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"THE CIRCULAR REVOLUTION: OPPORTUNITIES AND CHALLENGES FOR THE ITALIAN MANUFACTURING INDUSTRY"

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INTRODUCTION

Circular economy is gaining increasing attention worldwide because it represents a valid alternative to the linear model of take-make-dispose that prevails since the Industrial revolution. The linear paradigm no longer works and is not sustainable anymore because Earth's resources are limited and the environmental pollution is becoming acute. Instead, the Circular economy proposes a model of doing business that is feasible within the limits of our planet, repairs and regenerates and aims to decouple the economic growth from waste generation and resource consumption. The transition to the Circular economy is still in the early stages and requires important changes in the current socio-economic system. Organizations as the European Commission and the Ellen MacArthur Foundation are working to promote, facilitate and accelerate this transition. Circular economy can provide significant opportunities for businesses, the environment and the society. But there are many barriers to make the economy comprehensively circular. The objective of this study is to explore the concept and features of the Circular economy and its development in Europe and in Italy, to understand *why* and *how* an increasing number of firms is approaching this new model and which are the challenges they face and the opportunities they achieve. This study aims to contribute with new academics knowledge to the available researches on circular economy deepening the theme of the circular transition within the Italian context and the manufacturing industry. In particular, this study is structured as follows:

The first part provides an extensive review of the available literature on Circular economy from the 1960s until the present day to understand the circular concept and the main characteristics of this new model. Moreover, it touches on the main dimensions of a circular economy: the opportunities, the motives to become circular, the transition challenges and the strategic changes to enable the shift. Finally it explores the main measures and initiatives launched by the European Commission to enable the circular transition and in particular to support SMEs.

The second part of the study investigates the circular transition within the Italian manufacturing context. We provide an analysis of the circular practices and transition

opportunities and challenges within a sample of 53 Italian manufacturing firms that have already stood out for their circular projects.

The final part of this study investigates the relationship between firm size and circular engagement. Firm size is a firm-level characteristic that can impact many outcomes, and the scope of this final part is to understand whether firm size could impact the firms' participation to the circular economy and whether small firms experience more difficulties and lesser benefits than large ones when implementing circular business models.

Chapter 1

THE ROAD TOWARDS THE CIRCULAR ECONOMY

1.1 THE LINEAR ECONOMY: AN UNSUSTAINABLE PRACTICE

In the eighteenth century the Industrial Revolution began in Great Britain leading to dramatic economic and social changes. It represented a paradigm shift from hand production methods to mechanization. Before that, in preindustrial times the production of goods required great amount of time and work. Goods were crafted slowly and carefully by hand and no two pieces were alike. With the advent of mechanization the production of goods accelerated. The spinning jenny and the spinning mule revolutionized the textile sector. The mass production and the centralization introduced by Henry Ford changed drastically the automotive sector. Cars that originally were considered luxury items became affordable for an increasing number of people. The industrial revolution brought numerous positive social changes: new working opportunities in factories, improved living standards, increased salaries, longer life expectations. The new technologies improved the life of many people. When the revolution started there was no concern for the preservation and the quality of the environment. People believed that the resources were unlimited and vast and the Mother Earth was able to regenerate endlessly and absorb all the waste. The Western thought was that of submitting and controlling the dangerous wild nature. The industrial system was designed to be a linear, cradle-to-grave model (Braungart and McDonough, 2002). According to this model, natural resources are mined and extracted, turned into products and then sold, used and discarded as waste once they no longer work or no longer serve their function (Bonciu, 2014). What remains after use goes to the 'grave' that is a landfill or an incinerator. Every good is designed to be thrown away after the consumption. The profit is the rule of the game and the key driver of success. But more profit means more sales and more goods produced and sold.

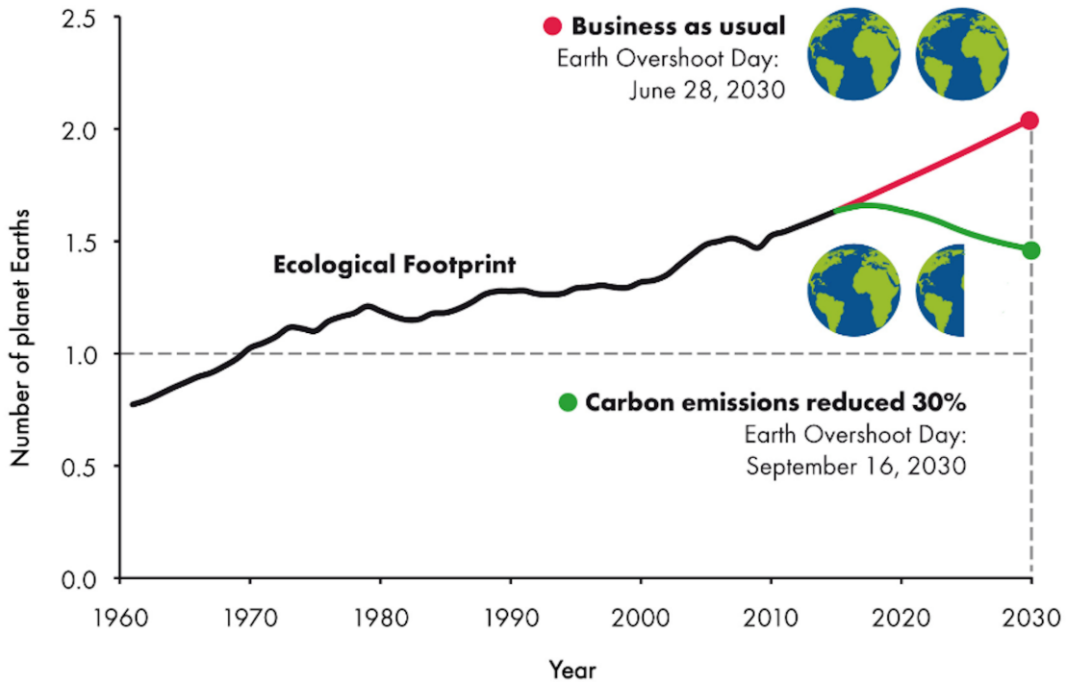
Since the industrial revolution, our economy is still locked into this linear model of production and consumption that is favoured by contracts, regulations and mindsets (Ellen MacArthur Foundation, 2012). Nevertheless the awareness of the precarious conditions of the

environment, the economic paradigm is unchanged. We continue to operate following the same economic principle of the Industrial revolution even if we are fully conscious of its limits and troubles.

But this resource-intensive model is unsustainable overtime.

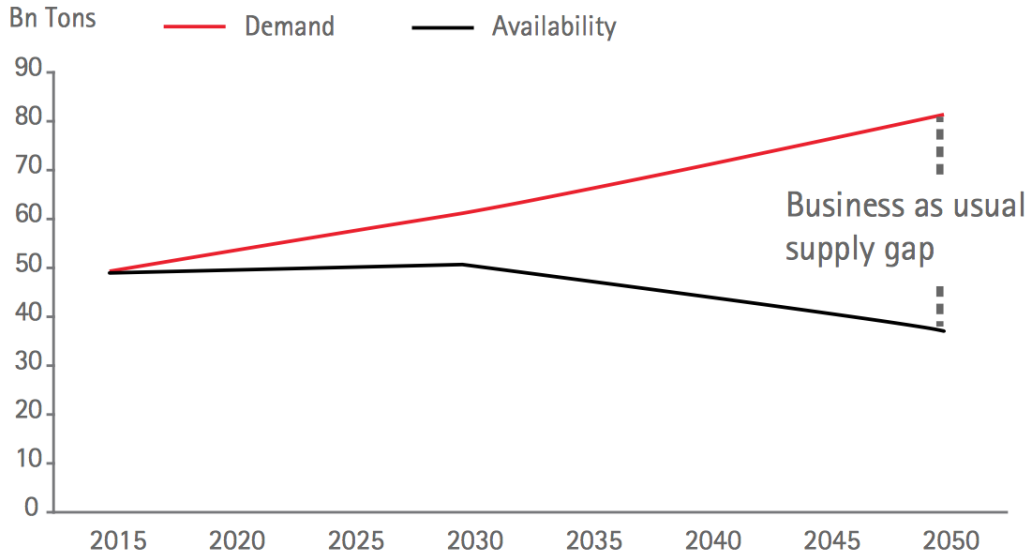
Natural resources are being exhausted. Many reserves are already very limited. The Forum for the Future estimates that the current consumption of resources is 50% faster than the regenerative capacity of the Earth. According to the Global Footprint Network it takes our planet one year and six months to regenerate what we use in a year and to absorb our waste. But, if the trend continues, our planet will take 2 years to restore 1-year consumptions by 2030 and even 3 years by 2050 (Global Footprint Network; Ellen MacArthur Foundation, 2012). Accenture estimates that the total demand for limited resources (biomass, metals, fossil energy) will reach 130 billion tons by 2050 in the more critic scenario where nothing is done to contrast the environmental decline or 80 million tons in a more optimistic scenario that takes into account technological innovation and improvements in resource efficiency. Even in the more optimistic scenario (Figure 2) there will be an overuse of the Earth's total capacity of around 40 billion tons by 2050 with devastating effects (Accenture, 2014).

Figure 1: Ecological Footprint



Source: Global Footprint Network www.footprintnetwork.org

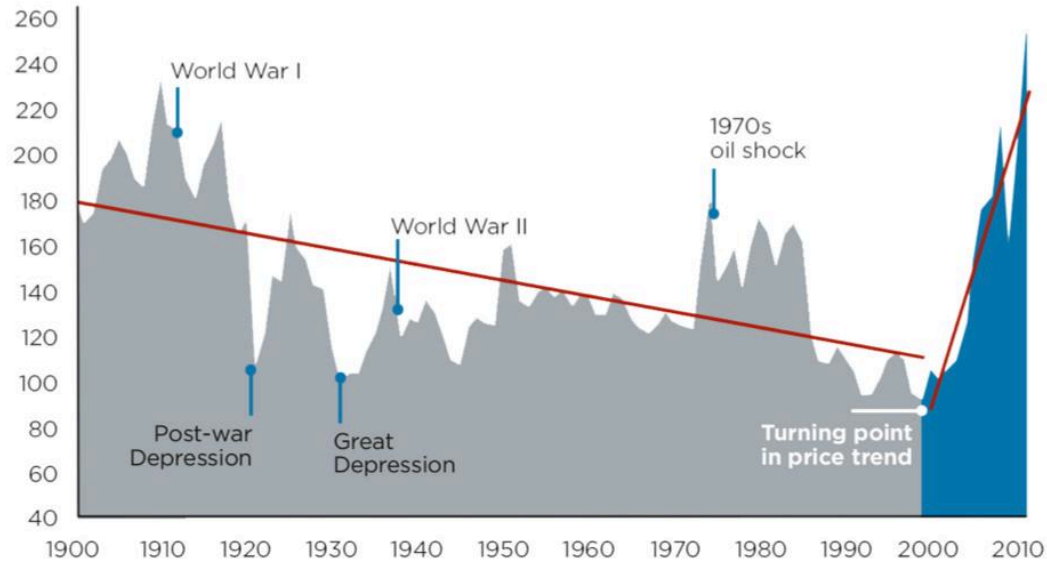
Figure 2: Resource supply/demand imbalance for limited resource stocks 2015-2050



Source: Accenture, 2014

This imbalance between natural resources and consumption has negatively impacted climate, water, soil productivity and conservation, fuel and natural resources' supplies. Hence, since 2000 dramatic price increases have hit natural resources and commodities such as food and metals. McKinsey Commodity Price Index in 2011 shows that the average prices of four commodities – food, non-food agricultural items, metals and energy- have registered a sharp spike reversing the past century's trend of declining prices (Figure 3) (McKinsey&co., 2011; Ellen MacArthur Foundation, 2012).

Figure 3: Sharp price increases in commodities since 2000.



Source: Ellen MacArthur Foundation circular economy team 2012. Based on arithmetic average of 4 commodity sub-indices: food, non-food agricultural items, metals and energy.

Significant volumes of resources are lost in the value chain from the extraction to the final manufacturing. The Sustainable Europe Research Institute estimates in OECD countries over 21 billion tonnes of resource losses in the manufacturing process. Commodity price volatility escalated dramatically over the past decade. This is caused mainly by the increased global demand for commodities and the consequent exhaustion of natural reserves following the fast macroeconomic expansion that characterized the earlier 2000s. This linear system rises companies' exposure to risks such as resource price and supply disruption. Prices in resource markets continue to increase and become less predictable, competition grows and consumer demand stagnates. Due to rising input costs companies should set higher sales prices. But this adjustment is not always possible because of the intense market competition. Hence, companies are forced to keep their sales prices low to align with those of the competitors, sacrificing their margins. To minimise this risk companies use hedging contracts. But the cost of hedging can reach up to 10% of the total hedged amount in terms of direct costs – financial service fees - and opportunity costs – lost opportunity to use that amount to invest, innovate and grow (Ellen MacArthur Foundation, 2012).

Resource scarcity, resource losses, price spikes and volatility are expected to persist over the coming years. China and India, the two most populated countries, are growing fast and three billion new middle-class consumers are expected to enter the global economy by 2030 and therefore increase their purchasing power and consumption of resources. Moreover, the majority of arable lands, oil and gas reserves are in countries with high political and infrastructural risk. The resource reserves are more difficult to access and huge investments in infrastructures and technology are needed. If these investments do not occur, the risk is that of enduring supply constraints. The political instability of these countries will push up prices and volatility and boost resource scarcity. Under the effect of globalization a regional price shock can rapidly become global (Ellen MacArthur Foundation, 2012).

The awareness on the limits of the linear economy has stimulated the research of an alternative model of doing business that is feasible within the limits of our planet. We are using more than we can replace with dramatic consequences on global climate, weather patterns and ecosystems, health and life expectancy. Therefore, business models have to be adapted to a more sustainable way of living, manufacturing, consuming (Murray, 2015).

1.2 WHAT IS THE CIRCULAR ECONOMY?

The circular economy represents the valid alternative to the linear model that currently prevails.

The Ellen McArthur Foundation defines the Circular economy as '*an industrial economy that is restorative by intention*' since it is conceived not only to reduce waste, pollutants and consumption of resources and energy, but also to repair the damages caused by the linear model through optimization and innovative design. The ultimate goal is to separate the economic growth from the depletion of natural resources and the environmental degradation (Ellen MacArthur Foundation, 2012; Murray, 2015).

The European Commission defines the circular economy as a system that *'keeps the value added in products for as long as possible and eliminates waste. It keeps resources within the economy when a product has reached the end of its life, so that they can be productively used again and again and create further value.'* (European Commission, 2014 a).

Kirchherr after gathering 114 CE definitions from different articles arrives to define the circular economy as "*an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations"* (Kirchherr, 2017).

The circular economy is characterized by closed material loops in which the materials circulate through the economic system and are maintained at their highest value for as long as possible and resources can be reintegrated in the economy or become nutrients to natural systems (Webster, 2015). The model differentiates between technical and biological cycles. Biological nutrients are designed to re-enter safely in the biosphere through composting and anaerobic digestion, whereas technical materials are designed to circulate in the economic system through different applications by reuse, repair, refurbish, remanufacture and recycle. The purpose is to minimise the extraction and depletion of natural resources and the generation of waste. By doing this, the circular economy mirrors the natural life cycle where organic materials decompose and become nutrients for other living organisms. As the leaves

fall to the ground and become food for plants and animals, the natural system is highly efficient and do not create waste (Ellen MacArthur Foundation, 2012).

1.2.1 CIRCULAR ECONOMY LOOPS

1.2.1.1 CIRCULAR ECONOMY LOOPS FOR TECHNICAL NUTRIENTS

The literature identifies four means to achieve the circularity for technical materials: reuse, refurbishment or remanufacturing, cascading of components and materials, and finally recycling. (Ellen MacArthur Foundation, 2012; Vanner, 2014)

Reuse is about using products that are not waste for the same purpose as in their original form or with little enhancement. Otherwise, it is about using products for different purpose than in their original form with few changes. Reuse implies large saving in terms of resources, energy and labour compared to the manufacturing of new products from virgin resources and this has a positive impact on the environment (Ellen MacArthur Foundation, 2012).

Refurbishment is the process of reporting goods back to good working conditions by repairing or replacing the damaged components and applying aesthetic changes to improve their appearance such as painting, cleaning and refinishing (Vanner, 2014; Ellen MacArthur Foundation, 2012).

Remanufacturing is the process of returning end-of-life products to like-new or better performance. The products are dismantled and their major components are restored or replaced. It is applied to complex manufactured products with valuable materials that can be restored through suitable techniques. This process differs from the traditional repairing technique because the manufacturer enhances the product from old to current standards of efficiency and productivity (Centre for remanufacturing & reuse, 2007).

Cascading of components and materials regards successive use of end-of-life products and materials for different applications to permit the full value extraction of resources and energy (Ellen MacArthur Foundation, 2012; Vanner, 2014).

Recycling refers to the recovery of used materials that are reprocessed into products and materials for their original purpose or for other purposes. Recycling of used products permits to benefit from still usable materials and reduce the amount of waste and the environmental impact. Ellen MacArthur Foundation distinguishes between functional recycling, upcycling and downcycling. Functional recycling is the recovery of materials for their original purpose or for other purposes. Upcycling is about converting materials into new ones with improvements in quality and functionality. Downcycling is about converting materials in new ones with with lesser quality and functionality. Circular economy is associated to recycling

but this principle is the less sustainable in terms of efficiency and profitability. For the entropy law some resources are dissipated in the environment and cannot be recycled. For complex and mixed materials the recycling is expensive and almost impossible due to the presence of contaminants as ink and metals (Ghisellini, 2016; Heshmati, 2015).

To give an example of the circular loop of technical materials we can think to mobile phones. There are many options available to maximize their economic value. The phones can be resold on the second-hand market after cleaning and repackaging. The internal components can be disassembled and reused for new devices. To do that the phones should be designed for easy disassembly and remanufacture. The most valuables parts of the mobile phones as camera, display, battery and charger should be standardized in order to be easily disassembled and re-used (Ellen MacArthur Foundation, 2012).

1.2.1.2 CIRCULAR ECONOMY LOOPS FOR BIOLOGICAL NUTRIENTS

For biological nutrients the literature highlights the following techniques as means to create circularity: cascading of biological nutrients, extraction of biochemical, anaerobic digestion and finally composting (Ellen MacArthur Foundation, 2012; Vanner, 2014).

Cascading of biological nutrients looks for other uses of biologicals across the different value streams. It requires effective collection systems and technologies to preserve volume and quality.

Extraction of biochemicals is the process of biomass conversion to produce chemical products and energy.

Anaerobic digestion breaks down organic materials through the action of microorganisms in absence of oxygen. The result is biogas used as source of energy and solid residual used as soil fertilizer.

Finally through composting micro and macro-organisms convert organic matter into compost upon particular environmental conditions as oxygen, temperature and moisture. It is a natural form of recycling.

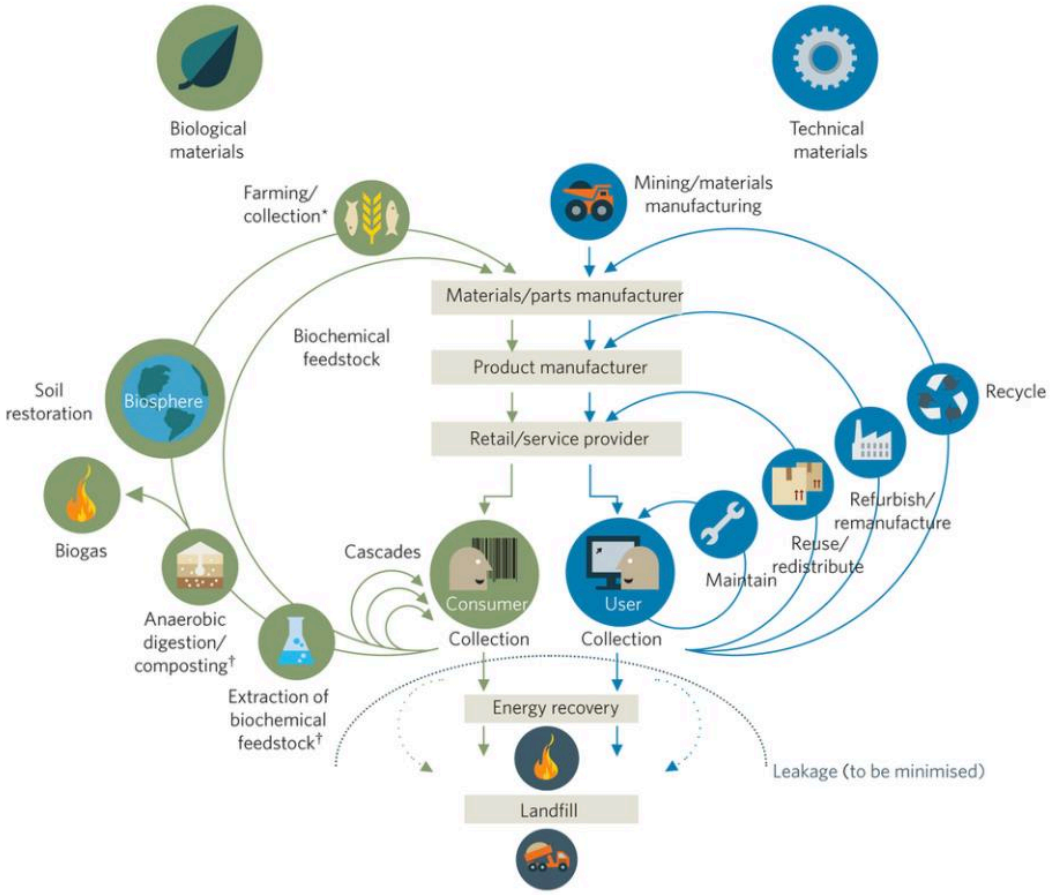
When the resources are exhausted and cannot circulate anymore in the economic system, the final loop is energy recovery. This process converts waste in energy through composting, gasification, pyrolysis, anaerobic digestion or landfill gas recovery.

