focus on the supply chain in general and product related barriers in particular. *Figure 6.1* showing the barriers identified by the companies. In addition to this, *Table 6.1* is presenting the barriers that are identified by companies and literature.

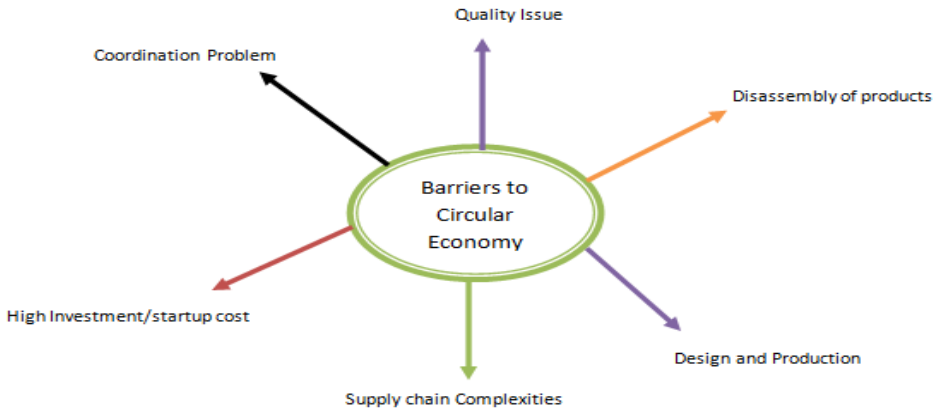

Figure 6. 1: Barriers identified by companies

Source: (Own compilation)

When explaining the circular economy barriers the first barrier that is mentioned by the respondents is the high start up cost this fact is also supported by the literature (Preston, 2012)Liu & Bai (2013).Every business needs to consider cost of transition towards any new model. Therefore moving towards circular economy would incur transition cost i.e. Research and development, asset investment, spending on enterprise infrastructure and subsidies would be the source of high investment cost (Mckinsey & Company, 2016).

"*Supply chain complexity is a barrier for successful implementation of circular economy. The reason behind this complexity is that companies have become global and the same is the case with supply chain. The bigger the company, the bigger the complexity of supply chains, and getting the synergy between all the partners would be tough*" as reported by the interviewee at GS1. This argument is also supported by the literature (Preston, 2012**;** Eijk, 2015).

The next barrier which two respondents have mentioned is the quality issue of recycled materials, as identified by (Torstensson, 2016). Another barrier identified is that, recycling requires a technology-intensive process that needs such high level testing protocols to ensure that the recycled materials is according to the specification of the customer which is difficult to attain. This is supported by (Holmes, 2018).

One respondent believes that coordination problem between companies can be a barrier, but it depends mainly on the company and the way they think about the environment and the world scarce resources. In the literature this phenomena is considered as barrier too (Preston, 2012)**.** This also requires an international coordination among companies because transition from linear to circular economy requires a change across borders (SMO Promovendi , 2017/2018).

In the EOL (End of life) management, the disassembly of products is considered to be an important element. It is considered that almost every product has some amount of disassembly i.e. irreversible joints, maintenance and up gradation and degradation during use. It is not actually the reverse process of assembly. If the instructions of disassembling are available with other relevant information such as design and life cycle information will ultimately help in product disassembly automation and decrease in disposal or components (Parlikad et al., 2003). All the respondents said that the disassembly of products is not easy and it is expensive and time consuming because of complex nature of products and this fact is also supported by the literature (Torstensson, 2016). The complexity comes due to different aspects. The number of materials has increased and many small materials are used with significant importance as well as the multiple components of different nature and connections assemble together and affect the transition towards circular economy. If the resources contained in these materials and components are taken back through repair, upgrade or remanufacture can benefit the overall world (Peiró et al., 2017)

Another barrier which the companies have mentioned technical sector is less attention towards end-phase of product (Eijk, 2015)**.** One of the problems is the production of cheaper goods, shorter-life expectancy and low cost and unsustainable products in today's corporate culture. The culture of companies is, when they make product, they don't feel the need for how the product will end its life. Once the manufacturers produce the product and send it off for sale, they are not usually responsible for the end-phase of the products' life. This led to many complications and waste of these products affecting our environment (GreenLivingIdeas, 2014). Furthermore, lack of information is there when recycling or reusing any product in their end phase of life because product information is necessary to identify and know about a product parts. This has concerned governments and organizations to make strategies to pressurize companies and corporate world to be more responsible while producing and have strict environmental considerations & policies (Hesselbach et al., 2001).