Landfilling is the last solution for non-recyclable waste since it creates negative externalities as damages to the land and greenhouse gas emissions. The circular economy aims at avoiding landfill and realizing full valorization of the materials.

To give an example, textiles can be reused many times and when no longer suitable for their original purpose, they can be transformed in car seating, mattresses, heat, sound and housing

insulation. The synthetic fibres can be re-polymerized into new fibres. Finally, when the quality is undermined, the textile fibres can be used for energy recovery (Ellen MacArthur Foundation, 2012). Figure 4 shows how technical and biological materials cycle through the economic system with their own peculiarities.

Figure 4: Schematic overview of circular economy activities.



Source: Ellen MacArthur Foundation, 2012

Tighter cycles generate higher savings due to reduced inputs, energy and labour in the production process and lower externalities as greenhouse gas emissions, water pollution and toxic materials. Higher savings derive also from longer cycles since the products or the components remain longer in the same cycle (life extension) or are used in consecutive cycles (multiple refurbishments) without becoming waste. By cascading of products and components into different uses the production costs are reduced since these cascading materials substitute the virgin ones. Finally, to permit the full valorization and value extraction from these materials, it is important to eliminate harmful and toxic substances that can prevent the recycle and remanufacture of the products and obstacle their circulation in the system (Ellen McArthur Foundation, 2012).

Table 1 lists the main characteristics of the circular economy.

Table 1: Key characteristics of a the circular economy

Key characteristics of a circular economy
Less input and use of natural resources • minimised and optimised exploitation of raw materials, while delivering more value from fewer materials; • reduced import dependence on natural resources; • efficient use of all natural resources; • minimised overall energy and water use.
Increased share of renewable and recyclable resources and energy • non-renewable resources replaced with renewable ones within sustainable levels of supply; • increased shares of recyclable and recycled materials that can replace the use of virgin materials; • closure of material loops; • sustainability sourced raw materials.
Reduced emissions • reduced emissions throughout the full material cycle through the use of less raw material and sustainable sourcing; • less pollution through clean material cycles.
Fewer material losses/residuals • build up of waste minimised; • incineration and landfill limited to a minimum; • dissipative losses of valuable resources minimised.
Keeping the value of products, components and materials in the economy • extended product lifetime keeping the value of products in use; • reuse of components; • value of materials preserved in the economy through high-quality recycling.

Source: EEA, Report No.2/2016

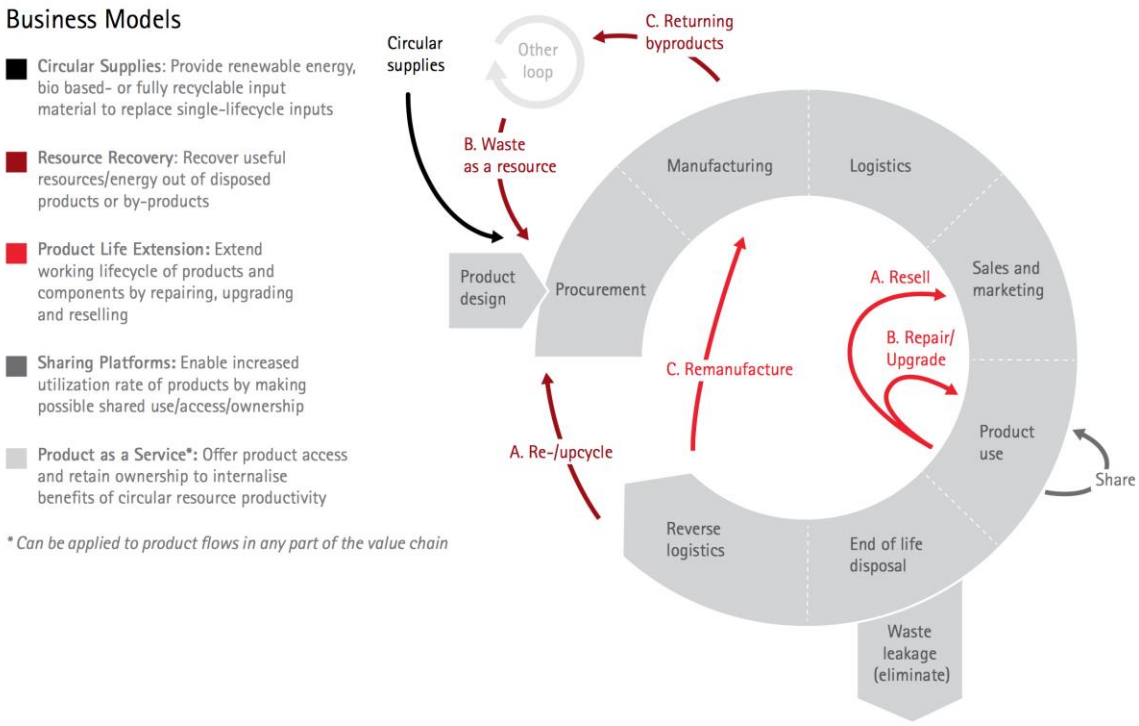
1.2.2 CIRCULAR ECONOMY BUSINESS MODELS

Accenture (2014) has identified five circular business models through an analysis of 120 case studies of innovative companies that have improved their resource productivity.

These circular models are:

1. Circular supplies: companies with this business model supply fully renewable, recyclable and biodegradable inputs that replace the virgin ones. This model is good especially for companies with scarce resources and great environmental impact.
2. Resource recovery: this model is based on recycling and upcycling of end-of-life products to transform waste into value. Some solutions are cradle-to-cradle design, industrial symbiosis and closed loop recycling. This model is suitable for companies that produce large amounts of byproducts.
3. Product life extension: companies extend the lifecycle of their products through repairing, upgrading, remanufacturing and reselling. This model works better for companies that operate in the B2B capital-intensive segment (as industrial equipment) and companies that operate in some sectors of the B2C where it is common to re-commerce pre-owned products (as cars and smartphones).
4. Sharing platforms: this model is based on a common platform for different users to facilitate the sharing of resources, technologies, ownership, overcapacity and underutilization. It is good for products that are characterized by low utilization and ownership rate.
5. Product as a service: companies retain the ownership of their products and sell to their customers only the performance through a lease or a pay-for-use agreement. It benefits those companies with skill advantages in the maintenance of products.

Figure 5: The five circular business models



Source: Accenture, 2014

1.2.3 THE PRINCIPLES OF THE CIRCULAR ECONOMY

Ellen MacArthur Foundation (2012) presents five principles that characterize the circular economy concept:

1. Waste is food
2. Build resilience through diversity (balance efficiency with adaptability)
3. Shift to renewable energy sources
4. Think in systems
5. Think in cascades
6. Design out waste

Waste is food. Waste does not exist in nature since one organism's waste is food for another and these processes guarantee the health of the whole natural ecosystem. In the economic system the materials can be designed to imitate the biological nutrients. Engineers should select and create safe materials, optimize the production process and design closed-loop goods.

Build resilience through diversity. Nature is characterized by diversity and complexity. Ecosystems are complex communities of living organisms with different characteristics that interact with each other and their physical environment. Engineers should elaborate sustainable design solutions that are inspired by and fit in the local natural system.

Shift to renewable energy sources. In nature the plants use the solar energy as a power source. Since the solar energy is a renewable resource, it should be used also in the economic system substituting the exhaustible resources.

Think in systems. Businesses, people and plants are parts of complex systems where parts influence each other and are influenced by the context. In these systems imprecise combinations of inputs lead to surprising consequences and outcomes that are not proportional to the original inputs. In the circular economy these influences and connections should be taken into account.

Think in cascades. Products and materials can be reused after end-of-life for different applications to permit the full value extraction of resources and energy.

Design out waste. When products are designed to fit in the biological or the technical cycle

waste does not exist. Biological nutrients should be designed out of toxic materials so that can be reintroduced safely in the biosphere through composting and anaerobic digestion. Technical materials should be designed for disassembly and refurbishment in order to remain in the economic cycle.

For our analysis of the CE principles we consider also the *4R Framework* adopted by the European Parliament in the Waste Framework Directive in 2008 (European Parliament, 2008; Kirchherr, 2017). The 4 R Framework identifies the principal CE practices: reduce, reuse, recycle and recovery. Reduction aims to minimize the inputs for the productive system such as energy and raw materials through improvements in production efficiency, the so-called eco-efficiency. Eco-efficiency is reached by increasing the value of products and reducing their environmental impact. It means using fewer resources per unit of value produced and substituting harmful materials with less harmful ones. Apart from reduction, the other practices have been largely discussed in paragraph 1.2.1.

1.3 LITERATURE OVERVIEW

An extended review of the existing literature on circular economy is needed in order to better understand the concept and its principles.

1.3.1 HISTORICAL BACKGROUND 1960-1990

The core ideas of the circular economy emerged in the 1960s. The first economist to study the relationship between the economic activities and the environment was Georgescu-Roegen in 1967. He explained that the economic system is constrained by the second law of thermodynamics, the entropy law, by which entropy increases in isolated systems with the dissipation of low-entropy energy and materials into high-entropy waste products generated by the economic and the natural systems. The evolution of the economic system is intertwined with that of the environment (Georgescu-Roegen, 1967 and 1977).

In 1966 Kenenth Boulding introduced the close-loop economy in his *Spaceship Earth*. He compared the Earth to a spaceship going through a long journey using only the solar energy as power source. The resources available in the spaceship were only those placed on board before take-off. As that stock is reduced, so the life expectancy of the astronauts decreases unless they find a way to recycle the resources and generate their own food. The author considered the Earth as a closed economic system where everything is an input into everything else and where economy and the environment have circular linkages. This closed

spaceship economy is opposed to the 'open cowboy economy' that is characterized by the lack of acknowledgement of limited resources of a finite planet (Boulding, 1966; Pearce & Turner, 1990; Brennan, 2015).

Ayres and Knees in 1969 analysed the externalities resulting from the production and consumption process. Nature does not permit the destruction of matter and the unwanted residuals are discharged in the environment, principally in watercourses and in the atmosphere. The inputs to the system as fuel, food and raw materials partly are used to manufacture final goods and partly become waste residuals. Final goods are consumed and ultimately become waste. The disposal of these residuals produces externalities, external costs, that are a normal consequence of the production and consumption process. These externalities are irrelevant in a context with low population and undeveloped economy but acquire importance as the population grows and the level of output increases (ex: depletion of resources and assimilative capacity of the environment being exhausted).

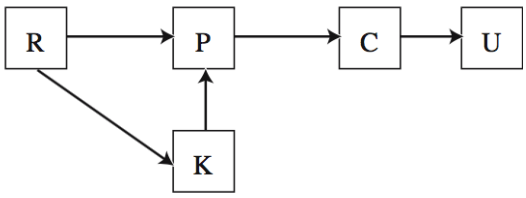
Economic activities rely on clean air and water as free resources and use them as inputs to industrial processes. These resources receive and assimilate the waste residuals of the economic system. Under conditions of intense economic activity and overpopulation the environmental media (water and atmosphere) that receive and assimilate waste are not free resources but become common-property resources with increasing value (Ayres & Kneese, 1969). Nevertheless these environmental goods do have neither a market nor a price even if they generate value and utility for the individuals, for these reasons such resources have been overused in the past (Cohen-Rosenthal, 1979). Nowadays, different policies as regulations and environmental taxes are used to internalize these externalities into the price of the products and services (Ghisellini, 2015). There are growing political pressures to force producers and users of heavy metals and fossil fuels to pay the 'unpaid' environmental damage costs (Ayres, 1994).

Ayres introduced the concept of the *industrial metabolism* in 1988. The industry has a metabolism that consists of the physical processes to convert raw materials, energy and labour into final products and ultimately waste. In the production process there are mainly five steps: extraction of raw materials, conversion, manufacturing of final goods, use and disposal. Each step has emission sources and negative impacts on the environment. Materials pass quickly through the economic system and become waste in no time. Moreover the use of materials is dissipative and materials are dispersed in the environment during production and consumption processes. To reach a regenerative and sustainable process it is necessary to modify this industrial metabolism (Ayres, 1989 and 1994; Anderberg, 1998).

Frosch and Gallopoulous promoted the concept of *industrial ecosystem* in their article *Strategies for Manufacturing* in 1988. In the industrial ecosystem the generation of wastes and pollution is minimized, the consumption of resources and energy is optimized and the waste stream from one factory is used as a resource for other companies. For this model to function both manufacturers and consumers need to change their habits. At the manufacturing level, processes should be designed to minimize the generation of waste and the consumption of scarce materials and energy sources. This should be accompanied by changes in consumers' demand patterns and in the treatment of the waste materials once they are purchased and used. Governments should drive this shift by promoting waste-minimization schemes and by adopting economic incentives for sustainable manufacturing in the regulative system. For example by increasing landfill costs, rising the infrastructures for collecting consumers' waste and introducing taxes and fees for pollution (Frosch & Gallopoulos, 1988; Brennan, 2015).

Pearce and Turner in their *Economics of Natural Resources and the Environment* used the term *Circular economy* for the first time in 1990. The authors examined the linkages among the economy and the environment. If we ignore the environment, the economy will follow a linear model. In the Linear Model (Figure 6) natural resources (R) are used as inputs for the production (P) of goods and capital goods (K) with the final aim of creating utility (U) from their consumption (C).

Figure 6: The linear model



Source: Pearce & Turner, 1990

The linear model captures only the first function of the environment that works as *resource supplier* providing inputs to the economic system.

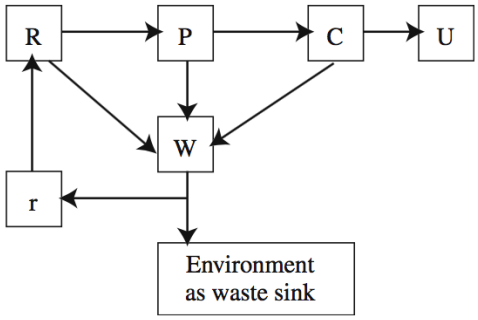
But this model is incomplete since it ignores the waste products. Waste is generated both by the economic system and the natural system. The main difference between natural and economic system is that the natural system recycles its waste. The economic system does not have this capability. Waste is generated at each stage of the production process, from mining (R) to production (P) and consumption (C). For the first law of thermodynamics, the amount

of waste is equal to the amount of resources being used. Therefore, it is impossible to destroy energy and matter.

$$R=W=W_R+W_P+W_C$$

Taking into consideration the recycling of waste the linear model can be converted into a simplified circular economy model (Figure 7).

Figure 7: The simplified circular economy model



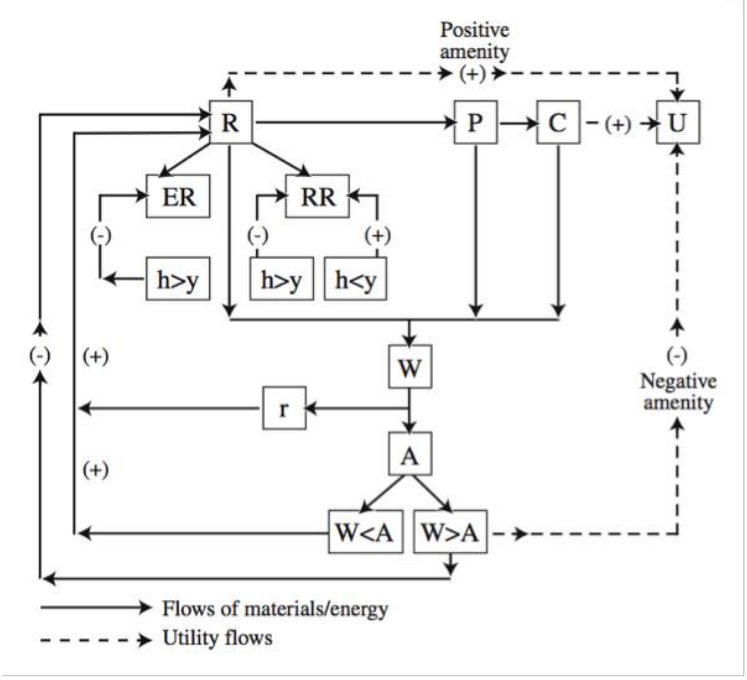
Source: Pearce & Turner, 1990

A percentage of waste (W) generated by the production process is recycled (r) and returns in the economic system. The other percentage ends up in the environment. It is no possible to recycle all the waste generated by the economic system. For the second law of thermodynamics, the materials are used entropically in the economic system and therefore they are dissipated within the system. For instance, very few components of a car can be recycled such as the aluminium, the steel and the lead from the batteries. The recycling of wood and plastic is really expensive and almost impossible. The energy resources cannot be recycled at all. Recycling of waste reduces the need for extraction of raw resources but the system still remains open, linear and unsustainable in the medium term.

Instead into the most sophisticated Circular Economic Model (Figure 8) the loop would be closed and a large amount of resource would be captured, recovered, reused, reinforced and finally repurposed. The environment works as *waste assimilator* – this is the second function of the environment – since has a certain capacity to assimilate the residuals from the economic system and to convert them into useful resources, making the economic system work as the natural system. But the assimilative capacity is a finite resource and when this capacity is exceeded the model begins to fail and the environment suffers.

Nowadays, our resource consumption and waste generation overcome this resource. The environment is not able to absorb all our waste. In addition, there are resources that are finite and cannot be renovated such as minerals, carbon and oil.

Figure 8: The circular economy model



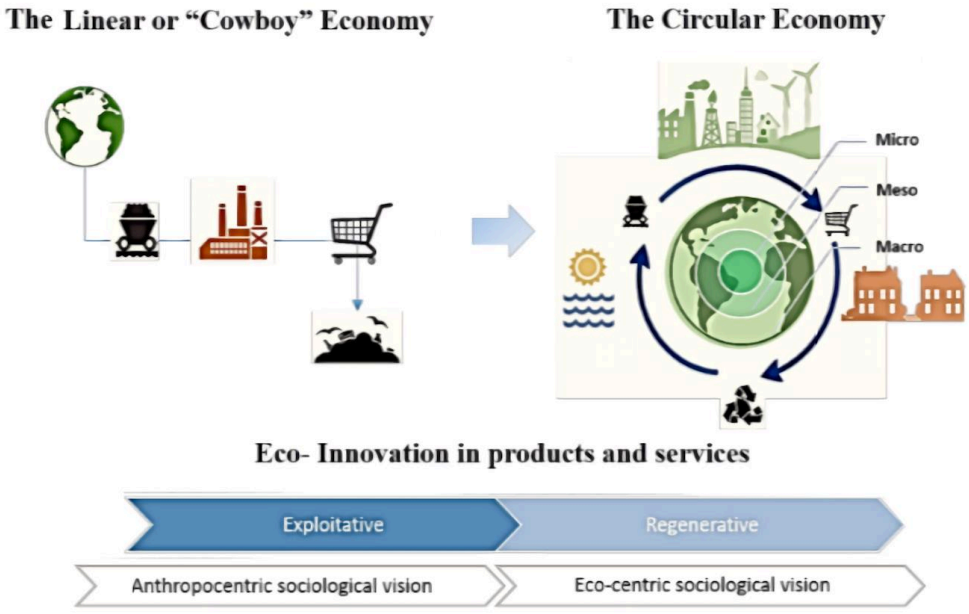
Source: Pearce & Turner, 1990

The natural resources R are of two types: Exhaustible (ER) that cannot be renovated, and Renewable (RR) that have the capability to renew themselves. The renewable resources need to be exploited at a rate (h) that is inferior to their natural regenerative capacity (y). The plus sign tells us that the resource stock grows, the minus sign that the resource stock decreases. These resources are inputs of the economic system used to produce goods (P) and consumed (C) to obtain utility (U). All the resources become waste (W) since energy and matter cannot be destroyed for the first law of thermodynamics. Some resources are recycled (r) and return in the economic system. Other resources return as waste in the environment that has an assimilative function (A). If the environment has the capability to assimilate it (A>W) then the circular system works. If A<W then the circular system does not work affecting negatively the environment. The circular model captures also the third function of the environment as *amenity provider.* Amenity is the pleasure and the enjoyment the environment supplies to the humans with no interference from the economic system. The beauty of landscapes is an example. Humans may attribute some value to the environmental amenity in terms of increased human welfare and may experience a loss if the environment deteriorates. Finally the environment works as a *life supporter* since its integrity is necessary for the survival of humans and non-humans (Pearce & Turner, 1990).

The change of paradigm from linear to circular economy implies also a sociological change from anthropocentric to eco-centric vision (Prieto-Sandoval, 2016). The anthropocentrism

considers the human beings as superior to nature and the most valuable entities in the world. The nature is a mere instrument in the hands of humans and can be justifiably exploited for the benefit of the humankind. With the advent of the environmental ethics this vision of the world was highly questioned giving birth to a new school of though, the eco-centrism. (Washington, &co, 2017) The eco-centrism is a value shift from the human being to the planet Earth. It is the ecosphere – consisting of Earth's ecosystems, atmosphere, water and land – the centre of the life. The Earth gives birth and sustains all the organisms. Therefore human needs and those of the other species are secondary to the needs of the Earth (Gray, 2018; Washington, 2017).

Figure 9: From linear to circular model.



Source: Prieto-Sandoval, 2016

1.3.2 CONTEMPORARY SCHOOLS OF THOUGHT

The contemporary circular economy framework has been enriched by the contribution of other relevant schools of thought: the performance economy by W. Stahel, the Cradle to Cradle design by W. McDonough and M. Braungart, the biomimicry by J. Benyus, the industrial ecology of R. Lifset, T. Graedel and H. Tibbs, the natural capitalism by H. Lovins and P. Hawken, and finally the blue economy by G. Pauli (Prieto-Sandoval, 2016, Ellen McArthur Foundation, 2012, Brennan, 2015).

1.3.2.1 THE PERFORMANCE ECONOMY

The performance economy outlined by Walter Stahel advocates a business model change from the sale of products to the sale of services. The manufacturers retain the ownership of the products and sell to the customers the service of their products for a defined period of time. The customers become users with the duty of stewardship and the benefits of flexible access to goods and fixed prices per used unit. When the customer finishes with the product, the manufacturer takes the old model back and uses its materials for new products. Systems are designed to reach high overall performance, through standardization of the components, product life extension, technological improvement and maintenance-free products (Stahel, 2010). The Internet of things and smartphones have eliminated the high costs and the logical barriers connected to on-demand services facilitating the sharing and renting of resources. Car sharing is the most clamorous example: users can rent a car from the owner, can hire the driver with his car for the travel, can connect with the driver that goes in the same direction to split the cost of gasoline. As a result pollution and resource depletion is considerably reduced (Esposito, 2015).

1.3.2.2 CRADLE-TO-CRADLE DESIGN

The American architect William McDonough and the German chemist Michael Braungart developed the Cradle-to-Cradle framework presented in their book *Cradle to Cradle: Remaking the way we make things*. Products should be designed to safely feed two metabolisms: the biological and the technical metabolisms. Products can be composed of nutrients that biodegrade and return safely in the biosphere or made of technical components that circulate continually in closed loops as valuable materials for the industry. It is important to keep separate the biological and the technical metabolism and avoid contaminations. This means that products that go in the biological metabolism must be designed free from toxins and pollutants that could damage the environment. Consequently, products that enter the technical metabolism should be conceived for continuous recovery and reutilization and free from biological nutrients that can weaken the quality of technical materials (Braungart & McDonough, 2002 and 2003).

1.3.2.3 BIOMIMICRY

Biomimicry is the study of the natural world to find solutions for the human problems. It advocates the learning from nature, the close examination and understanding of ecosystems

and organisms, and applies these findings to the design of industrial forms and processes. The nature is used as a *model* from which to get inspired and then as a *measure* to verify the appropriateness of the industrial innovations. The basic idea is that nature has already learned what works and what is appropriate on the planet and after 3.8 billion of years of evolution, what failed is fossil and what is around us contains the recipe for survival (Benyus, 1997; El-Zeiny 2012).

1.3.2.4 INDUSTRIAL ECOLOGY

Industrial ecology aims to understand and interpret the natural system and apply this information to reframe the industrial system in accordance with the design of the natural system. The main principles are:

- The creation of industrial ecosystems by recycling, optimizing the use of materials, minimizing the generation of waste, revaluing the waste effluents as inputs for other processes
- The balance of industrial input and output to natural ecosystem capacity by understanding the natural dynamics and ecosystem assimilative capacity and recovery times and adjusting the industry at the light of these data
- The dematerialization of industrial output - the declining of materials and energy in industrial production - through the reuse of materials, the use of more environmentally friendly materials and material-saving and energy-saving technologies
- The improvement in efficiency of industrial processes and materials use though the interchange of by-products and intermediates between manufacturers, the reduction of process steps and changes in technology to avoid dissipative use of materials
- The change in patterns of energy use by developing energy-supply systems with less or no impact on the environment and by using alternative energy sources
- The policy alignment to the industrial system evolution by introducing a market price for the environmental damage, by using a more exhaustive index to measure a nation's wealth rather than GDP, by using economic instruments to promote the move towards the industrial ecology (Lifset & Graedel, 2002; Tibbs, 1992).

1.3.2.5 THE NATURAL CAPITALISM

The natural capitalism emphasizes that the traditional industrial capitalism is unnatural because it just recognizes the money and goods as capital, ignoring the value of the natural

capital. The natural capital - including water, atmosphere, climate and all living organisms - provides biodiversity, supplies resources, assimilates waste and supports life. All these services worth at least $ 33 trillion a year but this value is not recognized by the market and do not appear in the companies' balance sheet. The natural capitalism proposes four principles to enable the businesses to properly value the natural services, reduce their losses in the production process while increasing profits. The first principle asserts to increase resource productivity through a most efficient use of resources, radical changes in process technology, and modifications in product design. The second principle concerns the elimination of waste through the adoption of biological patterns, processes and materials. The third principle regards the introduction of the *solution economy* that represents a critical shift in the economy from selling goods to provide to the customers what they want. It is a win-win solution where the business and the customer are rewarded by finding mutually beneficial and efficient solutions. This is completely opposite to the traditional logic of the industrial capitalism where the business aims to sell more goods more often and at higher price while the customer wants to spend less. The last principle consists in reinvesting profits in natural capital. Since the natural capital is valuable and precious, the businesses should invest in its restoration and expansion (Lovins, 2001 and 2006).

1.3.2.6 THE BLUE ECONOMY

The blue economy was introduced by Gunter Pauli to illustrate a business model shift from the economy of scarcity to the economy of abundance. In the economy of abundance it is possible to create new jobs, to increase productivity and to enhance resource efficiency. The key to this shift is the emulation of the natural ecosystems. Manufacturers should achieve the full use of the available resources, the creation of clusters to facilitate the exchange of by-products and the cascading of materials to extend the life of the products and avoid the depletion of virgin inputs. For example a coffee company could generate income from the production of coffee as its core business, then use the waste stream from coffee production to cultivate mushrooms and finally employ what is left from the harvest as fertilizer or animal feed. By doing this, the company generates revenues from three businesses and fully exploits the product without creating waste. Hence, the Blue economy aims to eliminate whatever is not needed. For example a traditional battery is not replaced by a green battery but by an alternative and free-from-metal source of energy. A German Institute has prototyped a phone that generates electricity from the difference in temperature between the body and the phone and from the pressure of the voice during a talking. All these strategies reduce the ecological

pressure on the environment and produce impressive savings in materials and costs (Pauli, 2010).

Table 2 recaps the main characteristics of the contemporary schools of thought influencing the definition of CE, and Table 3 links the CE principles to the literature stream.

Table 2: Key characteristics of the CE contemporary schools of thought

Literature	Key characteristics
The performance economy (Stahel, 2010)	Selling performance, retaining ownership
Cradle-to-Cradle Design (McDonough and Braungart, 2002)	Technical and biological metabolism, waste equals food, use of renewable energies and celebrate diversity
Biomimicry (Benyus, 1997)	Nature as a model, as a measure and as a mentor
Industrial ecology (Lifset & Graedel 2002, Tibbs 1992)	Industrial ecosystems, balance of industrial input and output to the natural capacity, dematerialization of industrial output, improvement in efficiency of industrial processes, materials and energy use, market price for environmental damage
Natural capitalism (Lovins B., Lovins H., Hawken 1999, 2001)	Importance of the natural capital, efficient use of resources, elimination of waste through biological patterns, solution economy, reinvesting profits in natural capital
Blue economy (Pauli 2010)	Cascading of materials, industrial symbiosis, optimised exploitation of raw materials

Source: Personal elaboration

Table 3: Linking the CE principles to the literature.

Literature stream	CE principles					
	Waste is food	**Build resilience through diversity**	**Shift to renewable energy sources**	**Think in systems**	**Think in cascades**	**Design out waste**
The performance economy (Stahel 2010)				X		X
Cradle-to-Cradle Design (McDonough & Braungart, 2002)	X	X	X	X		X
Biomimicry (Benyus 1997)	X	X	X	X		
Industrial ecology (Lifset & Graedel 2002, Tibbs 1992)	X		X	X		X
Natural capitalism (Lovins B., Lovins H., Hawken 1999, 2001)	X			X		X
Blue economy (Pauli 2010)	X			X	X	

Source: Personal elaboration

1.4 THE CIRCULAR ECONOMY OPPORTUNITY

The major opportunities carried by the adoption of the circular economy model interest different areas: the environment, the economy and the society.

On the environmental side, the circular economy would reduce the demand for raw materials and improve the efficiency in resource consumption. Nowadays, Europe imports 60% of metals and fossil fuels and 20 types of these materials are in danger of exhaustion. This dependence on imports causes high resource prices and vulnerability due to volatile prices and geopolitical uncertainties. It is estimated that the adoption of CE technologies and

practices would reduce the primary material consumption by up to 32% by 2030 and by 53% by 2050. Moreover, it contributes to decrease the European dependence on imports and the exposure to the risk of volatile prices for international commodities and supply uncertainty caused by resource scarcity or geopolitical factors. Keeping materials in the loop would reduce the emissions of greenhouse gas and enhance the ecosystem resilience. McKinsey Center for Business and Environment estimates a decrease in greenhouse gas emissions of 48% by 2030 and of 83% by 2050 compared to the levels in 2012. Farther, there will be reductions in externality costs of USD 500 million by 2030.

From the economic perspective, the CE practices are expected to generate significant cost savings in different industries. In the food, textile, packaging and beverage industries the potential is up to USD 700 billion per year globally. In the sectors of complex medium-lived products the costs savings could reach up to USD 630 billion. European GDP could increase as much as 11% by 2030 and 27% by 2050. The economic growth defined by the GDP would be the result of increased revenues from circular activities and lower cost of production due to the reutilization of the inputs. Moreover, a more innovative economy would stimulate technological development, materials' improvement, labour and energy efficiency.

In the social context, the consequences would be more sustainable consumer behaviours and the creation of many job opportunities, up to 2 million additional jobs until 2030. Employment opportunities are the result of labour-intensive activities and higher skilled jobs required by the circular economy. (Vanner, 2014; Ellen MacArthur Foundation, 2015; European Commission, 2014 a; European Commission, 2016; EEA 2016)

1.4.1 MOTIVES AND OPPORTUNITIES TO ENGAGE IN SOCIALLY RESPONSIBLE BEHAVIOURS

The literature focusing on corporate social responsibility (CSR) has examined the different economic motivations of firms to participate in CSR. We use the literature on corporate social responsibility as basis for our analysis since circular economy and in general the environmental concern is a dimension of corporate social responsibility (Arsic, 2016).

Why do firms engage in CSR?

Firms may have different motivations. They may be strategic driven, value driven or stakeholders driven. Performance-driven firms pursue CSR initiatives to increase sales, profit and return on investment. Value-driven firms engage in CSR because they have altruistic

intentions and think it is the right thing to do. Finally, stakeholders-driven firms to meet various stakeholders' expectations (Ellen, 2006). Moreover, they can engage in CSR to achieve other contracting benefits as to recruit, motivate and retain employees, to attract customers, to reduce production costs, to reduce business risks, to attract suppliers or to attract capital from investors (Sprinkle, 2010). In particular, cost advantages constitute one of the main motives to engage in circular practices. Cost advantages can be achieved through the redesign of production processes to be less polluting, the recycling of byproducts and scarps, the substitution of polluting inputs and the innovation of production process to be less polluting and to lose fewer resources. These changes lead to cost savings in production due to reduced use of raw materials, efficient exploitation and use of resources and energy, reduced costs for waste disposal and for the acquisition of raw materials. Green practices lead to reductions in internal and external failure costs. For internal failure costs, firms benefit from reductions in expenses of scrap, rework and inspection. For external failure costs, firms benefit from reduced customers' complaints and returns and reduced products' recalls.

Another reason is to achieve a differentiation advantage. This derives from environmental practices focused on products characteristics and product markets as the eco-design of products and packaging and the advertising of environmental benefits. These practices are likely to increase the price of products and result in higher revenues (Christmann, 2000).

CSR is a mean to attract, motivate and retain talents. The first effect is the reduction in employees' turnover and related costs.

CSR can enhance the motivation of the employees and reduce the costs related to performance evaluation and measurement systems. Employees experience higher commitment to the organization and job satisfaction when higher ethical values are introduced in the corporation (Springle, 2010; Lepoutre, 2006).

Moreover, CSR is a mean to build long-lasting relationship with customers.

Finally, CSR may facilitate the access to capital or firms may obtain more favourable lending terms as lower interest rates (Springle, 2010).

CSR decisions are made via an informed understanding of the potential benefits and costs. Many of the benefits of CSR mirror the motives to engage in CSR.

In particular, firms with different size may have different motivations to participate in CSR. Firm size as a combination of three attributes - visibility, resource access and scale of operations - can affect strategic motivations to approach CSR.

Firms with higher visibility are motivated to participate in CSR to benefit of enhanced reputation and legitimacy. CSR may be a source of enhanced legitimacy and positive

reputation. Large firms have more visibility than small firms and are motivate to engage in CSR since they obtain large reputational benefits. However, small firms may be equally motivated to perform CSR activities since the marginal utility of enhanced reputation and legitimacy is higher for less visible firms than for high visible firms.

Firms with larger scale of operations are motivated to engage in CSR because they can carry out CSR activities at little extra cost and can benefit from cost advantages that cannot be easily replicated. Large firms can exploit their economies of scale to benefit from CSR cost advantages and pursue a low cost strategy. On the other side, small firms without economies of scale cannot pursue a low cost strategy. They need to gain competitive advantage through a strategy of differentiation. The benefits achieved through CSR can help in pursuing this strategy. In particular CSR enhances the perceived value of products and as result consumers may be willing to pay a premium for them. Participation to CSR may help firms to improve the use of their existing resources and to build strategic relationships with suppliers. Small firms that cannot pursue a low cost strategy are motivated to engage in CSR to gain competitive advantage on the basis of a strategy of differentiation.

Finally, firms with more resources are motivated to enhance their competitive advantage through CSR since they have the financial and human resources to implement CSR-related practices into their business operations. On the contrary firms with limited resources are likely to engage in CSR because they may obtain access to critical resources. Significant benefits are associated to CSR as for example exclusive access to natural resources, human resources (the employees attracted by socially responsible firms) and social resources as legitimacy and networks. Small firms are resource-constrained and are motivated to participate in CSR to obtain access to these critical resources (Udayasankar, 2007).

Moreover, small firms may not only be driven by different motivations than large corporations, but they can even reap lesser benefits from the implementation of circular practices.

Because of their size they suffer from a lack of resources, including deficits in financial resources, knowledge and time, and cannot support the high costs of environmental initiatives (Noci and Verganti, 1999) or prefer to focus on issues that are at the core of the business (Biondi, 2000). Because they are small they have low visibility and cannot take advantage of the publicity that receives larger corporations when engage in environmental practices (Udayasankar, 2007; Brammer, 2012). On the contrary, due to their size, large firms are able to benefit greatly from environmental initiatives, partly because they have the resources and the economies of scale to face the complexity and the costs of environmental management, and partly because they have large visibility and hence they are able to show their

environmental actions to a wider set of stakeholders and benefit from reputation and legitimacy effects (Udayasankar, 2007; Brammer, 2012).

Table 4 lists the main opportunities achieved through circular economy initiatives. We include in the list also the benefits identified by the literature on CSR.

Table 4: Circular Economy Opportunities.

Main categories	Opportunities
Environment	• Reduced externalities • Reductions in the use of resources and energy
Society	• New jobs • More sustainable consumers' behaviours • Improved working conditions
Economy	• Significant cost savings • Increased revenues • Reduced import dependence on natural resources • Mitigation of price-volatility and supply-uncertainty risks • Differentiation advantage • Enhanced employees' motivation • Long-lasting relationships with stakeholders (customers, suppliers, buyers) • Customer loyalty • Enhanced legitimacy and reputation • Enhanced perceived value of products • Access to critical resources for SMEs • Access to financial resources and more favourable lending terms • Employees' attraction, retention and reduced turnover

Source: Personal elaboration. Based on Udayasankar 2007, Springle 2010, Lepoutre 2006, Christmann 2000.

1.5 THE CIRCULAR ECONOMY CHALLENGE

Achieving benefits is not a simple process since numerous barriers can hinder the resource efficient behaviours and the new business models. Circular economy poses specific challenges to firms that aim to reduce the environmental impact of their products. The

literature identifies four major categories: cultural, regulatory, market and technological barriers (Rizos, 2015; Vanner, 2014; de Jesus, 2018; Preston, 2012; Kirchherr, 2017). These constraining factors largely depend on the particular local conditions (de Jesus, 2018). Many barriers are specific to particular materials, products and sectors (Vanner, 2014). There are interaction effects between the different categories of barriers. For example lack of data on CE benefits and limited large-scale demonstration projects could abstain businesses from engaging in CE practices and therefore causing the persistence of linear business models and obstructing laws and regulations. These interactions can lead to chain reactions towards CE failure (Kirchherr, 2017).

Table 5 lists the main barriers to the circular economy transition in the EU.

Table 5: Barriers to the Circular Economy.

Main categories	Barriers
Cultural	• Lacking customer interest and awareness • Hesitant company culture • Limited willingness to collaborate in the value chain • Operating in a linear system
Market	• Low virgin material prices • High upfront investment costs • Limited funding for circular
Regulatory	• Obstructing laws and regulations • Lacking global consensus • Limited circular procurement
Technological	• Limited ability to deliver high quality remanufactured products • Lacking circular design • Too few large-scale demonstration projects • Lack of data

Source: Kirchherr, 2017

1.5.1 CULTURAL BARRIERS

Cultural barriers regard consumers' behaviour, company culture, and cooperation between companies along all the value chain.

The success of the circular economy in the long term will depend on the perceptions the consumers have about the sustainable products. If they do not change their consumerist mindsets and habits, the circular economy will be not a viable option. Consumers are not always rational, objective and utility maximizing. They base their decisions on subjective beliefs. They are resistant to change since they want to preserve their habits and their status quo. The behaviour of consumers is more influenced by non-functional motives, like enjoyment and entertainment, rather than pure utility function. Individuals prefer to buy new goods rather than repair the old ones simply because the shopping experience provides self-gratification and sensory stimulation. They are not motivated to change their behavior even if they are aware of the economic and ecologic benefits of the reuse and refurbishment of goods. Enjoyment is perceived more positively than usefulness when it comes to an innovation. If a product does not produce amusement and enjoyment for the consumer, its high utility has only a limited impact on the consumer's decision making. In addition, social pressure has a great impact on consumers' behaviors. Consumers in their purchasing decisions are biased by the network of their peers, the so-called *network effect*. When the network effect occurs, the value of a product is determined by the customer base and therefore increases according to the number of the users. If many people have purchased a certain good, then additional people will purchase the same good because the perceived value exceeds the price. For the early adopters of the circular economy is challenging to encourage their peers to do the same. The CE strategies should be assessed taking into account these non-rational motives that drive consumer behaviours (Planing, 2015).

The organizational culture is another critical barrier. Entrepreneurs may have little familiarity with the sustainability matter, may perceive that sustainability is irrelevant to their business or may not see any benefit to engage in sustainable practices (Rizos, 2015). The discussion about the circular economy is often restricted to the sustainability department and does not interest the strategically most influential departments such as finance and operations. In SMEs, ownership and management usually reside in the same person that has the power to affect strategic decisions according to his personal values and could determine the attitude of the firm towards green projects. Moreover the barrier 'lacking customers interest and awareness' could cause the 'hesitant corporate culture' since the fear that the customers will not change their habits stops the businesses from investing in CE (Kirchherr, 2017; Rizos, 2015).

Finally critical challenges to the CE transition are the limited willingness to collaborate among the industry players and the relevance of linear practices.

To facilitate the adoption of CE practices and technologies companies should exchange and share resources, energy and know-how in a mutually beneficial manner. By working together, companies could achieve a collective benefit that is greater than the sum of the benefits achieved by working alone. The residuals from one factory can be used as a resource for other companies resulting in resources remaining in productive use for longer, reduced depletion of natural resources and lower generation of waste residuals. Moreover, they could overcome the technological barrier by sharing knowledge and best practices. But nowadays companies are still reluctant to disclose their know-how and best practices because they are afraid of competition and misappropriation. In addition, incorporating CE practices would mean for companies to adjust their operations. This means large transaction costs and reorganization of the supply chain towards sustainable practices and materials. It means choosing circular suppliers or convince the current suppliers to adopt CE practices. However the supply chain is very conservative and is still operating through the linear system. Suppliers are reluctant to foster sustainable practices due to the high costs that could affect their competitiveness (Chertow, 2000; Preston, 2012; Kirchherr, 2017).

1.5.2 MARKET BARRIERS

Even if new sustainable technologies are available there is limited application in the marketplace due to economic, financial and market obstacles. The most pressing barriers are the 'high upfront investments costs' and the 'low virgin material prices' (Kirchher, 2017). In the short term the adoption of CE practices implies significant upfront investment costs and risks for companies. It means retooling machines, relocating factories, retraining the staff (Preston, 2012). Transforming the company's business model is risky and costly. Especially SMEs are highly sensitive to the financial costs of the CE transition because they lack the economic resources and the economies of scale that have the large enterprises (Rizos, 2015; de Jesus, 2018). SMEs have also difficulties to obtain bank financing since they cannot provide the collaterals and the guarantees requested by the banks for the loans (Rizos 2015). Moreover, the 'high upfront investment costs' create the 'hesitant corporate culture' because discourage the entrepreneurs from adopting the CE model (Kirchherr, 2017).

The low cost of virgin inputs is another critical impediment for the CE transition. The current prices of virgin inputs create economic signals that do not encourage the CE practices of refurbish, remanufacture and recycle. The prices of linear products are low if compared to the circular ones and this is due to the fact that the negative externalities of the linear productive model are not taken into account. The 'environmental damage' is not considered by the

market when assessing the product's price (Vanner, 2014). These low prices feed the cultural barrier of 'customers awareness and interest' since customers are cost-conscious when make purchasing decisions (Kirchherr, 2017).

1.5.3 REGULATORY BARRIERS

Many companies consider the lack of government policy, support and encouragement as the key factor of their poor circular performance. 'Obstructing laws and regulations' is the main obstacle in this category. Current governmental initiatives are focused on overcoming technological barriers, but the CE practitioners show that it is not the technological barriers that hinder the transition towards the CE. Therefore, the current regulatory framework is inadequate and inconsistent and contributes to make the linear paradigm more persistent (Kirchherr, 2017; de Jesus, 2018). This regulatory framework induces the consistency of the market barriers as 'upfront investment costs' and 'low virgin prices'. There is need for change of current laws and regulations and targeted governmental interventions against these identified market barriers.

Moreover, SMEs are at disadvantage if compared to large corporations. They have limited resources and are highly depended on external support. Governments should develop ad hoc programmes for SMEs (Kirchherr, 2017). The literature conveys that governments should especially address the following issues: lack of internalisation of externalities and resource pricing, lack of incentives to reuse/recycle/repair, lack of investments in recycling and recovery infrastructures and technologies, weakness in policy coherence, lack of waste separation at source, lack of circular procurement incentives for public authorities (Vanner, 2014).