6.2 Recommendation and answer to R2

RQ2: How product information management system could help in overcoming most of these barriers?

For the internal identification in the technical companies i.e. Company A and Company B use the ERP BAAN, their internal identification information system and Bridgelogix for the labelling and identification of the products and components in their company. Brigelogix provides set of bar code data collection solution for ERP systems in Company A. This company also uses BAAn system for the LOT control and for tracking the items backward and forward through their supply chain. Company B has an "*info system"*to know about their details of their products, component type and date of production etc. Company A faces a challenge in assembling and disassmbling of products and component s of products. According to the response of interviewee, many of company`s components are anonymous in which often it is very difficult to get the information about the LOT control number and item number. There is a problem to track a certain LOT or run the report, identifying each component by its specific LOT number. This needs specialized bar code technology to be recognized, assembled, shipped and transferred to their different warehouses.

They feel the need to optimize or have a transparent internal processes while assembling the parts. If the components are not identified it would be difficult for recycling company to recycle each component efficiently.

The authors have developed a model as shown in *figure 6.3* would help technical companies in transition towards circular economy with visibility of internal processes and would also support the recycling organizations to recycle the technical components by using the standard of "Idenification endoced" in the barcodes. This model with the standard of "Identification" would help in overcoming most of the barriers identified by the companies.

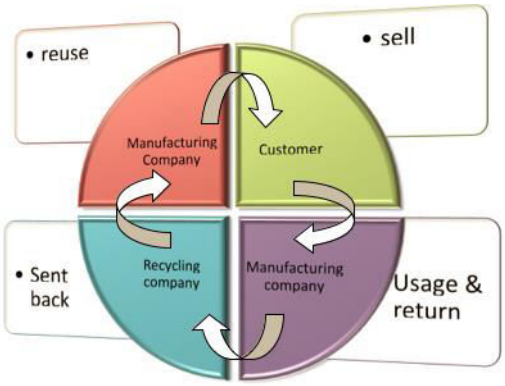

Figure 6. 2: Circulation of Technincal Products in Norwegian Companies

Source: (Company B)

Companies to have greener products and the information about how products and components of any product should be traced by customers. Taking the case of FTrace.com as an example for tracing one`s food is a service by GS1 Germany. FTrace.com improves the efficiency of entire supply chain of food industry using GS1 standards. It basically provides traceability and information about origin and product master data for consumers and retailers demand. Standards and identifications help products with pricing information, product details, supply chain details, quality and certification data and safety of any product. *Figure 6.2* is demonstrating the circulation of technical products in the Norwegian technical sector. The technical products are sold to customers and after their usage and end life of product the customers send the products back to the company back. The producer company sends these products to recycling companies(*Norsk Gjenvinning and Romerike Avfallsforedling IKS)* and these companies recycle the products and send back to the producer company to reuse the material in production.

6.3 Recommended Model:

6.3.1 GTIN identifier encoded in Barcode of components

The concept of this model is based on the identification standard. Through this identification standard the identity of products and product components would be found at the end-phase of product life when scanning the product identifiers and looking up related information. The identifiers therefore, needs to be attached in the initial design and engineering stage of components and products. To illustrate we use a crane as example. In the model, the crane has different components namely, trolly, hook, sewing bearing, cab, wedges and counterweight. These components are given different GTINs. GTIN is the global trade item number which can be used internally and externally with the same

features. Even if the GS1 standards are now being used mostly in outbound logistics,we suggest it can be used in inbound logistics activities as well. The respondent from GS1 acknowledged that this is feasible, each component is given a unique identifier to be attached on the component. The unique identifier can be encoded in e.g. a UPC barcode or an RFID tag. When these components are assembled together, the final product "crane" gets another unique identifier to increase the visibility in the supply chain. The GTIN attached to each of components would help in the later stages of disassembly such as recycling, reusing, refurbishment etc. Since it can be used to look up information on the product and its components stored in a database as described in the next section.