1.5.4 TECHNOLOGICAL BARRIERS

The availability of technologies and information is a facilitator for the development of a CE and difficulties in developing these technologies and obtaining the right information constitute a barrier. Technological barriers include technology gaps, lack of educated personnel and the existence of appropriate technology (de Jesus, 2018). Nevertheless, among all the other categories, the technological one is the less pressing for businesses (Kirchherr, 2017).

1.5.5 CHALLENGES TO ENVIRONMENTAL IMPLEMENTATION IN ITALY

The barriers to environmental implementation in Italy are mainly related to market and regulations. The Country Report on Italy written by the European Commission in 2017 depicts the common challenges within the Italian context.

On the market side, the scarcity of risk capital and public funding for adoption and implementation of circular economy projects is a great impediment for firms. Innovative SMEs are the backbone of Italy and play a significant role in term of value added and jobs but they perform below the EU average in terms of productivity (value added per capita), R&D intensity and environmental performance. The main impediment to these firms is the lack of public support. Therefore, Italian SMEs have to rely on their internal sources as primary way of financing since it is quite hard to obtain finances through public funds and other sources. In particular, the Italian financial system is bank-centric and banks are the principal source of external financing for the Italian entrepreneurial system. However, banks are reluctant to finance SMEs especially when they are risky businesses, or businesses that cannot give adequate collaterals. Moreover, product prices do not reflect the environmental costs. This is due to the fact that environmentally harmful subsidies are still present and actions to remove them have been very limited (European Commission, 2017). These subsidies guarantee financial assistance and tax concessions to firms with large environmental footprint and beyond impacting negatively on the environment they represent also a burden to the national budget because they constitute an excessive expenditure and a loss of tax revenue (Umwelt Bundesamt, 2017). Moreover, another concern regards the tax system. In Italy there are environmental taxes in place and especially taxes on energy and transport generate significant revenues and Italy ranks at 6th place in the EU in term of ratio of environmental taxes on GDP. However, there is still work to do on the tax system. The European Commission in occasion of the European Semester 2014 has recommended shifting the tax burden from labour to environment, consumption and property. To this purpose, it is critical to reduce the harmful subsidies, reform the cadastral system to align the tax base of immovable properties to the market values, fight against tax evasion, shadow economy and undeclared work (Eunomia Research & Consulting, 2014).

On the regulatory side, several barriers hinder the effectiveness of actions in the Italian public administrations. The governance system is highly decentralized and this causes coordination problems among national, regional and local authorities. Competences are unclearly shared among local and central administrations leading to overlapping and institutional conflicts and causing uncertainty about the duration and outcomes of administrative processes. There are problems of transparency and control over the administrative activities and insufficient compliance assurance mechanisms that impede to control the application of the EU law and to sanction the infringements. There is high fragmentation at the regional and local levels and high disparities in terms of economic and environmental performances, with some regions

performing much better than others. These disparities are accentuated by the lack of national level coordination mechanisms for the environment. The Ministry of Environment is under-resourced and this leads to problems in environmental integration and implementation in all policy areas. Furthermore, there is a problem of policy coherence, due to the incorrect transposition in Italian of the EU regulations and directives that have triggered several infringements and complaints by the EU Commission (European Commission, 2017).

1.6 CHANGES TO PRIMARY AND SUPPORT ACTIVITIES

The firms adopting circular business models need to reorganize their primary and support activities. Primary activities include inbound logistics, production, outbound logistics, marketing and after-sale service. Support activities consist of technological development, resource procurement, human resource management and infrastructure activities (Porter, 1985). The characteristics of the circular products directly impact the way the value chain is constructed and managed. The traditional approach of creation, production and commerce of the products is challenged (De Ios Rios, 2017). For firms it is imperative to adopt green supply chain management practices as green design, green procurement, green processes and green logistics.

To prevent pollution and preserve energy and resources firms should optimize the design of the whole process of product life cycle including purchase, production, logistics and use process (green design). They should use green materials as recyclable materials, biodegradable materials and renewable materials (green procurement). The productive process should be implemented to be harmless to workers and guarantee low energy consumption, reduction of waste and environmental impact (green production). Logistics should be adapted to the new paradigm including for example green packaging and reverse logistics (green logistics). Green packages contain recycled or degradable materials without poisoning ingredients such as mercury, tin and lead. Reverse logistics indicates the collection of end-of-life products - as exhausted oils, damaged fabrics, slag from incineration of municipal waste, coffee grounds – to recover or recycle them and give them new life (Ying, 2012). There is need to develop consumer awareness on the new circular products since for green products there is a problem of information because it is very difficult for the consumer to assess the environmental friendliness of a product even after the purchase. Therefore, it is necessary to inform about the environmental qualities of the products through green marketing campaigns, the use of eco labels and through environmental standards (Rex, 2007; De Marchi, 2012).

In the context of green supply chain management practices, it is essential for manufacturers to build collaborations with various stakeholders. Circular products require knowledge and skills that the traditional firms do not possess. Companies must develop new knowledge and capabilities to operate in a sustainable way and to integrate the new technologies in the internal manufacturing and production processes (De Ios Rios, 2017; Geffen and Rothenberg, 2000). Especially suppliers are a source of expertise, and strong relationships with them can increase the ability of a manufacturing firm to access and utilize new external knowledge (Geffen and Rothenberg, 2000). Moreover, cooperation with suppliers is critical to verify that the suppliers fulfill the environmental requirements and supply eco-friendly inputs and components (De Marchi, 2012). Cooperation with customers helps firms to reduce the risks associated with the introduction of products in the market, to understand the user behavior and to find the right balance between performance and price. Cooperation with research institutes and universities is important to access specialist technical support, to obtain information on the emerging technologies and to complement internal R&D. Cooperation with consultants provides applied knowledge and specialist skills and information (Tether, 2002).

1.7 EU POLICY FRAMEWORK FOR THE CIRCULAR ECONOMY

The European Commission is developing policies to improve the resource efficiency of the European economy and enable the transition towards the circular economy. At the moment the key initiatives are the following:

- The Circular Economy Package
- The Roadmap to a Resource Efficient Europe
- The 7th Environmental Action Programme
- The European Resource Efficiency Platform (EREP) – Manifesto and Policy Recommendations.
- The Europe 2020 strategy for smart, sustainable and inclusive growth (Vanner, 2014).

The EU is trying to obtain these results:

1. Promoting new, resource efficient business models
2. Boosting Extended Producer Responsibility
3. Enabling consumers to make more sustainable choices
4. Developing employment and skills
5. Financing to enable the transition
6. Speeding up the development and use of indicators (European Commission, 2012).

These initiatives constitute a good starting point but further action is needed. By themselves they are not sufficient to make the shift happen since they focus only on individual sectors and products, whereas the transition requires an integrated approach that considers the interlinkages between sectors, economic actors and across value chains. The current commitments are focused on certain sectors such as manufacturing, collection and recycling for technical materials, and cultivation/collection for biological material. The other loops as reuse, repair, refurbishment, remanufacture and upgrading have received little attention and mainly from the private sector. These latter loops represent unexploited opportunities that can be supported through targeted actions.
There is need to revise the existing legislation in order to better support the circular economy.

Moreover, legislative measures should be accompanied by other instruments as voluntary agreements, fiscal and economic incentives, awareness raising campaigns and targeted information and advisory services (Vanner, 2014).
The voluntary agreements are agreements between businesses along the supply chain or between businesses and governments. A successful example is the WRAP Programme in UK. The WRAP - *Waste and Resource Action Programme* - helps businesses, communities and local authorities to reduce waste, to use resources efficiently and develop sustainable products. It provides tools, information and advices to reach these objectives and a space where businesses can share their best practices and collaborate. The main areas of interest are: food and drink, clothing and textiles, electricals and electronics (WRAP, 2000).
Fiscal incentives can be a valuable initiative against the barrier of low virgin prices. This mechanism can regard increased prices on inputs upstream in order to affect the choice of materials in the production process or taxes on products and waste disposal downstream.
In France there is a particular fee mechanism for manufacturers that pay a fee for the waste disposal of their products according to certain requisites: the weight and number of products collected, the amount of recycled materials in the product, if there is presence of contaminants that can hinder the recycling. This mechanism incentivises eco-design, recycling and collection practice.
Awareness campaigns and information services are critical to spread circular economy knowledge between producers and users. Tesco, a supermarket chain in UK, has specific internal policies to educate its employees.
Moreover, public investments are required to support the firms so that they can engage in CE practices. Public funds could be used to support pilot projects to prove the success of the circular economy practices and encourage the other businesses to do the same. They can be

useful to finance R&D and innovation and to extend the knowledge base and awareness of circular economy opportunities. They can be employed to educate the workforce and support clusters, industrial symbiosis and platforms to share the best practices (Vanner, 2014).

1.7.1 POLICIES IN SUPPORT OF SMES

SMEs have characteristics that distinguish them from large corporations. In particular they are independent and owner-managed, multi-tasking and cash-limited, built on personal relationships and informal control mechanisms (Spence, 1999). They have a permanent lack of time and knowledge that result in short-termism and lack of specialization and expertise. Moreover, they have low bargaining power, are largely local in their operations and rarely have access to external sources of financing (Lepoutre, 2006; Perrini, 2007).
Therefore, implementing circular practices in SMEs is not the same as in large firms. Due to their specific characteristics, SMEs experience greater challenges than large firms when approaching circular economy.

Therefore, the European Commission is adopting ad hoc legislation for SMEs with the intent of *'enabling SMEs to turn environmental challenges into business opportunities'*. (European Commission, 2014 b) The most important initiatives are:

- The Green Action Plan for SMEs (GAP)
- The Europe 2020 Strategy
- The Small Business Act

The GAP aims at supporting SMEs through (1) resource efficiency, (2) green entrepreneurship, (3) greener value chains and (4) facilitated access to new markets for green SMEs (European Commission, 2014 b).
European SMEs are aware of the importance of resource efficiency but most of the time they do not have specialized knowledge and funds to improve their technologies and processes. For this reason the EU has established the European Resource Efficiency Excellence Centre and the Enterprise Europe Network (EEN) to assist, inform and advise European SMEs seeking to improve their practices. The European Investment Bank (EIB) and the Private Finance for Energy Efficiency instruments will provide financing for resource efficiency improvements, whereas the European Regional Development Fund (ERDF), the European Maritime and Fisheries Fund (EMFF), the European Agricultural Fund for Rural Development (EAFRD) will support SMEs competitiveness.

In SMEs the entrepreneur has significant power in the strategic decisions and could determine the attitude of the firm towards green projects. It is important to foster green entrepreneurship through the education of the future leading generation and by helping the entrepreneurs to identify the new CE opportunities. In this context, the EU has set up the European Enterprise Promotion Awards and the Cluster Excellence Programme to support innovative ideas and green entrepreneurship.

SMEs need to establish industrial relationships and networks to develop and share knowledge and to exchange byproducts in order to reduce waste. It is estimated that 44% of large companies exchange their byproducts whereas only 24% of SMEs do so because they lack specialized knowledge and technologies and they are hampered by the high transaction costs and high investment costs needed to enter the transaction. The Horizon 2020 will allocate 75% of the total budget to support innovation in SMEs. The European Cluster Observatory will facilitate the creation of networks for SMEs.

Few SMEs in Europe offer their products and services in international markets ad 87% of European SMEs just operate in their national market. SMEs need to compete internationally and to look for international partners to do business with and learn new skills and technologies from. European Strategic Cluster Partnerships will facilitate access to international markets by fostering alliances between clusters. The Low Carbon Business Action will provide assistance to create alliances between European SMEs and businesses in other countries.

These actions need to be monitored on an annual basis, and the EU Commission has established The SME Performance Review to monitor and assess the progress of each Member State and a platform for the exchange of best practices (European Commission, 2014 b).

The EU has funded the GreenEcoNet platform for SMEs to collect case studies of successful green SMEs. These case studies are published online to encourage other businesses to become circular, to share their best practices and challenges and to permit an exchange of information among SMEs. (Rizos, 2015; GreenEcoNet)

1.8 RESEARCH QUESTIONS

The circular economy is a viable strategy to relieve tensions between economic development and environmental concerns. It represents an alternative to the linear model of take-make-dispose that is in use since the Industrial Revolution. A growing body of literature has emerged since the 1960s and has contributed to the implementation of the CE concept and practices. The EU Commission has adopted numerous policies to support the CE transition in the EU. The circular economy offers many unexploited opportunities for businesses as increased productivity, enhanced efficiency in resource consumption, minimised risk of volatile prices and supply uncertainty, reduced externalities, significant cost and material savings, new jobs and increasing resilience. But, at the current stage, European companies face numerous cultural, market, regulatory and technological barriers that should be overcome through public and private initiatives. These barriers are particularly accentuated for SMEs that lack the capital, the knowledge and the networks to make the shift.

Although the literature at European level is quite extensive, there is a lack of studies devoted to CE opportunities and challenges for particular European regions.

Moreover, the literature has widely investigated the firms' barriers to the CE adoption and implementation, but little has been said about the specific CE opportunities for firms, with the majority of the studies just focusing on the general benefits of the CE for the economy as a whole, the society and the environment. Finally, when deepening the theme of CE challenges, the available studies highlight the difference among large corporations and SMEs, with the latter having more difficulties in embracing the circular paradigm. Further, the literature on the corporate social responsibility, of which the environmental responsibility is an important dimension, has investigated the relationship between the firm size and the CSR participation concluding that small businesses are driven by different motivations when engage in CSR initiatives and expect different benefits than large corporations. Because of their size, small firms suffer from a lack of resources, including deficits in financial resources, knowledge and time, and have low visibility and therefore are more likely to reap lesser benefits from the implementation of circular practice than large corporations.

Taking into account the available literature, the aim of this research is to increase knowledge and understanding about the barriers and the benefits for firms when implementing circular economy business models and to extend this study to the Italian context and to the manufacturing industry. Finally, this research aims to examine the relationship between the firm size and the circular engagement to verify whether small firms encounter more difficulties and reap lesser benefits than large corporations in the transition towards CE.

Specifically, it addresses the following questions:

(1) Which are the opportunities the Italian manufacturing firms achieve?
(2) Which are the challenges they face?
(3) Which is the relationship between firm size and circular engagement?

The structure of this study is as follows. Chapter 2 describes the methodology used to select the sample, collect the data and analyse the results. Chapter 3 presents the main findings from the interviews. Finally, Chapter 4 analyses the relationship among firm size and circular engagement to understand whether small firms are at disadvantage with regard to large ones when implement circular practices.

Chapter 2

METHODOLOGY

2.1 METHODOLOGY

This chapter provides a description of the process used to select the sample, collect and analyze the data. Moreover, it illustrates the design of the questionnaire and the statistical models employed to describe and compare the results.

2.1.1 SAMPLE SELECTION

The participants were selected from different databases: Trenoverde, Storie di economia circolare, Remade in Italy and Io penso circolare. We used these databases because we wanted to focus our research on the 'Green Champions', those firms that have already adopted circular practices and have achieved significant results.

Trenoverde is a campaign financed by Ferrovie dello Stato Italiane and Legambiente to promote environmental sustainability and to share the experiences of Italian firms that have already adopted sustainable practices (http://www.trenoverde.it).

Storie di economia circolare is a competition that invite writers, photographers, storytellers, journalists, viodeomakers to tell with their art a story of circular economy in Italy. The aim of the project is to spread awareness of the circular economy and benefits deriving from virtuous and sustainable practices (http://www.economiacircolare.com).

Remade in Italy is an environmental certification to assess the percentage of recycled material within a product. To obtain this certification, a company is required to prepare a traceability plan of materials within the productive process, to continuously monitor its suppliers, to classify all the incoming materials and to have the maximum transparency in the documentation that shows the correctness of and the care in the process (http://www.remadeinitaly.it).

Finally, Io penso circolare is a competition supported by the Italian magazine La Stampa and Aquafil, an Italian manufacturing firm that is global leader in the regenerated nylon fiber. The competition is made for start-ups born after the 1st November 2014 and research centers that

have developed products, technologies, projects in the circular economy field. The aim is to support the circular economy in Italy and to publicize the companies and research centers that adopted CE practices (http://www.lastampa.it/iopensocircolare).

From these sources we identified a population of 322 firms that stood out for their circular economy projects. The research was conducted together with Laboratorio Manifattura Digitale of Padova University and Legambiente Onlus.

Then we gathered information on the population by reading their websites and other publications and selected the firms that corresponded to our research criteria:

- Firms from the manufacturing industry
- Firms adopting circular economy practices

We reduced the population at 231 firms that were contacted to participate to our survey.

2.1.2 DATA COLLECTION AND ANALYSIS

Our research is based on primary data collected through sample surveys. To collect the data we conducted structured interviews based on a well-designed questionnaire. The initial contact with the firms was by telephone. We presented the purpose, the object and the methodology of our survey and asked for the email address of managers qualified to respond to our questions. The second contact was by email since we sent a written presentation of the project and a copy of the questionnaire that would have been used for the interview. Firstly by phone and then by email, we explained that the answers would have received a confidential treatment and that the purpose of our study was purely scientific and the data would have be treated anonymously and only in an aggregate manner. This statement was necessary to ensure the respondents that their answers would be held confidential and totally anonymous.

We decided to organize phone interviews to talk directly with the respondents and have the opportunity to clarify the questions and give further explanations in order to avoid misunderstandings. Phone interview is also a medium to quickly collect data and gain more information about the firm and its industry beyond that obtained by answering the pre-established questionnaire. But, phone interviews have also some cons. Sometimes it is hard to obtain the trust of the respondent who may not be willing to answer all the questions, especially the more sensitive ones. Moreover, phone interviews should be kept short not to upset the respondents and this reduces the amount of data collected (Burke, 2001). The survey forms have been filled by the researchers and not by the respondents. In this way, data could be validated at the time of collection improving data quality.

The collection of data lasted four months, from March to June 2018. In total, 53 firms participated to the survey – this constitutes our final sample.
At the end of all the interviews, the data have been interpreted through statistical analysis. We used descriptive statistics in Excel to summarize, describe and represent what the data show. At the end of the investigation, the aggregate data have been presented to the 'Ecoforum dei Rifiuti', a conference on the circular economy promoted by Legambiente and held in Rome at the end of June 2018.

2.1.3 QUESTIONNAIRE DESIGN

The format of the questionnaire is visible from the Appendix. Our questionnaire is eight pages long and is structured in three sections: there are 23 questions on the Circular Economy, 4 questions on the Industry 4.0 and 10 questions on the Characteristics of the Firm and the Industry, for a total of 37 questions. It is designed as an exploratory instrument to collect information about the circular economy practices of the Italian manufacturing firms.
The questions on the Circular economy ask about the characteristics of circular practices and business models, the strategic motivations to adopt the CE, the economic benefits achieved, the principal challenges faced, the changes, collaborations and the sources of financing needed to make the shift.
The questions concerning the Industry 4.0 regard the type of technologies used and the impact of the industry 4.0 in the adoption of the circular economy model. We wanted to verify if some circular firms in the sample adopted 4.0 technologies and how this affected the adoption and implementation of CE practices.
Finally, in the last section the respondents were asked about the industry, the number of employees in different functions, the turnover, the export, the expense in R&D and in circular economy and the evolution of certain indicators as ROI, export, employment and market share.
Some questions have multiple choices and respondents were asked to select the options from a given list. Other questions have an open-ended nature and respondents were asked to provide an explanation in their own words. Finally, a group of questions has an integer scale of evaluation from 1 to 5 representing the frequency or the importance of various events, where 1 indicates that the frequency or the importance is very low and 5 indicates that the frequency or the importance is very high.
We chose to send the questionnaire by email to all the firms of the sample so that they could take vision of the questions and have the time to search for the requested information. Then,

we scheduled an appointment with the respondents to conduct the interviews by telephone. Each phone interview lasted about 20/25 minutes.

2.1.4 STATISTICAL MODELS

We used descriptive statistics to present the data collected through the interviews in a meaningful way both numerically and graphically. Histograms and pie charts have been used to obtain a visual presentation of the parameters. We used descriptive statistics also to evaluate and interpret the data in order to answer the first two research questions:

(1) Which are the opportunities the Italian manufacturing firms achieve?

(2) Which are the challenges they face?

Next, we used analysis of variance, the ANOVA test, to answer the third question:

(3) Which is the relationship between firm size and circular engagement?

Through the ANOVA test we compared the challenges and the opportunities for three different-sized groupings. We categorized the sample firms according to firm size in: micro, small and medium/large firms. Then, we performed the one-way ANOVA test to examine the relationship among the three different-sized groupings and each of the challenges and opportunities. The purpose of this further analysis was to understand whether micro firms benefit less and face more challenges when engage in circular practices than small and medium/large firms.

The ANOVA test compares the means of the three different-sized groupings to determine whether those means are statistically different from each other. Specifically it tests the following hypothesis:

$$\text{The null hypothesis: } H_0 = \mu_1 = \mu_2 = \mu_3$$

It means that there is no difference between groups and there is equality between means.

To understand whether the null hypothesis should be rejected or not we consider both the P value and the F ratio.

P value tests the null hypothesis that all the three groupings have equal means. If the overall P value is large, the data do not give us any reason to conclude that the means differ and therefore we cannot reject the null hypothesis. Instead, if the overall P value is small we can reject the null hypothesis. To test the null hypothesis we compare the p value with different alpha levels. In our study we use three different alpha levels: 1%, 5% and 10%. We reject the null hypothesis when p value is smaller than the alpha level.

F ratio is the ratio of two mean square values. Precisely it is calculated as follows:

$$\text{F ratio} = \frac{MS_{between}}{MS_{within}}$$

Where: $MS_{between} = \frac{SS_{between}}{df_{between}}$ and $MS_{within} = \frac{SS_{within}}{df_{within}}$

Mean square is computed by dividing the sum-of-squares by the appropriate number of degrees of freedom. $MS_{between}$ is the population variance plus a variance produced from the differences between the groups. MS_{within} is the population variance.

If the null hypothesis is true the F ratio has a value close to 1 since $MS_{between}$ and MS_{within} estimate the same value. If the null hypothesis is false, $MS_{between}$ is larger than MS_{within} and the F ratio will be larger than 1. The F ratio then will be compared with the F critical value that can be found in the F distribution Table. It tells where the null hypothesis must be accepted and when it must be rejected for each alpha level. Since the ANOVA hypothesis test is right-tailed, we reject the null hypothesis when F ratio is larger than 1 and larger than the F critical value (Illowski, 2013).

Chapter 3

OPPORTUNITIES AND CHALLENGES FOR THE ITALIAN MANUFACTURING INDUSTRY

3.1 FINDINGS

In this Chapter the data obtained through the interviews are described and interpreted.

3.1.1 STRUCTURE OF THE SAMPLE

The sample is heterogeneous and characterized by firms different in location, size, economic sector, degree of internationalization and R&D.
Considering the region where is located the registered office, we found that our sample of firms is spread across Italy with a major concentration in Lombardia, Veneto, Emilia Romagna, Lazio and Toscana. The 30% of the sample is located in the Northeast, the 23% in the Northwest, the 25% in Central Italy, the 13% in the South and the 9% in the Islands. Table 6 and Figure 10 give a clear picture of the location of the sample.

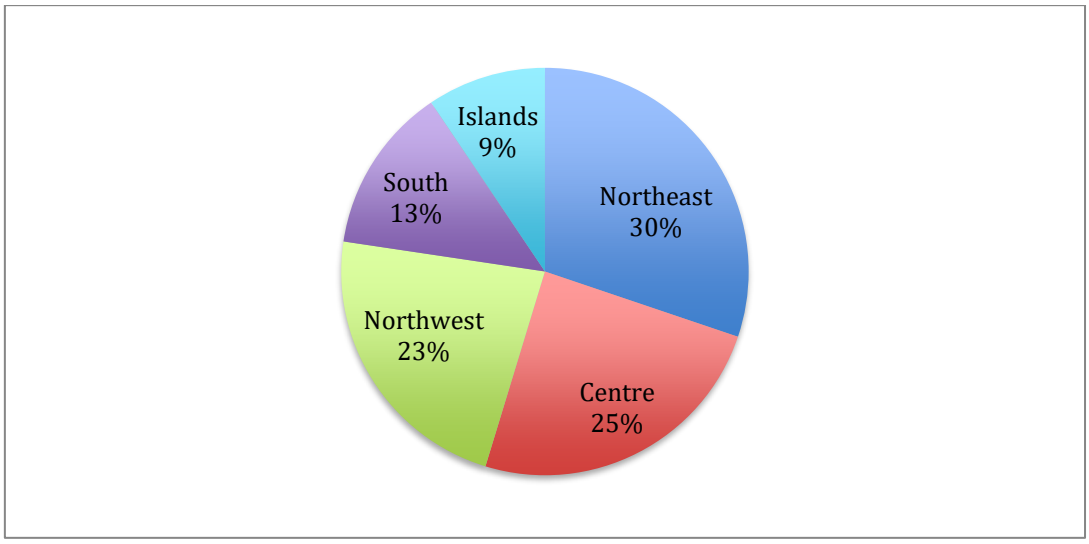
Table 6: The location of the sample

Region of Origin	Frequency
Lombardia	9
Veneto	7
Emilia Romagna	7
Lazio	6
Toscana	5
Sicilia	3
Basilicata	2
Calabria	2
Piemonte	2
Trentino Alto Adige	2
Sardegna	2

Umbria	2
Campania	1
Liguria	1
Molise	1
Puglia	1
TOT	53

Source: Personal elaboration

Figure 10: The location of the sample



Source: Personal elaboration

According to the *size of the firm* as defined by the European Commission, our sample is constituted by 43% micro firms, 33% small firms, 14% medium firms and finally 10% large firms.

The European Commission (2003) defines the SMEs as '*enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.'*

In particular:

- Small enterprise is defined *'as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million.'*
- Micro enterprise is defined '*as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.'*

Following these definitions we can classify our sample as follows:

Table 7: The size of the sample

Size of the firm	Frequency
Micro (< 10 employees)	21
Small (< 50 employees)	16
Medium (< 250 employees)	7
Large (> 250 employees)	5
Not responding	4
TOT	53

Source: Personal elaboration

Some firms chose not to answer all the questions of the interview and therefore for 4 of them we cannot assess their size due to the lack of information.

The respondent firms represent a variety of industries with large concentration in green building, green textiles and ecological chemistry. Among the other activities, the main business is the manufacturing of secondary raw materials through the treatment and processing of municipal waste or industrial scraps.
Table 8 provides the industrial breakdown of our sample.

Table 8: Industrial breakdown of the sample

Industry type	Frequency
Stone, clay, glass, plastics	16
Textiles, wearing apparel, leather	9
Chemicals	5
Wood, wood products	5
Food, beverage	4
Paper, paper products, printing	4
Fabricated metal, machinery, equipment	3
Other activities	7
TOT	53

Source: Personal elaboration

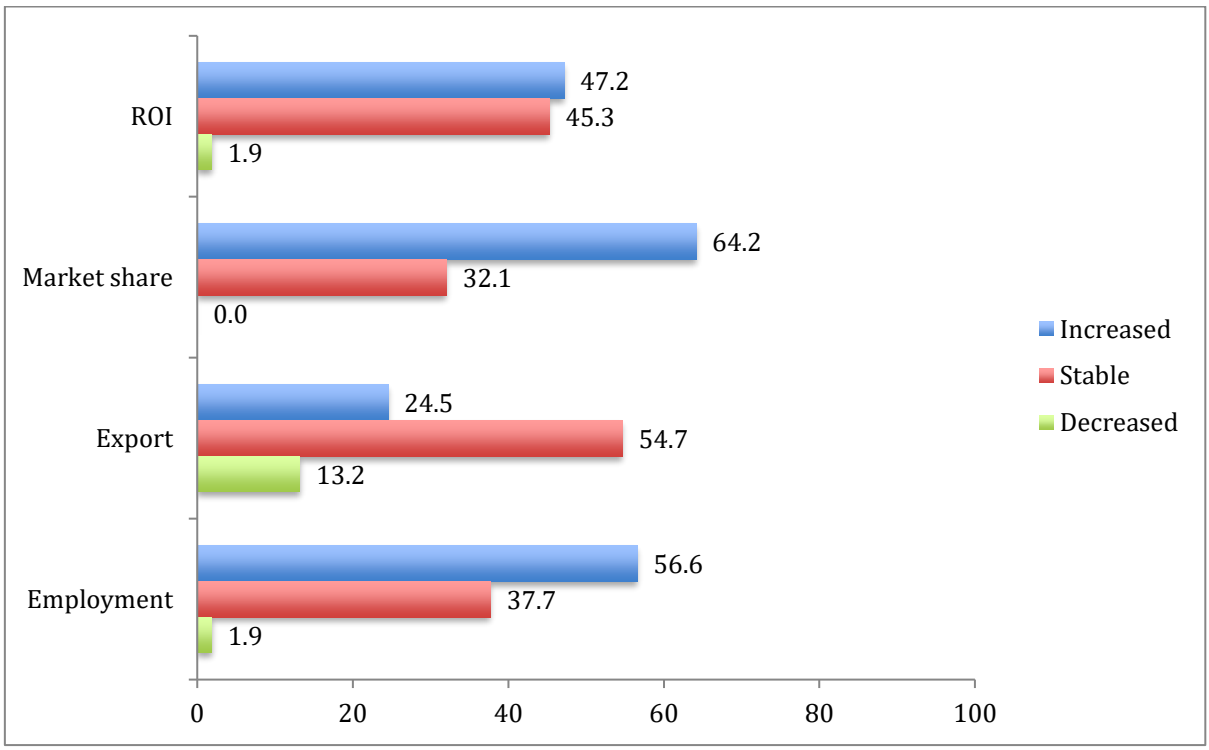
Analyzing the degree of internationalization, we found that the 36% of the sample firms are exporting abroad, especially inside the EU, and the principal target markets are France, Germany, Austria and Belgium. Instead, the level of internationalization in production is

lower since only the 11% of the sample firms have located abroad their production sites. The majority has the production located in the region of origin (60%) or spread across Italy (29%). The 91% produces finished goods and the 9% components or byproducts. Among the firms that produce finished goods, the majority works in the B2C business.

Analyzing the expenditure in R&D, we observed that the 60% of the firms invested in R&D in 2017 employing in average the 12,3% of their annual income. We found that the amount of internal resources destined to R&D varies enormously among the sample firms with a minimum of 1% of the income to a maximum of 80% of the income generated in 2017.

Finally we considered the evolution of four indicators – ROI, market share, export and employment – for a period of three years from 2015 to 2017 to verify the performance of these firms (Figure 11). We noticed that the majority of the sample firms have grown up in the last three years increasing their profitability, market share and jobs, while the level of export has remained stable.

Figure 11: The evolution of principal indicators in the period 2015-2017



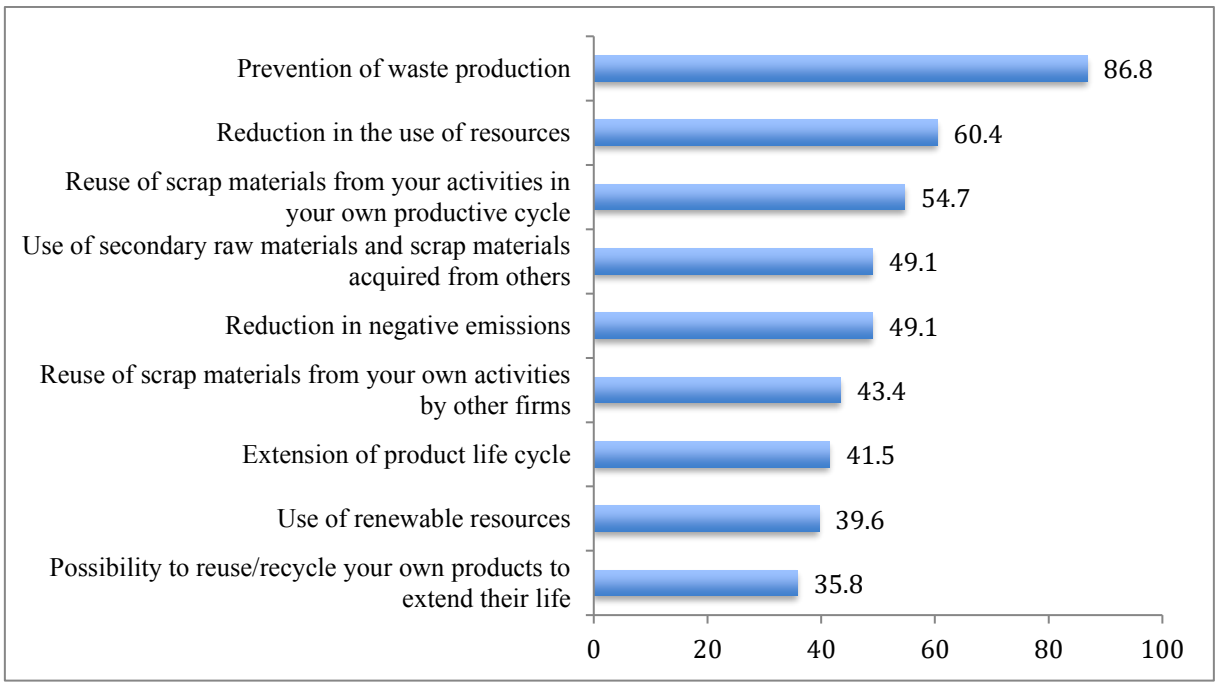
Source: Personal elaboration

3.1.2 CIRCULAR ECONOMY PRACTICES & BUSINESS MODELS

The first question asks the managers which circular activities their firms perform. Figure 12 illustrates the responses of the sample.

The literature defines the circular economy as a model conceived to reduce waste, pollutants and consumption of resources and energy, to increase share of renewable and recyclable materials and to keep the value of products, components and materials in the economy through reuse, refurbishment, remanufacturing, cascading and recycling (EEA, 2016; Ellen MacArthur Foundation, 2012; Vanner, 2014; Murray, 2015; Kirchherr, 2017; Webster, 2015).
From our analysis, we found that the prevailing CE activities performed by the sample firms are: (1) prevention of waste, (2) reduction in the use of resources, (3) reuse of their own scraps and (4) acquisition of secondary raw materials, byproducts and scraps from other firms even in different and not related sectors.
The Circular Economy for the sample firms is above all prevention of waste and reduction of resources. Moreover, the CE has opened new untapped opportunities in the market of byproducts and secondary raw materials. The 54,7% of respondents has confirmed to reuse the scrap materials in the production process, the 49,1% has reported to acquire secondary raw materials from other companies and the 43,4% to supply secondary raw materials to other companies in the same or in other industries. The exchange of byproducts has become very popular in the Italian context and has contributed to dissolve the boundaries among the industries and to create industrial networks and strategic collaborations in order to facilitate the transaction.
On the contrary, the extension of product life cycle and the use of renewable resources and energy sources are not yet fully embedded within the firms' organizational strategies.

Figure 12: Circular activities performed by the sample



Source: Personal elaboration

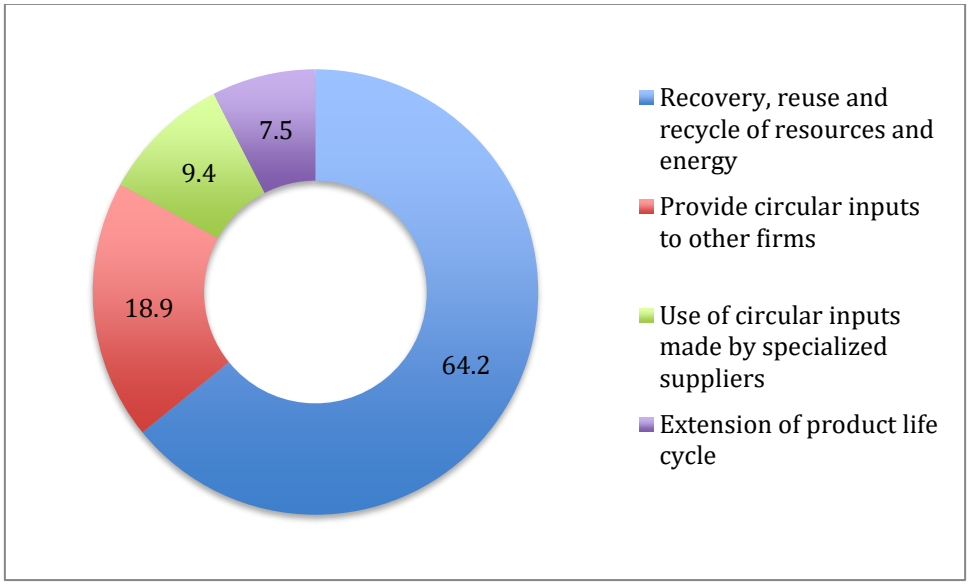
Following, we asked the respondents which is the prevailing circular business model in their firms (Figure 13).

Accenture (2014) has identified 5 major circular business models: Circular supplies, Resource recovery, Product life extension, Sharing platform and Product as a service.

In our research, we note that the majority of firms (64,2%) have a Resource Recovery business model. This model aims at transforming waste into value through cradle-to-cradle design, industrial symbiosis and closed loops recycling (Accenture, 2014). As showed above (Figure 12), the prerogative for the sample firms is the prevention of waste and the reduction in the use of resources. To obtain these results, the majority of them choose a resource recovery business model.

Further, the 18,9% of the sample firms adopts a Circular Supply business model with the aim to provide biodegradable, renewable and recyclable resources to other firms (Accenture, 2014). This result is in line with the findings in Figure 12 where the majority of the respondents have confirmed to use, acquire or supply byproducts and secondary raw materials in order to replace the virgin ones. Instead, the Product Life Extension business model is used only by the 7,5% of the respondents.

Figure 13: The circular business model



Source: Personal elaboration

Successively, respondents are asked to specify how much in their production inputs derives from recycled, renewable, reused and non-renewable materials (Figure 14). And how much from the scraps of production is sent to recycle, reuse or becomes waste (Figure 15). The sum must be 100. We report the overall mean of the answers. From the figures below it is clear

that recycling is the most popular CE practice among Italian manufacturing SMEs. 33,8% of production inputs come from recycled materials and 57,7% of scraps from production are sent to recycle. 27,5% of productive inputs derives from renewable materials and 19,7% from non-renewable materials. 21,6% of scraps are reintroduced and reused in the production process or sent to other firms as byproducts, and 20,7% of scraps become waste.

As we can see from Figure 15, the practice of reuse is not yet fully consolidated and the percentage of waste sent to landfills and incinerators is still high.

Figure 14: The source of the productive inputs

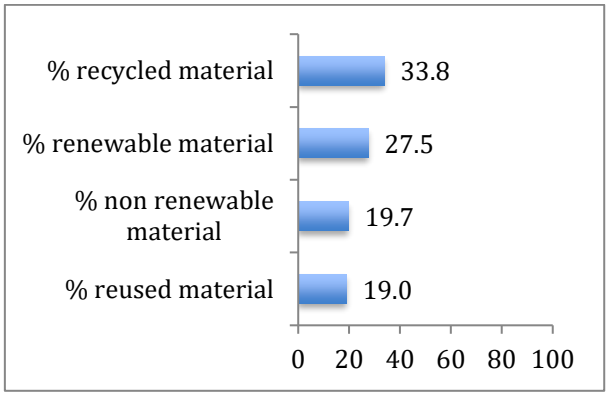
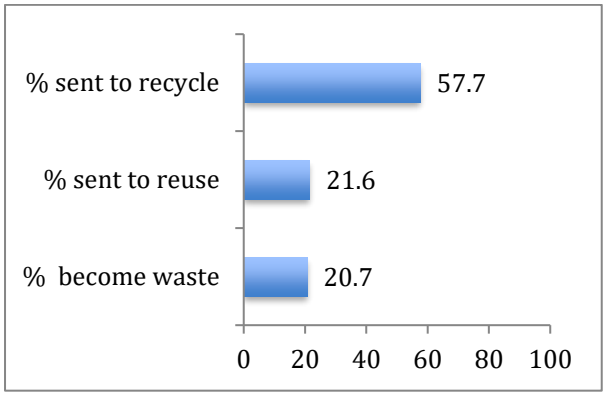


Figure 15: The destination of the manufacturing scraps



Source: Personal elaboration

On the energy front (Figure 16 - 17), the fossil sources are widely used by the sample firms, with the majority of them continuing to acquire energy from fossil fuels suppliers. The firms that use renewable energy constitute only the 21,2% of the sample firms with regard to the electrical energy, and the 13,4% of the sample firms for the thermic energy. The firms that self-produce their own energy have declared that they can do that only for a very limited amount that is not sufficient to cover their daily needs and therefore they are forced to draw on fossil sources. Among the firms that self-produce energy, the majority use photovoltaic panels. The energy transition towards circular economy seems to be a step backwards compared to other sectors and the use of renewable sources is not fully consolidated within the industrial system. To permit the transition towards the circular economy it is necessary to shift to completely renewable sources (Accenture, 2018).

Figure 16: The source of input electrical energy

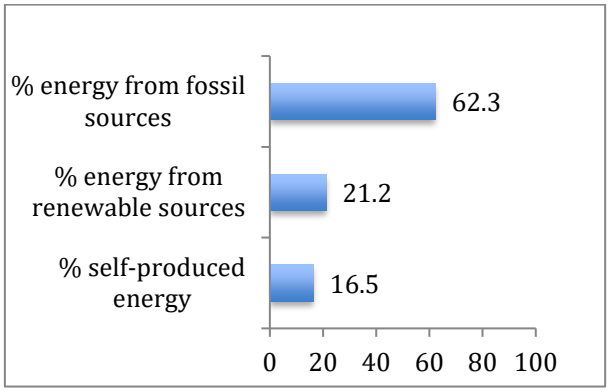
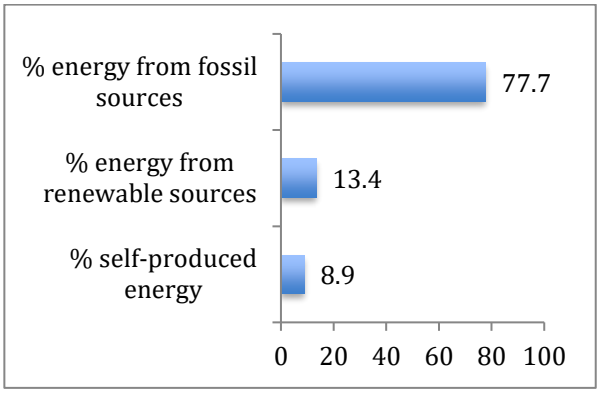


Figure 17: The source of input thermic energy



Source: Personal elaboration

3.1.3 MAIN MOTIVES & OPPORTUNITIES TO ADOPT CIRCULAR ECONOMY

Adopting circular economy practices may be a source of opportunity, value and competitive advantage (Babiak, 2011; Battisti, 2011).

Respondents were asked to rate the motives from the list on a Likert scale from 1 (not important) to 5 (very important). We consider positive a response of 4 or 5 and we report in Figure 18 only the percentages of respondents who gave positive responses.

The literature on corporate social responsibility (CSR) has identified the different motives to engage in socially and environmentally responsible behaviors. Firms may be values-driven and therefore having altruistic intensions and engage in CSR because they think it is the right thing to do. Firms may be stakeholders-driven and engage in CSR to respond to external stakeholders' pressure. Or they may be performance-driven and pursue CSR initiatives to obtain economic benefits (Ellen, 2006). Firms may participate to CSR to recruit, motivate and retain employees, to attract customers, to reduce production costs, to reduce business risks, to attract suppliers or to attract capital from investors (Sprinkle, 2010). They aim also at enhancing legitimacy and reputation, obtaining cost advantages, obtaining a competitive advantage based on a strategy of low cost or differentiation, having access to critical resources and building networks and long-lasting relationship with various stakeholders. Moreover, firms with different size may have different motivations (Udayasankar, 2007; Springle, 2010).

In our sample, the first reason to perform circular activities is to improve business ethics and social responsibility. The 86,8% of respondents would like to obtain reputational and legitimacy benefits.