6.3.2 Information flow in Company database

This GTIN information from crane component is stored in the company database. GTIN will have information about manufacturing companies, the suppliers and material used e.g. Master data and information about bill of materials. The sharing of information is under the control of the manufacturer due to the security issue and threat from competitors (when the authors asked from respondents they argued that threat of copying of our components and material used inside the component is a big challenge they can not share it publicly).

6.3.3 Information flow to GS1 database:

In our opinion, the master data of company is saved in the GS1 data base i.e. GS1 cloud and GDSN (Global data synchronization network).

6.3.3.1 GDSN (Global data synchronization network):

GS1 can be connected to different companies that want to exchange product data with their supplier or recycling companies. The information sharing of GS1 include data standards for master data, business transaction data, and physical event data, as well as communication standards for sharing this data between applications and trading partners (GS1, 2018). Master data is valuable information about products of any company. The master data is stored in GDSN (Global Data Synchronization network) and available through scanning or reader. In order to obtain information, the companies should register in the global register data pool, which is secured and organized by GS1.The GDSN can automatically share the business data with their trading partners (GS1, 2018). This means that the required information regarding the product or its components will be shared and

updated between these two actors, i.e, the technical company and recycling company. In particular to the company and GS1, GDSN will be a connecting network that will help the company to share and exchange their data in order to recycle, reuse, its products and attain sustainability. For the sustainability of products, companies need to identify, measure, compare and transform the factors that improve production and consumption. Many of these factors inhibit the supply chain, a lot have problems in complexity and problem in disassembling the parts. Using GS1 standards will help systematize supply chain data, ease its exchange and make efficient reporting against a sustainability profile (GS1, 2018).

6.3.3.2 GS1 Cloud

In the GS1 Cloud, the data maintained in the GDSN database about brand-sourced data and the member organizations product catalogs are combined together with six new features about GTIN, Brand, label description,target market, product classification, company name.

The data about crane components will be shared with the GS1,GDSN and GS1 cloud with permission from the producer and the information would only be given to the recycling companies i.e. *Norsk Gjenvinning and Romerike Avfallsforedling IKS* by allowing access only by using the passwords and encryption of data . The recycling companies if get all the necessary data related to components and their material content. It would help companies in disassembling of components and recycle efficiently. For the privacy of information of manufacturing companies and their confidential data about product components there can be passwords, encryption that would be allowed to its users only.

6.3.4 Sharing with Recycling companies

As evidenced by previous sections, circular economy works with “designing out” waste. In CE waste doesn’t exit. Nothing should be wasted in particular. For consumables all the biological products should be recycled in such a way that it should become a part of bio-sphere. In contrast to, the technical durables such as machines, electric equipment and other products with harmful substances should be extracted and reused in order to avoid any negative impacts on environment. Hence, GS1 standards can help companies in extracting the harmful substances by giving company a specific identifier to each of their product and components.

The lack of product information about product design and production is a barrier and this barrier can be removed by making the products more reliable by providing accurate information. For this purpose, product information must be exchanged to product designers for later use in recycling, reusing and repairing. Consequently, another strategy to overcome this barrier can be, by formulating more regulations for technical and manufacturing industries to make them obliged to share product design information to the concerned recycling companies. When laws are enforced on companies, they will be restricted by law to make policies to be more visible and transparent throughout the supply chain, this will enable the product tracking efficient and help them in designing the products with all the necessary information needed in later stages. GDSN can help in advancing the overall quality of the product by automatic exchanging of information through trading partners. As GDSN has already improved the efficiency of healthcare commodities by implementing unique device identification (UDI) in pharmaceutical companies like ABOTT. This implementation has increased the efficiency, flexibility and support the regulartory requirements and has simplified the use of healthcare specific data models (GS1, 2018). We have come up with the same suggestions to the technical industries.