Following, 77,4% of respondents has adopted circular economy practices to enhance the value of their products. In fact, circular activities add perceived value to the firm's products and as a

consequence customers may prefer the firm's products and may be willing to pay a premium price (Udayasankar, 2007).

The 67,9% has invested in circular economy to expand in new markets and the 54,7% to overcome the competitors in the existing market. Many firms initiate circular activities to gain a competitive advantage through a strategy of low cost or differentiation. The type of strategy pursued largely depend on the size of the firm, with large firms engaging in low cost strategies and small firms differentiating their products among different customers' segments. Circular activities can help firms to increase their competitiveness (Udayasankar, 2007).

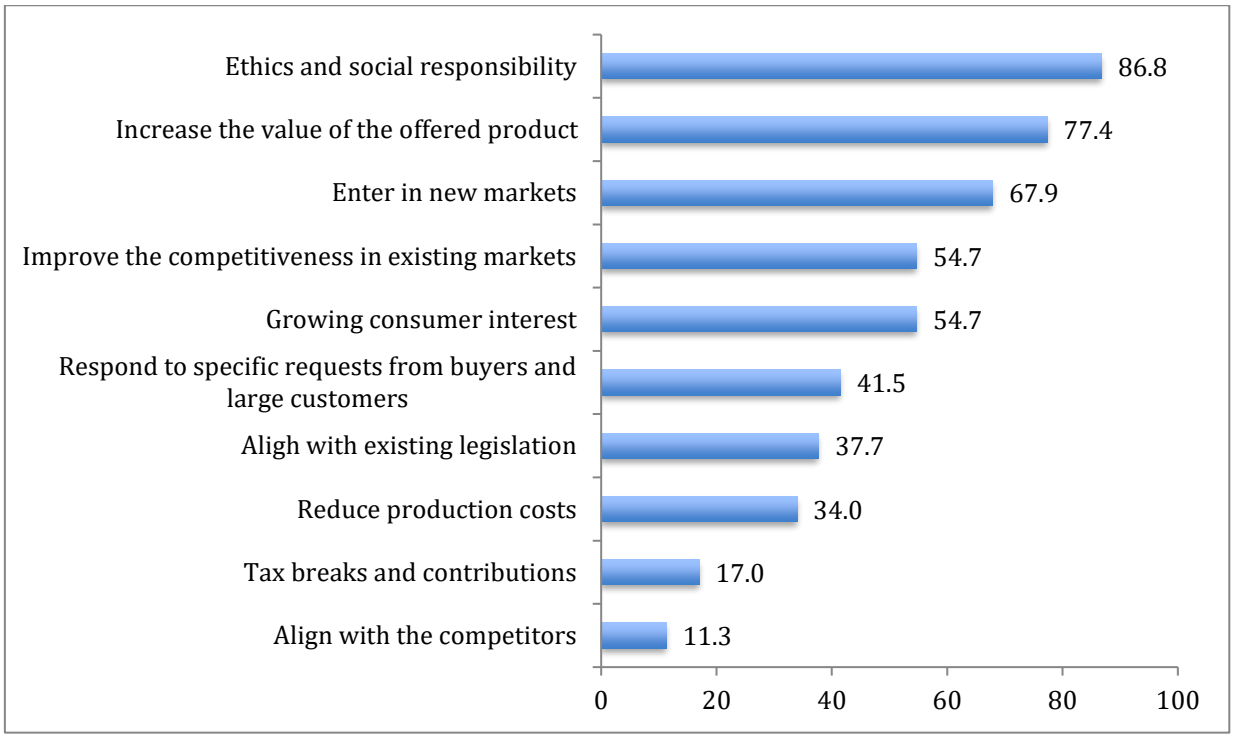
Instead, the 54,7% of respondents has declared that it has been necessary to shift to circular activities in order to satisfy the growing interest of customers that are more careful to the origin and the material composition of the products, and to respond to the requests of suppliers and other important economic actors (41,5%). Therefore some firms are stakeholders-driven and try conforming to the external pressures and expectations of a wider set of stakeholders. These firms perceive that the customers are changing their expectations and interests towards more sustainable products and they are moving to satisfy this new demand. They are engaging in circular activities to acquire and retain new customers and to build with them mutually beneficial and long-term relationships. Some firms (41,5%) are facing the pressure from large buyers/clients that encourage their suppliers (the Italian firms) to implement circular practices and obtain environmental certifications.

In general, we notice that many respondents have proven to be confident and optimistic towards the market and the customers. Whereas the literature states that the customers are resistant to change and do not constitute a proper incentive for firms to take action towards circular economy (Kirchherr, 2017; Planing, 2015).

Only the 37,7% of firms is driven by regulatory compliance concerns. Regulation is not the main factor to drive circular practices since the actual legislation is still inadequate and contradictory. Finally, the 34% is mainly driven by cost-reduction purposes, the 17% by tax motives and the 11% wants to align with the competitors.

Moreover, by categorizing the motives from Figure 18 following the classification of Ellen (2006) of performance-driven and stakeholders-driven motives, we discovered that the sample firms are mostly performance driven with an average score of 3.3 on the Likert scale from 1 to 5 against the 2.8 average score of the stakeholders-driven motives. Therefore, the sample firms have mainly a proactive approach rather than a reactive approach and engage in circular practices primarily to obtain economic benefits and increase competitiveness. The results of this analysis are visible in Table 9.

Figure 18: Motives to adopt circular economy practices



Source: Personal elaboration

Table 9: Motives to adopt circular economy practices

	TOT
PERFORMANCE DRIVEN	3,3
of which:	
Increased value of products	4,2
Entry in new markets	4,0
Improved competitiveness in existing markets	3,6
Reduced production costs	2,7
Tax breaks and contributions	2,0
STAKEHOLDERS DRIVEN	2,8
of which:	
Growing consumer interest	3,5
Specific requests from buyers and large customers	2,8
Alignment with legislation	2,9
Alignment with competitors	2,0

Source: Personal elaboration. Note: Values are means scores.

Many of the benefits of circular economy mirror the motives to engage in socially and environmentally responsible practices.

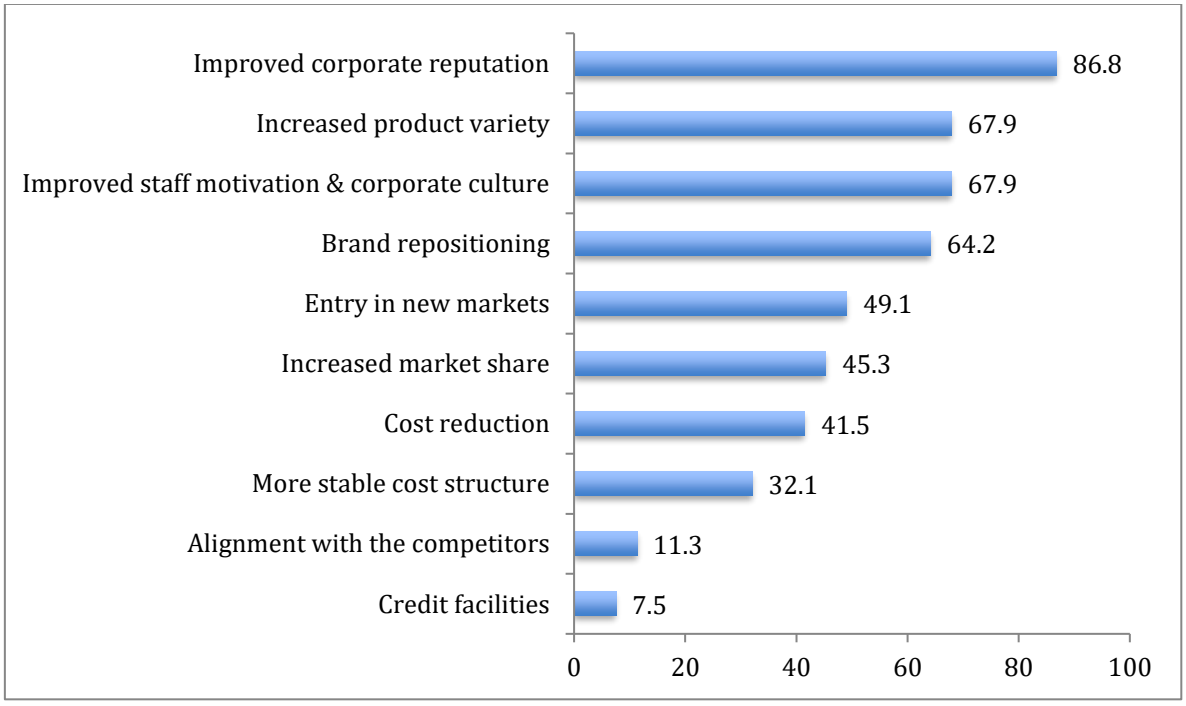
The majority of respondents (86,6%) have achieved improvements in corporate reputation.

Following, firms have registered an increase in product variety (67,9%) and improvements in staff motivation and in the corporate culture (67,9%).

Other benefits have been brand repositioning, entry in new markets and increased market share. On the cost side, the respondents have registered cost savings and cost structure stability. These effects on costs are the consequences of reductions in the use of resources, energy and waste generation and reduced exposure to the risk of price volatility and supply uncertainty (Ellen MacArthur Foundation, 2015; EEA, 2016).

Few firms have aligned with the competitors or have obtained credit facilities.

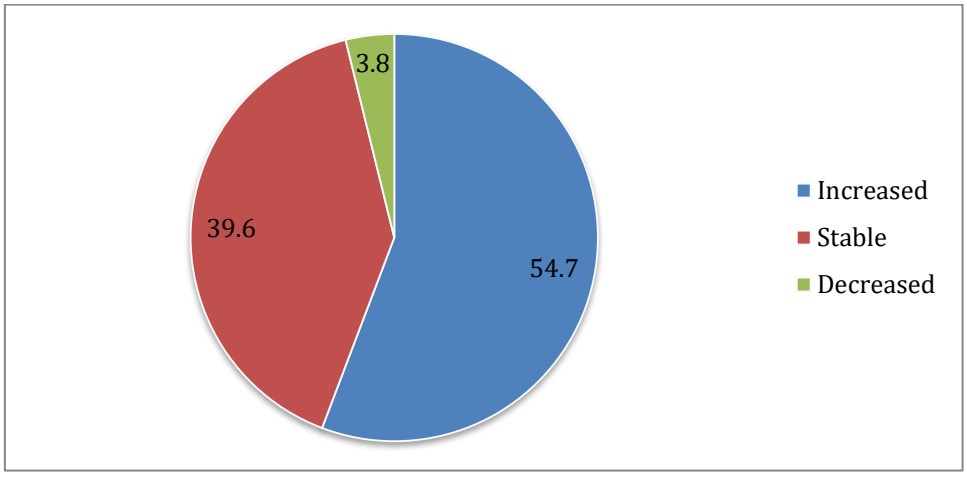
Figure 19: Main opportunities of circular economy in Italy



Source: Personal elaboration

Moreover, we asked which has been the effect of circular economy on the employment in 2017. The literature estimates that the circular economy offers new job opportunities (Ellen MacArthur Foundation, 2015; EEA, 2016). This is confirmed by our analysis. From Figure 20 we see that the employment has increased for the 54,7% of firms and has remained stable for the 39,6%. The impact of the circular economy on the employment has proven to be very positive with new jobs related to reuse, repair or recycling.

Figure 20: The impact of circular business model on the employment



Source: Personal elaboration

3.1.4 MAIN CHALLENGES

The literature on circular economy has highlighted 4 major categories of barriers to circular economy transition: cultural, regulatory, market and technological barriers (Kirchherr, 2017; Rizos, 2015; Vanner, 2014; de Jesus, 2018; Preston, 2012). These barriers largely depend on specific local conditions (de Jesus, 2018).

Within the Italian context, the regulatory framework and the market are the main challenges to the environmental implementation. On the market side, the main impediments for Italian firms are the lack of risk capital and public funding and the low prices of linear products that do not reflect the environmental costs. On the regulatory side, the main barriers to the Italian firms are caused by inadequate legislation and low level of environmental procurement caused by the high decentralization of the governance system, the lack of coordination among local, regional and national authorities, the lack of transparency and control over the administrative activities and insufficient compliance assurance mechanisms over the application of the EU directives (European Commission, 2017).

In line with the literature, our analysis reveals that the main challenges to the CE transition come from the legislation and the market (Figure 21).

The major challenge is the inadequate and contradictory legislation. Italy meets many problems in the implementation of EU environmental legislation due to the low level of governance effectiveness.

At the second and third position we find market barriers. The second barrier is the high price of circular products. The current prices of circular products are higher than those of linear

products and this creates economic signals that do not encourage the adoption of CE practices. The externalities of the linear productive model (pollution, resource use etc.) are not internalized in the price of products and there is still the presence of environmental harmful subsidies that confer advantages to companies with great environmental impact (Vanner, 2014; European Commission, 2017).

The lack of capital is the third obstacle for the sample firms. This is mainly caused by the scarcity of public financing and the limited access to other financial sources for the creation and continuation of CE projects (International Environment House, 2017). As we can see from Figure 22, 83% of firms use equity to finance investments in R&D and circular economy. 39,6% of firms have access to bank financing, whereas only the 18,9% receives European funds and only the 15,1% obtains regional funds. Italian firms have to rely on their internal sources as primary way of financing since it is quite hard to obtain finances through other sources such as venture capital, business angels or crowd-funding, which are not common in our market. Crowd-funding has been used only by the 3,8% of the sample. Banks, that are the principal source of external financing for the Italian entrepreneurial system, are reluctant to finance SMEs especially when they are risky businesses, or businesses that cannot give adequate collaterals (European Commission, 2017; International Environment House, 2017).

Following, cultural barriers figure in fourth, fifth and eighth position. The literature has identified the importance of the networks between different economic actors as a critical determinant to spread the circular economy. To close the loops, companies should exchange and share resources, byproducts and energy. To adopt CE business models they should share knowledge and best practices. It means also to adjust their operations and reorganize the supply chain choosing circular suppliers and sustainable materials. But this is not possible if there is an atmosphere of fear and mistrust towards the other economic actors (Chertow, 2000; Preston, 2012; Kirchherr, 2017). Italian companies are still reluctant to share their know how and experience, that give them a competitive advantage, to help other businesses to make the shift. Some efforts will be necessary to convince these firms to share their case studies. As a consequence, this provokes lack of knowledge and information about circular economy. The surveyed firms have already started the transition but some of them do not know how to find circular suppliers, how to identify the right distribution channels, how to reorganize their value chain.

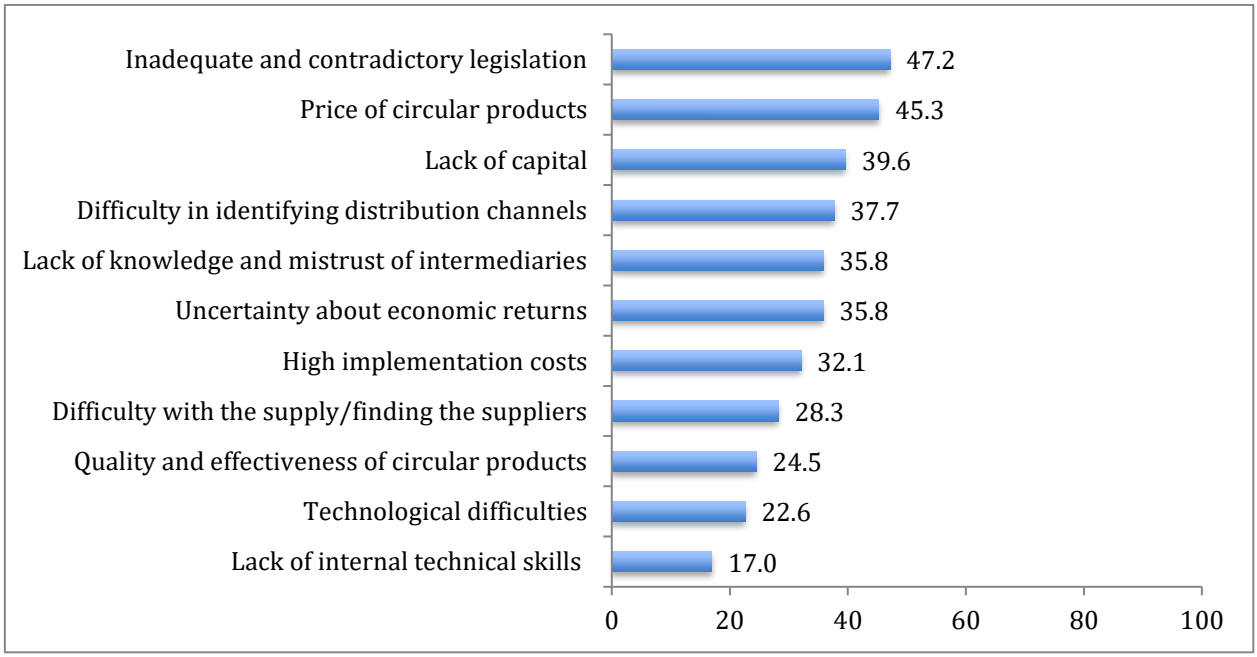
The uncertainty about economic returns is at the sixth place with 35,8% of respondents being afraid of the uncertainty of their investments. Even if the majority of the respondents have proven to be optimistic and confident about the reactions of the market and the economic

actors, there is a 35,8% of respondents who fears that the market is not ready to accept the circular products, that they cannot win the competition of linear products, that the customers do not change their consumerist habits and mindsets, that the other economic actors are not willing to collaborate.

High implementation costs are another significant market challenge for the Italian firms. This sample is constituted by firms that have already overcome the burden of high upfront investment costs identified as one of the main market barriers by the literature (Kirchherr, 2017; Rizos, 2015; Preston, 2012). Despite the overcoming of the initial financial difficulties, 32% of these firms find difficult to address the high implementation costs. Without the public support and innovative forms of financing, Italian firms will have many troubles in continuing the transition.

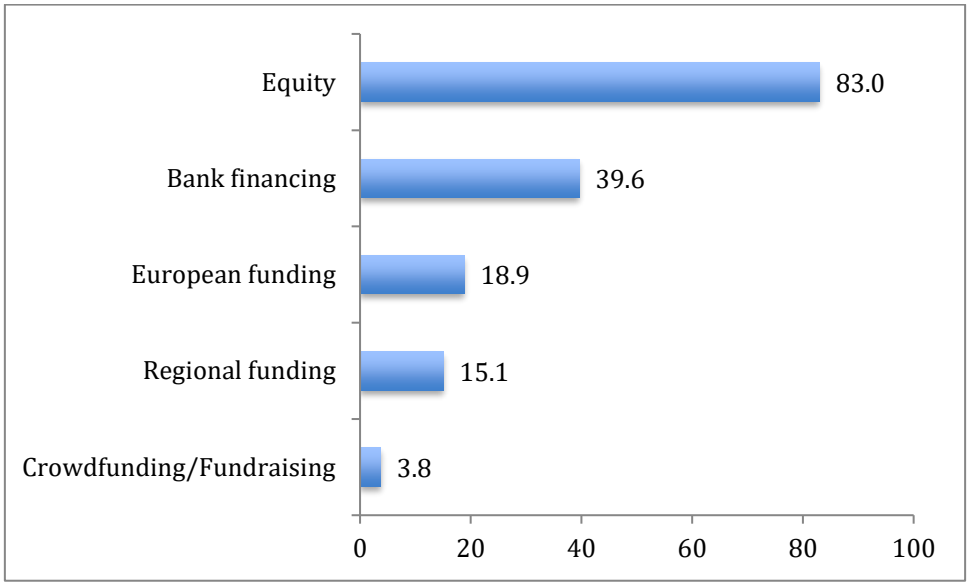
The technological barriers are at the end of the chart. Therefore Italian firms encounter little difficulty in improving the quality and effectiveness of their products (24,5%), in developing new technologies and infrastructures (22,6%) and in updating/acquiring new technical skills (17%). Italian industrial system is dominated by SMEs, which represent the 99,8% of the firms and that are strongly committed to innovation and R&D activities to grow and preserve their competitiveness (Abel-Koch, 2015).

Figure 21: Main challenges in the adoption of circular economy in Italy



Source: Personal elaboration

Figure 22: The main sources of financing to support circular economy investments



Source: Personal elaboration

3.1.5 MAIN CHANGES TO PRIMARY AND SUPPORT ACTIVITIES

The firms adopting circular business models need to reorganize their primary and support activities. The characteristics of the circular products directly affect the way the value chain is constructed and managed. (De Ios Rios, 2017)

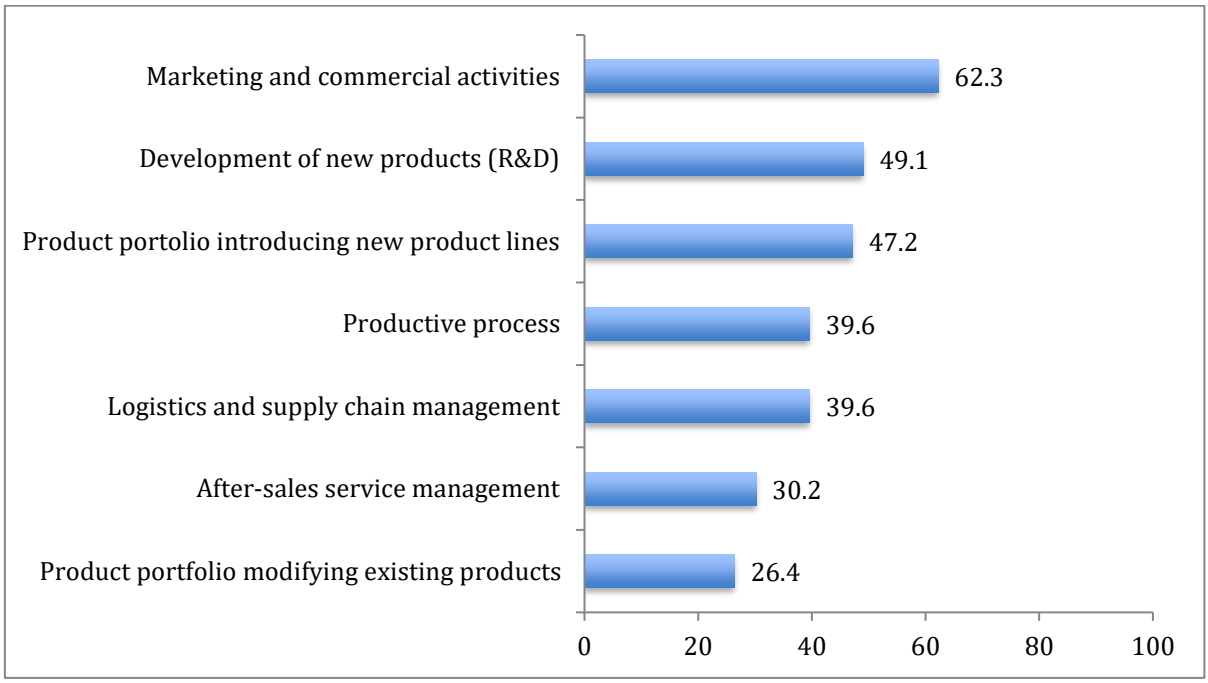
From Figure 23 we notice that changing the business model implies above all changes in marketing and commercial activities for the 62% of companies. There is need to develop consumer awareness on the new circular products. For green products there is a problem of information because it is very difficult for the consumer to assess the environmental friendliness of a product even after the purchase (Rex, 2007; De Marchi, 2012). Therefore, there is need to transmit this information to the customers through green marketing campaigns.

Next, it has been necessary to invest in R&D to develop new circular products (49,1%). Circular products require knowledge and skills that the traditional firms do not possess. Companies must develop new knowledge and capabilities to operate in a sustainable way and therefore they invest in R&D and engage in strategic collaborations with various stakeholders (De Ios Rios 2017; Geffen and Rothenberg, 2000). Moreover, many firms have introduced new product lines in the product portfolio (47%). Circular economy is a mean for the firms to pursue differentiation strategies and stay competitive in the marketplace (Udayasankar, 2007).

For the 39% of firms has been necessary to change the productive process, the logistics and the supply chain. Firms have adopted green supply chain management practices as green

design, green procurement, green production and green logistics. The production processes has been implemented to guarantee low energy consumption, reduction of waste and environmental impact. Many firms have obtained the ISO14001 certification to attest the respect of environmental standards in their productive process. Also logistics has been adapted to the new paradigm including green packaging and reverse logistics (Ying, 2012).
In the 30% of cases it is changed the after-sale service and in the 26% of cases the existing products have been modified to conform to circular standards.

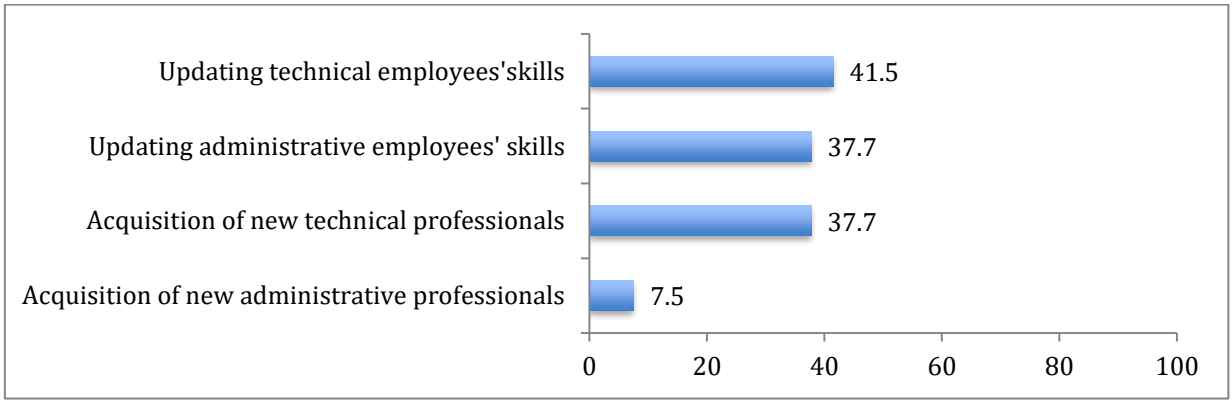
Figure 23: Main changes to primary and support activities



Source: Personal elaboration

Adopting circular economy practices requires peculiar skills that are not in the traditional knowledge base of the firm. Therefore, many firms have introduced training courses to update the competences of the existing workforce or have hired new experts. It has been necessary the updating of the technical personnel for the 41,5% of the firms. The 37,7% has hired new technical professionals as consultants, environmental engineers and industry-specific technicians since they did not have the right know-how to start the transition. The updating of the administrative personnel has been necessary for the 37,7% of the sample whereas only the 7% hired new administrative employees (Figure 24).

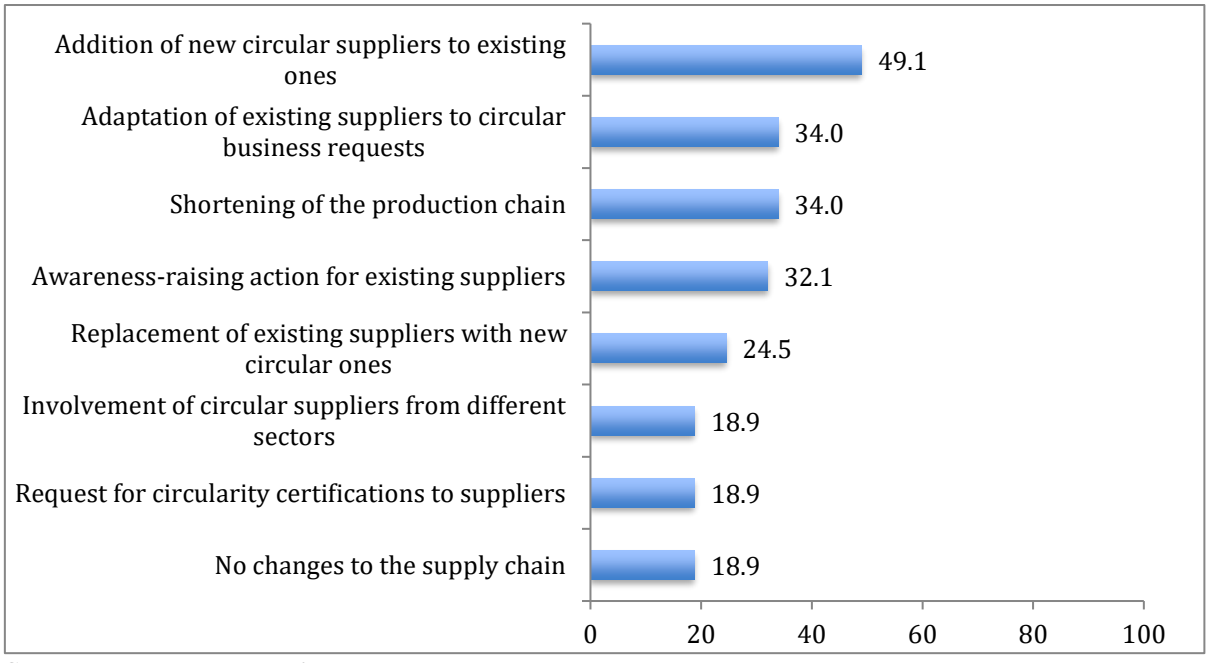
Figure 24: Personnel changes to adopt circular economy practices



Source: Personal elaboration

On the supply side, the Italian firms search for new suppliers that respect circular and quality standards. Suppliers are a source of expertise, and strong relationships with them can increase the ability of a manufacturing firm to access and utilize new external knowledge (Geffen and Rothenberg, 2000). Moreover, cooperation with suppliers is critical to verify that the suppliers fulfill the environmental requirements and supply eco-friendly inputs and components (De Marchi, 2012). The majority adds circular suppliers to the existing ones (49,1%). The 34% of the firms involves the existing suppliers in circular practices. Many have the aim of extending circular virtuosity to all their stakeholders. The 34% has shortened the production chain to reduce waste generation and resource use and to minimize the environmental impact. The 32% is committed to awareness-raising actions and the 24,5% replaces the existing suppliers with new circular ones. Some firms request environmental certifications to their suppliers.

Figure 25: Changes in the supply chain

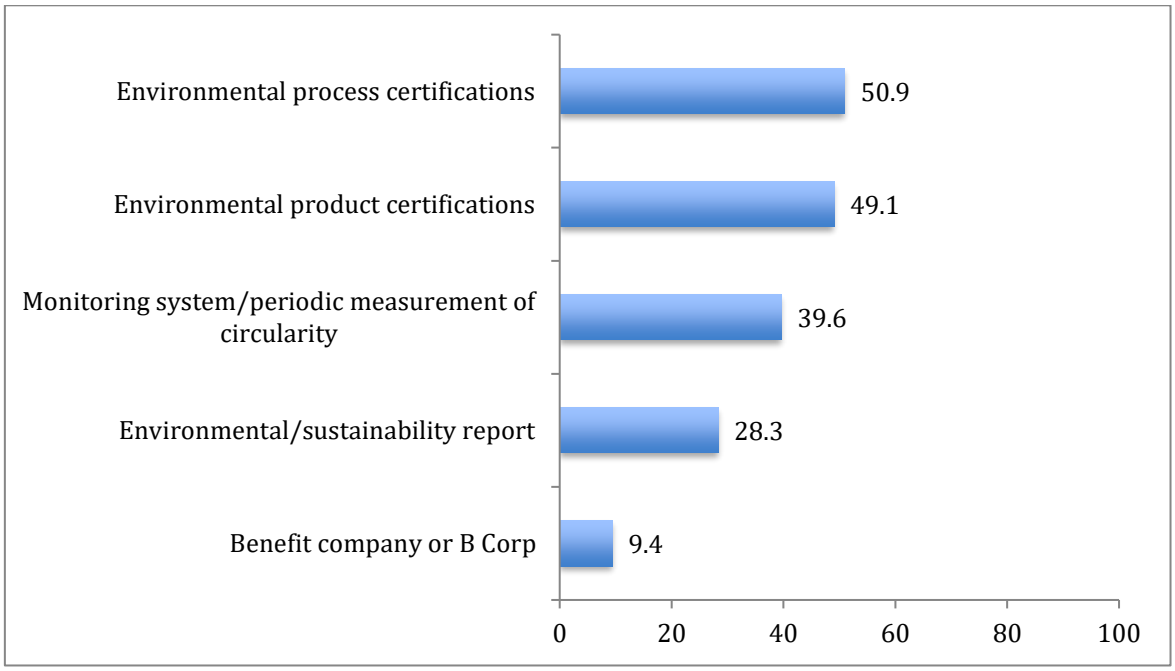


Source: Personal elaboration

Italian firms have environmental process and product certifications (Figure 26). These firms voluntarily choose to obtain environmental certifications to ensure the final consumers that they meet environmental standards. The majority has ISO9001, ISO14001 and OHSAS 18001 certifications, which assess respectively the effectiveness of the environmental management system, the quality management system and the health and safety within the workplace. The certifications are needed since for green products there is a problem of information and it is very difficult for the consumer to assess the environmental friendliness of product even after the purchase (Rex, 2007; De Marchi, 2012).

Some firms have systems to monitor the circularity and others are investing in new technologies to increase material traceability and accountability. Only the 28,3% prepares a sustainability budget and very few firms are Benefit companies or have obtained the B Corp certification.

Figure 26: Environmental accountability and certifications



Source: Personal elaboration

Italian circular firms collaborate with external professionals (Figure 27). The internal and traditional know-how and skills are not sufficient to implement the circular practices. They develop strategic relationships with circular material suppliers, universities and public bodies as research institutions and consultants. Suppliers are a source of expertise, and strong relationships with them can increase the ability of a manufacturing firm to access and utilize new external knowledge (Geffen and Rothenberg, 2000). Cooperation with research institutes and universities is important to access specialist technical support, to obtain information on

the emerging technologies and to complement internal R&D. Cooperation with consultants provides applied knowledge and specialist skills and information (Tether, 2002).

Many respondents have declared that the strategic collaboration with these bodies has been essential to face the technological burdens of the circular economy.

Figure 27: Strategic collaborations to adopt circular economy practices

Source: Personal elaboration

3.1.6 INCIDENCE OF INDUSTRY 4.0 TECHNOLOGIES IN CIRCULAR ECONOMY IMPLEMENTATION

Our survey was principally focused on the opportunities that motivate the Italian firms to participate to the circular activities and on the challenges that hinder their participation. However, we added in the interview few questions concerning the Industry 4.0 to understand whether the Italian circular firms have invested also in 4.0 technologies and whether these technologies can enable more circular behaviours.

Among the sample firms only the 28,3% of them has invested in 4.0 technologies (Figure 28). Of this 28,3%, the majority has chosen big data (53,3%), robotics (33,3%), additive manufacturing and Internet of things (26,7%) as we can see from Figure 29.

Figure 28: Firms adopting 4.0 technologies

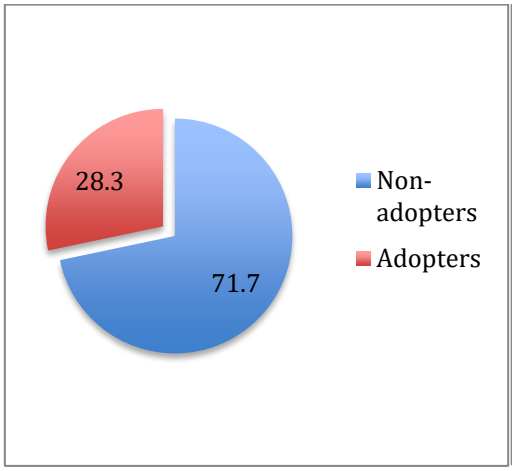
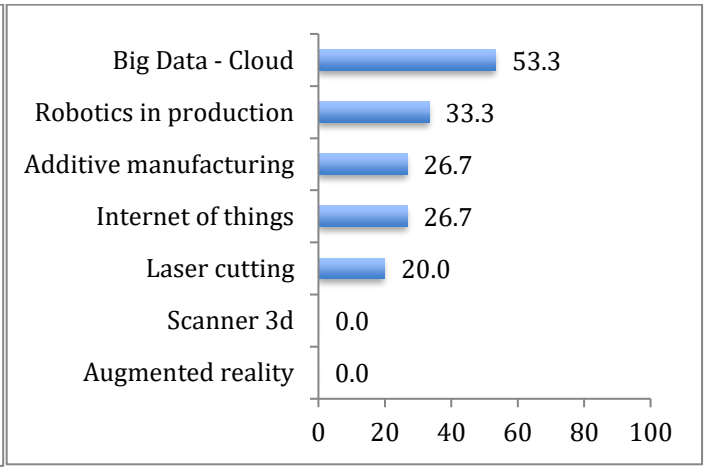


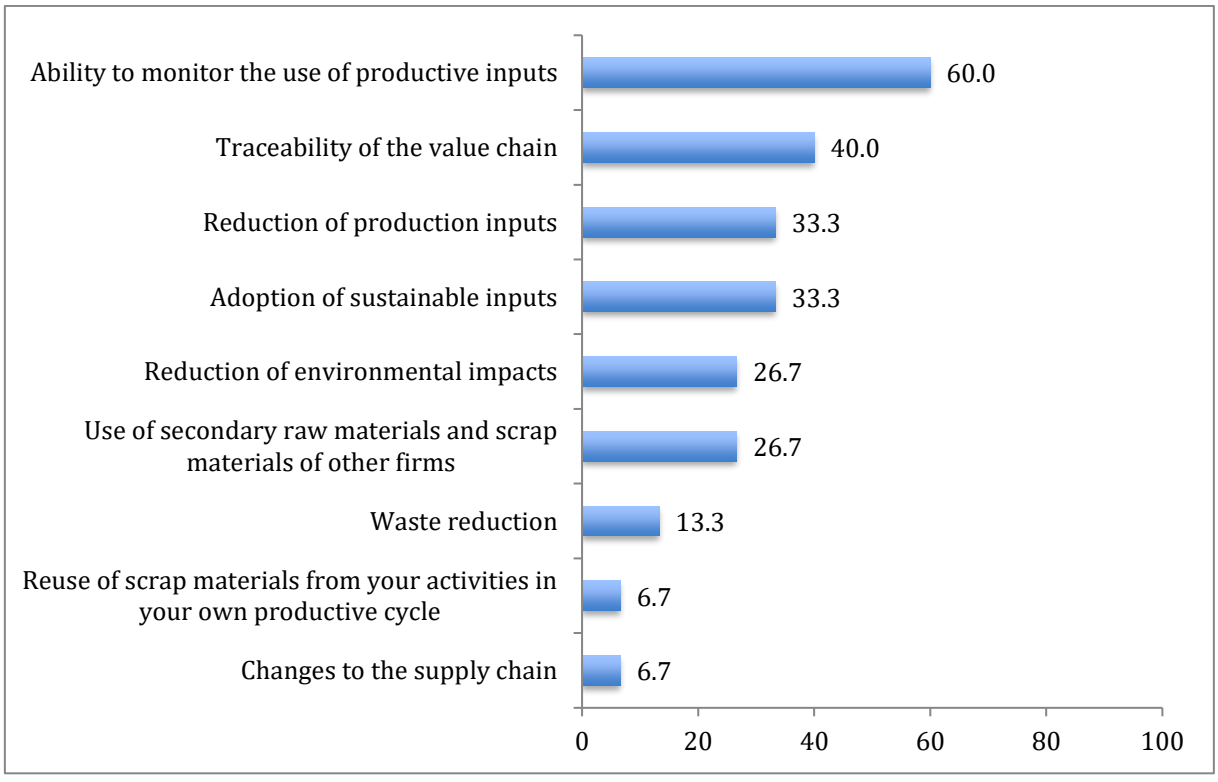
Figure 29: 4.0 technologies adopted by the sample



Source: Personal elaboration

In general, 4.0 technologies have improved the circular performance of the adopting firms. Through these technologies, the 60% of firms has enhanced the monitoring system. The 40% has improved the traceability and the accountability across the value chain. The 33% has reduced the production inputs and has employed more sustainable materials. Some firms have registered reduction in environmental impacts and in waste production. Moreover, using these new technologies has facilitated the reuse of byproducts and scrap materials originated from the internal productive process or acquired by other firms.

Figure 30: Circular benefits provided by technology 4.0



Source: Personal elaboration

3.2 OVERVIEW OF THE RESULTS

The present study was designed to explore the opportunities and challenges of Italian manufacturing firms in the transition towards a circular economy.
The results indicate that these firms have a positive perception of the circular economy and are optimistic about the future.

The Italian firms engage primarily in waste prevention and resource reduction activities though recycling and reuse of materials. They acquire or supply byproducts and secondary raw materials. The most popular business models are Resource recovery and Circular supply.
These firms invest in circular economy mainly for performance-driven and stakeholders-driven motives. They want to improve their performance and their competitiveness and respond to the pressures and expectations of various stakeholders (Ellen, 2006).

They have mainly benefited from enhanced corporate reputation, enhanced perceived value of products, improved employees' motivation, increased competitiveness, significant cost savings and minimized business risks.

The results show that in Italy there are mainly legislative and market challenges. The legislation is inadequate due to problems of coordination between national, regional and local authorities and insufficient compliance mechanisms. The price of circular products is higher than the virgin ones because there is still the presence of harmful subsidies and taxation on labour and it is difficult to obtain public and private financing (European Commission, 2017; International Environment House, 2017).

Becoming circular involves a reorganization of primary and support activities, above all marketing and commercial activities and R&D. For green products there is a problem of information because it is very difficult for the consumer to assess the environmental friendliness of a product even after the purchase and firms have to transmit this information to the customers through marketing campaigns and environmental certifications (Rex, 2007; De Marchi, 2012). Many firms have ISO9001, ISO14001 and OHSAS 18001 certifications. Moreover, adopting circular economy practices requires peculiar skills that are not in the traditional knowledge base of the firm and there is need to invest in R&D and to update the skills of the existent workforce and in some cases to acquire new professional figures (De Ios Rios, 2017; Geffen and Rothenberg, 2000). These firms have adopted green supply chain

management practices as green design, green procurement, green production and green logistics with green packaging and reverse logistics. Many firms add circular suppliers to the existing ones, encourage their existing suppliers to adopt circular standards or search for new ones with high environmental standards. Collaboration with suppliers is critical to access external knowledge (Geffen and Rothenberg, 2000) and to verify that they fulfill the environmental requirements (De Marchi, 2012).
Moreover, these circular firms collaborate with external professionals since their internal know-how and skills are not sufficient to implement the circular practices. These relationships with circular material suppliers, universities and research institutions are critical to share knowledge and jointly create green products (Tether, 2002).

Few firms invested in 4.0 technologies but this investment has impacted positively on circular economy performance since has facilitated the monitoring and the traceability of materials and the efficient use of resources.

In our research, the sample is characterized by firms with different size: 21 micro firms, 16 small firms, 7 medium firms and 5 large firms. In the transition towards CE small firms experience greater challenges because they lack the capital, the knowledge and the economies of scale. And because of their peculiar characteristics, they engage in circular economy practices driven by different motivations than those of large firms and may achieve also different benefits. In the next chapter we want to compare micro, small and medium/large firms to investigate the relationship between firm size and circular engagement.

Chapter 4

ANALYSIS OF THE RELATIONSHIP BETWEEN FIRM SIZE AND CIRCULAR ENGAGEMENT

4.1 DOES SIZE MATTER?

Small firms have characteristics that distinguish them from large corporations. In particular they are independent and owner-managed, multi-tasking and cash-limited, built on personal relationships and informal control mechanisms (Spence, 1999). They have a permanent lack of time and knowledge that result in short-termism and lack of specialization and expertise. Moreover, they have low bargaining power, are largely local in their operations and rarely have access to external sources of financing (Lepoutre, 2006; Perrini, 2007). They have greater level of flexibility that allows them to quickly respond to changes in the markets and competitors' actions (James, 2014; Brammer, 2012). And, since they are owner-managed, the personal values and attitudes of the owner-manager greatly affect their environmental behaviours (Moore, 2009; Brammer, 2012). They have small scale of operations and little environmental impact if compared to large firms (Brammer, 2012). Small firms experience additional challenges when engaging in circular economy or CSR practices and they reap lesser benefits. They are even driven by different motives than large corporations and expect different benefits (Springle, 2010; Udayasankar, 2007).