Furthermore, supply chain complexity is a barriers as mentioned in the literature study as well as the analysis of qualitative data. Supply chain complexity and co-

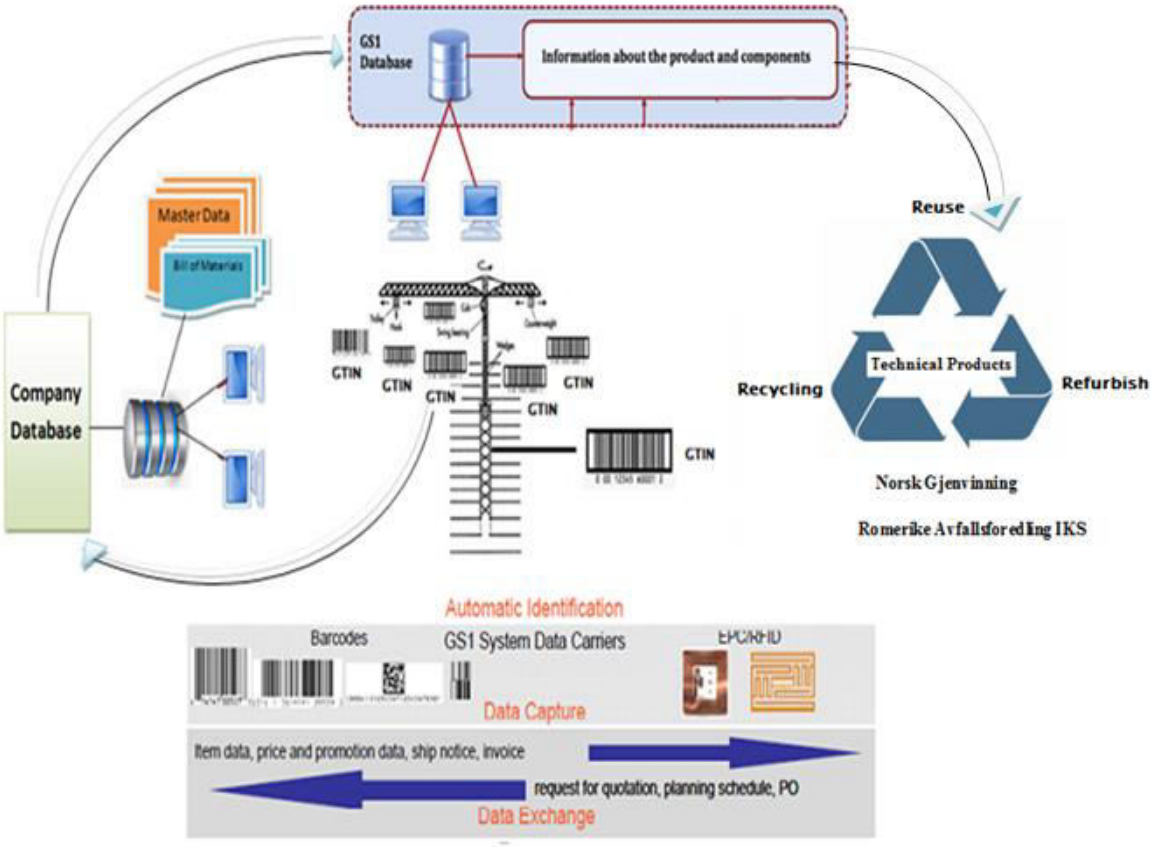

Figure 6. 3: Recommended Model for shift towards circular economy

Source: (Own Compilation)

ordination problems depend on the system they are using and differs company to company. GS1 provides *trace and track information* of products through [4]EPCIS and master data synchronization through the GDSN-standard, the goal of EPCIS and GDSN is to enable applications to leverage electronic code data via EPC related data sharing across the supply chain. This sharing helps them to have a shared view of information related to each businesses by using standard of GS1 there would be reduction in supply chain complexity, more visibility and coordination. In addition, sharing of information about components and material contents to GS1 data registry from the producers` database would help the recycling companies in the disassembly of products and recycling in particular. Hence, through identification standard with EPCIS code and GDSN, sharing would be possible with all the recycling companies and other relevant partners to overcome the barriers of complexity and cooperation in supply chain, disassembly of products by the recycler and product design and production by the engineers and producers. *Figure 6.4* is showing an example of the use of the GTIN identifier and the flow of information. It can be seen that as the product is built, each component by various companies has its own GTIN. The use of GTIN is not only for the external use (outbound delivery) but can increase the visibility of processes and tracking of raw materials and components internally by looking up information via GTIN identifier.

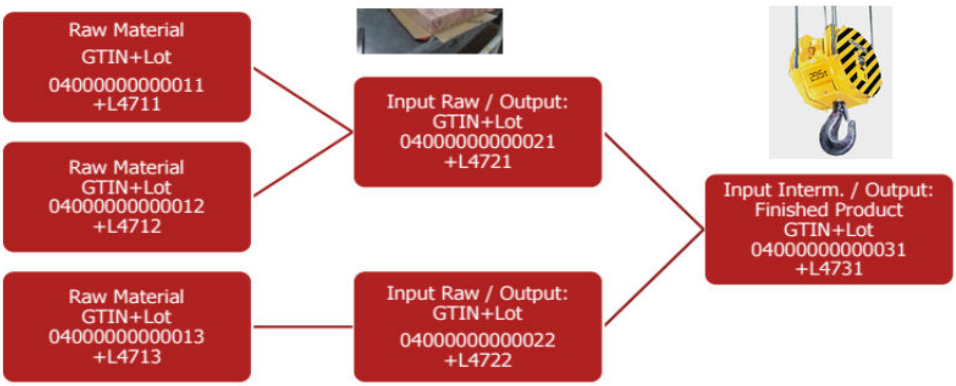

Figure 6. 4 GTIN example, Source: (Adopted from GS1, 2018)

[4] EPCIS is a GS1 standard that enables trading partnenrs to share information about the physical movement and status of products as they move along supply chain from business to business and from business to consumers. It answer the questions what, where and why.

Chapter 7: Conclusion, Limitations, Further Research

7.1 Conclusion

In our research, we have explored how the transition towards a circular economy takes place in technical industries by studying three companies. For our first research question *RQ1: what are the barriers to circular economy in technical industries supply chain? We have* found that the major barriers for implementation of circular economy were quality issue in recycled materials, supply chain complexities, coordination problem between companies, design and production of the product, disassembly of products and high startup/ investment cost.

In the second part of our thesis, we explored whether product information management systems can be used to support companies. Thus, our second research question was *RQ2: How product information management system could help in overcoming most of these barriers?*. We proposed to use the GS1 standard for identification to overcome the complexities and coordination problems between companies and their supply chains, and we designed a new model to overcome the barrier with efficient disassembly of products in a circular economy.

The barriers we identified in RQ1 confirm what we have found in the literature on barriers. This shows that the companies are well aware of the challenges of moving towards the circular economy. Our model resulting from answering RQ2 could help companies in their efforts to move to a Reuse, Refurbish and Recycle operational approach.

7.2 Limitations:

There are always some limitations that exist while writing any research. These limits can be due to unavailability of accurate data, time and resources that can affect the study.

The main limitation of this research is the unavailability of sufficient amount of data due to companies concern about confidentiality . Another limitation is that this study only focuses on one standard “identification” due to time constraint. Circular economy concept is

emerging and many companies know this concept but actual shift towards circular model is missing, Companies in this research have answered about circular economy and barriers in implementation but they in reality haven't adopt this concept in full. Companies have more focus in sustainability and number of interviewed companies were limited due to this reason the reliability and validity of data should be checked although we tried our best to validate our research through theoretical approach.

7.3 Further Study:

It is not possible to analyze and explore everything in one master thesis there are always some issues and contents remained which can be explored in future research.

- Future research can be conducted by taking into account all the standards of GS1 i.e. identification, capture and share.
- Compare the GS1 standards with other Global standards provider company i.e. BRC global standards.
- The gaps between circular economy and solution to the barriers can be filled using other technologies other than GS1 standards i.e. RFID, and other track and trace systems.
- Demonstrate the framework through which circular model can be implemented in technical sector.
- The saving of cost through the implementation of circular economy can also be taken into account in future research.

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Appendices:

Interview Guide 1:

Company: …….

Date: ……

Person Name: ……..

Role in the company: ……..

Questions:

1. How GS1 can help the environment globally?
2. What actions would have been taken by GS1 to solve the environmental problems?
3. What are the challenges faced by GS1 in responding to the sustainability issue?
4. What could be technological hurdles in way of sustainability?
5. What do you understand by the term 'Circular Economy'?
6. How ethics or code of conduct of your company play role in circular economy?
7. How GS1could help companies in starting journey towards circular supply chain?
8. Does GS1 work for recycling and minimizing wastes?
9. Can you help the companies by making their information systems more efficient?
10. Do you think in technological products these could be the barriers towards circular economy?
    a) Less attention towards end-phase of product
    b) Separation of biological substance from technical is lacking due to less Information
    c) Recovery of material is not possible due to complex nature of product
    d) Recycling is expensive than the virgin materials
    e) Quality Issue
    f) Expensive, Time consuming
    g) Supply chain complexities
    h) Hygienic issues
    i) High start up cost
    j) Difficulties' between companies coordination

11. How GDSN (The Global Data Synchronization Network) can enable different companies to share product data in order to make it easy for recycling?
12. Could there be possible benefits to organizations using GS1 in their end-phase of product?
13. Can GS1 standards prove to be helpful in informational flow of technical products at the recycling process in gaining circular economy?
14. How can we identify the product information through Role of GS1?
15. Do you see any connection with ERP-systems, Baan System, and SAP with GS1 and can it improve the operations of manufacturing company to approach a circular supply chain?
16. What do you think about introducing internal identification standards along with external identification standards?
17. What can be the advantages of implementing GS1 standards in company who has too many technical wastes?
18. What can be the reasons and barriers of implementing circular economy in GS1?
19. How to improve the information flow of technical companies tending to achieve circular economy?
20. How can we examine the efficiency of product identification in closed loop system?
21. How can a technical industry take advantage of track and trace technologies?

Interview Guide 2:

Company: **Date: ……..**

Person`s Name: ……..

Role in the company: ……..

Questions

1) What do you understand by the term ‘Circular Economy’?

2) In your opinion Circular Economy is

a) A business model
b) just a strategy for environmental protection

3) How does your company work for sustainability today?

a) Reducing carbon footprints
b) Reducing waste
c) Using Recycle material

4) In your opinion what are the barriers to circular economy in your company?

5) Do you think in technological products these could be the barriers towards circular economy?

a) Less attention towards end-phase of product
b) Separation of biological substance from technical is lacking due to less Information
c) Recovery of material is not possible due to complex nature of product
d) Recycling is expensive than the virgin materials
e) Quality Issue
f) Expensive, Time consuming
g) Supply chain complexities
h) Hygienic issues

6) Are there any systems or standards that identify the parts or components in your company? If yes, please mention the name and explain the parts.

7) How do you tackle with the end-phase of your product?

a) Recycle/reuse the products
b) Throw them to landfills
c) Sale the products to other disposable companies

8) Can product identification standard (information about the parts and components) be helpful in end-phase of your company`s products?

9) What are your internal systems in identifying the components and materials in your company?

10) Does your internal standard prove to be helpful in informational flow of your products at the recycling process?

11) What systems do you use for identification of components and parts of your products?

a) ERP system
b) Baan system
c) SAP
d) GS1
e) None

12) How do these systems improve the operations of manufacturing company to approach a circular supply chain?

13) What can be the advantages of implementing standards in your company?

14) How to improve the information flow of a company who is tending to achieve circular economy or sustainability?

15) Have you heard of GS1 standards?

16) If yes, how and do your company feel the need to use global standardization?