Because of their size, small firms suffer from a lack of resources, including deficits in financial resources, knowledge and time, and cannot support the high costs of environmental initiatives (Noci and Verganti, 1999) or prefer to focus on issues that are at the core of the business (Biondi, 2000). Because they are small they have low visibility and cannot take advantage of the publicity that receives larger corporations when engage in environmental practices (Udayasankar, 2007; Brammer, 2012). On the contrary, due to their size, large firms are able to benefit greatly from environmental initiatives, partly because they have the resources and the economies of scale to face the complexity and the costs of environmental management, and partly because they have large visibility and hence they are able to show their environmental actions to a wider set of stakeholders and benefit from reputation and

legitimacy effects (Udayasankar, 2007; Brammer 2012).

Firm size, as a combination of resource access, scales of operations and visibility, is a factor that can influence the environmental engagement of a firm (Udayasankar, 2007; Sharma, 1999; Henriques, 1996).

The goal of this chapter is to make a comparison of micro, small and medium/large firms to understand the relationship between firm size and environmental engagement. We expect that small firms experience greater challenges and reap lesser benefits than large corporations and therefore are less likely to engage in environmental initiatives. In Chapter 3 we asked the respondents to rank the circular opportunities and challenges of the questionnaire on a Likert scale from 1 (less important) to 5 (very important). In this chapter we want to test each factor of the listed opportunities and challenges for different-sized groupings to understand whether in our sample smaller firms have faced greater challenges and have benefited less from circular economy.

4.2 CONTEXT OF ANALYSIS AND HYPOTHESES

4.2.1 THE VARIABLES

4.2.1.1 FIRM SIZE

Firm size is the explanatory variable for this study. We expect that firm size has an influence over the environmental engagement of the sample firms. In this study, following the approach used by Udayasankar (2007), firm size is conceptualized as a combination of visibility, access to resources and operating scale. Moreover, Firm size is measured by number of employees. According to the number of employees we have classified the sample firms following the definitions given by the European Commission (2003) and precisely:

- Micro enterprise: an enterprise which employs fewer than 10 persons
- Small enterprise: an enterprise which employs fewer than 50 persons
- Medium enterprise: an enterprise which employs fewer than 250 persons
- Large enterprise: an enterprise which employs more than 250 persons.

We have categorized the sample firms according to the European Commission definitions of firm size in three different groups as shown in Table 10.

Table 10: Break down of firms by firm size.

Firm size	Micro	Small	Medium & Large
Number	22	17	13
%	42	33	25

1. Micro firms: firms with less than 10 employees
2. Small: firms with less than 50 employees
3. Medium & Large: firms with 50 employees and more.

With this categorization the micro firms represent the 42% of the sample, the small firm are the 33% and the medium and large firms account for 25%.

4.2.1.2 OPPORTUNITIES & CHALLENGES

The circular opportunities and challenges represent the dependent variables for this study. We expect that firm size is positively associated to circular opportunities and negatively associated to circular challenges.

In Chapter 3 we have reported ten opportunities achieved by the sample organizations through the adoption of CE business models, namely:

1. Improved corporate reputation
2. Increased product variety
3. Improved staff motivation and corporate culture
4. Brand repositioning
5. Entry in new markets
6. Increased market share
7. Cost reduction
8. More stable cost structure
9. Alignment with the competitors

We have found that the sample firms have experienced different benefits in the implementation of circular economy practices. The majority has improved the corporate reputation, increased the variety of the product offering and enhanced the motivation of the personnel and the corporate culture. Other benefits have been brand repositioning, entry in new markets and increased market share. On the cost side, the respondents have registered cost savings and cost structure stability. Few firms have aligned with the competitors or have obtained credit facilities.

With regard to the challenges, in Chapter 3 we have listed the challenges resulted from the interviews to the sample organizations, namely:

1. Inadequate and contradictory legislation
2. High price of circular products
3. Lack of capital
4. Difficulty in identifying the distribution channels
5. Lack of knowledge and mistrust of intermediaries
6. Uncertainty about economic returns
7. High implementation costs
8. Difficulty with the supply and in finding the suppliers
9. Quality and effectiveness of circular products
10. Technological difficulties
11. Lack of internal technical skills

The majority of the sample firms has faced regulatory and market challenges. In particular, the highest impediments have been inadequate and contradictory regulations, high price of circular products and lack of capital. Following there are cultural barriers as the difficulty to identify distribution channels, mistrust and lack of knowledge of the intermediaries. Some firms are afraid of the uncertainty of their investments and of the high implementation costs. Finally, few firms experience technological challenges as difficulty in improving quality of circular products, in developing green technologies and infrastructures and in updating and acquiring technical skills.

4.2.2 TESTABLE HYPOTHESES

Studies on corporate social responsibility have found that firms with different size and various combinations of visibility, resource access and scales of operations participate to CSR to achieve different benefits (Springle, 2010; Udayasankar, 2007). Studies on environmental management found that large firms have more resources and large scales of operations and therefore they are able to obtain larger benefits from the environmental practices (Brammer 2012; Sharma, 1999; Henriques, 1996). We expect that the opportunities identified by the sample firms in the previous chapter have different importance among micro, small and medium/large firms and that micro firms achieve the lowest benefits since they lack the resources and the scale economies to support the high costs and challenges of the environmental practices.

We test the following hypothesis:

Hypothesis 1. Each of the listed opportunities has different importance among micro, small and medium/large firms and micro firms experience the lowest benefits from the engagement in circular practices.

To verify this hypothesis we use the ANOVA test (analysis of variance) and we compare micro, small and medium-large firms for each of the listed opportunities.

Studies on circular economy have emphasized the greater difficulties of small firms in facing the complexity of the circular economy (Rizos 2015). The literature on corporate social responsibility has found that small firms experience greater challenges than large corporations since they have lower resources and smaller scales of operations and they are less visible (Udayasankar, 2007; Lepoutre, 2006; Perrini, 2007).

Therefore, we expect that the challenges identified by the sample firms in the previous chapter have different importance among micro, small and medium/large firms and that micro firms face the highest challenges in the implementation of circular practices.

We test the following hypothesis:

Hypothesis 2. Each of the listed challenges has different importance among micro, small and medium/large firms and micro firms face the highest challenges in the implementation of the circular practices.

To verify this hypothesis we use the ANOVA test (analysis of variance) and we compare micro, small and medium-large firms for each of the listed challenges.

The results of the ANOVA test are presented in Table 11 and 12.

4.3 ANALYSIS AND RESULTS

Table 11: A comparison of circular opportunities for micro, small and medium-large firms.

Opportunities	Firm size			Statistical significance		
	1. Micro	2. Small	3. Medium & Large	1,2	1,3	2,3
Improved corporate reputation	4,09	4,59	4,31	*		
Increased product variety	4,09	3,82	3,46		*	
Improved staff motivation & corporate culture	3,91	3,65	3,85			
Brand repositioning	3,86	4,00	3,23			
Entry in new markets	3,45	3,53	3,08			
Increased market share	3,14	3,53	3,08			
Cost reduction	3,32	2,53	2,85	*		
More stable cost structure	3,05	1,94	2,69	***		*
Alignment with the competitors	2,41	1,65	2,00	**		
Credit facilities	1,86	1,71	1,77			

Source: Personal elaboration. Note: ANOVA statistics for continuous variables. Values are means scores. *p<0.1;p<0.05;***p<0.01.**

Table 12: A comparison of circular challenges among micro, small and medium-large firms.

Challenges	Firm size			Statistical significance		
	1. Micro	2. Small	3. Medium & Large	1,2	1,3	2,3
Inadequate and contradictory legislation	3,23	3,35	3,23			
High price of circular products	3,36	2,59	2,69	*		
Lack of capital	3,68	2,94	2,23	*	***	
Difficulty in identifying distribution channels	3,45	2,71	2,62	*	**	
Lack of knowledge and mistrust of intermediaries	3,23	2,94	2,69			
Uncertainty about economic returns	3,36	2,94	2,77			
High implementation costs	2,95	2,53	2,92			
Difficulty with the supply/finding the suppliers	2,82	2,88	2,54			
Quality and effectiveness of circular products	2,77	2,76	2,08			
Technological difficulties	2,36	2,18	2,62			
Lack of internal technical skills	1,73	2,18	2,46		*	

Source: Personal elaboration. Note: ANOVA statistics for continuous variables. Values are means scores. *p<0.1;p<0.05;***p<0.01.**

4.3.1 OPPORTUNITIES

The ANOVA test shows a significant difference of 10% between micro and small firms for the opportunity "Improved corporate reputation". In particular micro firms experience lesser benefits in terms of improved corporate reputation than small firms. One possible explanation is that micro firms have less visibility than small firms. Firms that are more visible tend to gain more as result of improved reputation and legitimacy from the participation to circular practices (Udayasankar, 2007).

Following, the factor "Increased product variety" is statistically significant at 10% among micro and medium/large firms. In terms of increased product offerings, micro firms have more advantages from circular activities than medium and large firms. One possible explanation is that circular economy helps small firms to access critical resources as natural resources, human resources (attract new talents), financial resources (attracting capital and obtaining financing at lower interest rates) and social resources as legitimacy networks and can enhance the perceived value of the product offerings (Springle, 2010; Lepoutre, 2006; Udayasankar, 2007). Through these benefits micro firms can obtain a differentiation advantage.

Next, there is a significant difference of 10% on the importance of the factor "Cost reduction" between micro and small firms. In general, firms adopting circular practices experience significant cost savings as result of efficiency in resource consumption, reduction in the use of resources and energy, minimized generation of waste and reduced exposure to the risk of price volatility and supply uncertainty (Ellen MacArthur Foundation, 2015; EEA, 2016). The cost reductions are more accentuated for micro firms than for small firms. On the cost side, also the factor "More stable cost structure" reveals a difference between the two groupings. In fact, it is significant at 1% between micro and small firms. Micro firms have a more stable cost structure than small firms.
To understand this result, we analyzed the circular performance of micro, small and medium/large firms considering the number of circular activities performed, the percentage of investment destined to circular economy in 2017, the percentage of renewable, reused and recycled inputs and the percentage of recycled and reused outputs (Table 13). We found that micro firms are more engaged in circularity than small and medium/large firms. In particular they perform more circular activities, invest more in circularity, use more recycled and renewable inputs and reuse or recycle their outputs in a major percentage than small and medium-large firms. This virtuosity brings to micro firms large cost benefits in terms of cost reductions and a more stable cost structure.
Moreover, the ANOVA test shows that the factor "More stable cost structure" is significant at 10% between small and medium-large firms. Medium and large firms have large-scale operations and can

benefit from economies of scale and farther they can achieve the cost advantages of circular economy without incurring in high additional extra costs.

Another opportunity of strategic importance is the "Alignment with competitors" that is statistically significant at 5% between micro and small firms. Micro firms perform better in circularity than small firms (Table 13) and the positive effects of circular initiatives (increased perceived value of products, long-lasting relationship with customers, efficiency in the use of resources, exclusive access to various resources etc.) permit them to align with their peers and even do better.

Finally the ANOVA test does not show significant differences among the different groupings for the factors: "Improved staff motivation and corporate culture", "Brand repositioning", "Entry in new markets", "Increased market share", "Credit facilities".

Table 13: The circular performance of micro, small and medium/large firms

CIRCULAR PERFORMANCE	MICRO	SMALL	MEDIUM & LARGE
Number of circular activities performend (from 1 to 10)	5	4	4
% of circular investment in 2017	90	77	62
% of inputs from reused, recycled and renewable materials	84	75	73
% of outputs sent to recycling and reuse	60	33	31

Source: Personal elaboration

4.3.2 CHALLENGES

In chapter 3, the sample firms have identified the inadequate legislation in Italy as a major challenge for the transition towards CE. From the ANOVA test we notice that there is no significant difference on the importance of the factor "Inadequate and contradictory legislation" by company size. This factor is critical to all companies independently from their size. Italy has a contradictory regulatory framework and ineffective governance mechanisms that equally affect micro, small and medium/large corporations.

Following, we find that there is a significant difference on the importance of the factor "High price of circular products" by firm size. In particular, this challenge is statistically significant at 10% between micro and small firms. Micro firms experience greater obstacles than small firms with regard to the price of circular products. The market does not recognize yet the premium price of circular products and the environmental impact of linear products and this mainly affects micro firms.

Next, the ANOVA test reveals that the variable "Lack of capital" shows a significant difference by company size. It is statistically significant at 10% between micro and small firms and at 1% between micro and medium-large firms. In chapter 3 this market barrier has been considered the third major obstacle to the CE adoption by the sample firms. Now, from the ANOVA test, we notice that the lack of capital represents an issue especially for micro firms. Micro firms lack the financial resources to invest in circular economy. Therefore they have to rely on external sources of financing. But in Italy it is very difficult to obtain public funds or financing from banks that are reluctant to finance innovative and risky businesses without adequate collaterals (European Commission 2017).

Also the factor "Difficulty in finding the distribution channels" reveals a difference among the three organizational groupings. In fact, it is significant at 10% between micro and small firms and at 5% between micro and medium-large firms. It reveals that micro companies are at a disadvantage in comparison to small, medium and large-sized companies. They are not vertically integrated and do not have strategic networks with key economic actors such as distributors.

Another challenge of strategic importance is the "Lack of internal technical skills" that is statistically significant at 1% between micro and medium-large firms. Surprisingly medium and large firms have reported to have more difficulties than micro firms in facing this barrier. Micro firms perform better in circularity than medium and large firms, as we can see from Table 13, and therefore they are more likely to have the technological skills to apply the circular practices.

Finally the ANOVA test does not show significant differences among the different groupings for the factors: "Lack of knowledge and mistrust of intermediaries", "Uncertainty about economic returns", "High implementation costs", "Difficulty with the suppliers/finding the suppliers", "Quality and effectiveness of circular products" and "Technological difficulties". For these challenges the hypothesis that micro firms have greater difficulties than small, medium and large firms is not confirmed.

4.4 DISCUSSION OF THE RESULTS

In our sample a significant proportion of micro firms is engaged in circular activities. With this study we wanted to understand if these firms have faced major difficulties and reaped minor benefits from their engagement in circular practices.

Consistent prior research on corporate social responsibility and environmental management has argued that larger firms are significantly more engaged in environmental initiatives than small firms

and that large firms experience fewer challenges and reap larger benefits than the small ones. Firm size, as a combination of resource access, scale of operations and visibility, influences the adoption of environmental responsible actions. Large firms are more visible and receive more pressures from stakeholders and have more financial resources and capabilities to handle the environmental issues (Udayasankar, 2007; Brammer, 2012).

Surprisingly, from our study results, micro firms have shown to achieve higher benefits from the circular practices than small and medium/large firms. In particular they have largely benefited from increased product variety, cost reductions, more stable cost structure and alignment with the competitors. Analyzing their circular performance we have noticed that micro firms are more engaged in circularity than small and medium/large firms and they invest more in circular economy and these results can explain why they achieve also major benefits than small and medium/large firms. Only with regard to corporate reputation they have shown to experience less benefits than small and medium/large firms and this can be due to the lower visibility they have in the marketplace. The first hypothesis is not satisfied and this result, that contrast with the literature, needs more investigation in order to understand which have been the internal and external factors that have contributed to micro firms' success in the adoption of circular practices.

On the contrary, the analysis on the challenges to circular economy has partially confirmed our second hypothesis. Micro firms face greater challenges when engaging in circular practices. In particular, they are at disadvantage with regard to small and medium/large firms because of the high price of circular products, the lack of capital and the difficulty in finding the distribution channels. These results are in line with the existing literature on corporate social responsibility, environmental management and circular economy that has argued that small firms cannot support the high costs and the complexity of the circular economy and in general of the environmental practices (Noci and Verganti, 1999; Udayasankar, 2007; Brammer, 2012; Rizos, 2015). From these results it is clear that the greater difficulties for micro firms come from the market that does not recognize yet the premium value of circular products and does not provide adequate financial support to small firms (Kirchherr, 2017). Micro firms have difficulty also in finding distribution channels. While large firms are vertically integrated or have strategic relationships with suppliers and distributors, small firms have more difficulties in finding green networks or in securing the respect of green practices and traceability of resources along the value chain (Rizos, 2015). Following, surprisingly, the results reveal that micro firms experience less difficulties than medium/large firms concerning the lack of technical skills and this is probably due to the fact that they are more engaged in circular practices and invest more in circularity. Concerning the contradictory and inadequate legislation, the ANOVA test does not reveal significant difference among the three different-sized groupings, but this issue represents the major obstacle for all the Italian firms, independently from their size. On the regulatory

side, Italy faces some problems due to the high decentralization of the governance system, the lack of coordination between the local, regional and national authorities and the lack of compliance assurance mechanisms (European Commission, 2017). The regulatory burden has proven to be the greatest challenge that the firms engaging in circular practices have to face.

For the other challenges the ANOVA test does not reveal significant relevance among micro and small and medium/large firms, but looking at the average scores, we can notice that micro firms experience slightly greater difficulties than small and medium/large firms with the only exception of the technical difficulties.

CONCLUSIONS

This study aimed to present the key features of the Circular economy concept, to increase knowledge and understanding about the circular transition in the manufacturing industry in Italy and to examine the relationship between the firm size and circular engagement.

The theoretical analysis presented the circular economy concept, the key features and principles. Moreover it explored the main motives for firms to become circular, the transition challenges and opportunities and the needed changes to integrate the circular practices into the business processes. Finally it described the European initiatives to support this transition. From the theoretical analysis emerged that the circular economy represents an opportunity for firms in terms of significant cost savings, increased revenues, reduced import dependence, mitigation of business risks, differentiation advantage, enhanced employees' motivation, customer loyalty, access to critical resources and enhanced reputation. But it also poses significant cultural, market, regulatory and technological challenges.

The theoretical framework has been used as basis for the exploratory analysis of the 53 Italian manufacturing firms that constituted our sample. Analyzing the results from the interviews, it has emerged that the Italian firms engage primarily in waste prevention and resource reduction activities and adopt a Resource recovery or Circular supply business model. These firms invest in circular because they are performance-driven or stakeholders-driven and therefore want to improve their performance and competitiveness, or they respond to pressures and expectations of various stakeholders. These firms benefit mainly from improved reputation and legitimacy, enhanced perceived value of their products, improved employees' motivation, increased competitiveness and significant cost savings. Further, these firms face mainly legislative and market challenges. In particular, contradictory and inadequate legislation, high price of circular products, lack of capital and public support.

Finally, from the comparative analysis of the sample firms categorized in three different-sized groupings (micro, small and medium/large firms), it has emerged that firm size cannot be a predictor of circular engagement in our sample. Surprisingly micro firms have shown to experience higher benefits from circular practices than small and medium/large ones. They have largely benefited from

increased product variety, cost reductions, more stable cost structure and alignment with competitors. Only with regard to corporate reputation they have benefited less than small and medium/large firms. In order to understand these results we have investigated the circular performance of the three different-sized groupings and we have noticed that micro firms are more engaged in circular practices and invest more in circularity than small and medium/large ones. Therefore, thanks to their virtuosity, they are able to reap greater benefits from the circular economy. These peculiar results need further investigation in order to understand which internal and external factors have contributed to the circular success of micro firms.
On the contrary the analysis of the transition challenges has shown to be in line with the circular literature. Micro firms have revealed to face greater difficulties than small and medium/large ones in the transition. Especially, they are in disadvantage because of the high price of circular products, the lack of capital and the difficulty in finding the distribution channels.

We recommend further research on the Italian circular transition in order to understand better the specific challenges in this context and the reasons why micro firms succeed in circularity. Recently Accenture has published a ‘‘Position paper’’ for the circular economy in Italy where reveals that Italy has some distinctive characteristics that can facilitate the transition towards circular economy. In particular the predisposition of Italian firms to invest in R&D to compensate the scarcity of resources in Italy, the presence of industrial districts of highly - specialized SMEs, the high - quality standards of the firms of the ‘‘Made in Italy ’’ and the presence of entire value chains with geographical proximity that can count on direct connections. These peculiarities can make Italy a laboratory of circular innovation and a European leader for the circular economy (Accenture, 2018). Therefore, we recommend further research to test whether these distinctive factors can positively impact on the circular engagement and performance of Italian firms and can become strong points in the transition of Italy to the circular economy.

APPENDIX: QUESTIONNAIRE

Questionario
Economia circolare e industria 4.0
DSEA - Università di Padova e Legambiente

Denominazione azienda:_____

Economia circolare

1. La Vostra Azienda nell'ambito delle sue attività, pratica una

a. Riduzione dell'utilizzo di risorse (acqua, energia, materie prime)
b. Prevenzione della produzione di rifiuti e riduce gli sprechi
c. Riduzione dei livelli di emissioni negative
d. Riutilizzo degli scarti delle proprie attività all'interno del ciclo produttivo
e. Riutilizzo degli scarti delle proprie attività da altre imprese
f. Utilizzo materie prime seconde e materiali di scarto acquisiti da altri
g. Utilizzo materie prime rinnovabili
h. Allungamento della durabilità dei prodotti
i. Possibilità di riparare/riutilizzare i propri prodotti per allungarne vita utile
j. Nessuna delle precedenti/non fa economia circolare
k. Altro (specificare)_____

Se ha risposto j, risponde solo alle domande indicate con *

2. Da quando l'economia circolare è diventata un obiettivo strategico per la sua azienda?
   _____

3. Il vostro modello di business circolare si basa prevalentemente su (1 risposta ammessa):
   - ☐ recupero, riciclo e riuso delle risorse/energia
   - ☐ utilizzo di 'input di tipo circolare' realizzati da fornitori specializzati
   - ☐ fornire 'input di tipo circolare' ad altre imprese o istituzioni
   - ☐ allungamento del ciclo di vita dei prodotti realizzati
   - ☐ dematerializzazione di prodotti/passare dal prodotto al servizio (pay-for-use, product as a service)

4. Fatto 100 i materiali utilizzati come input produttivi, specificate in termini percentuali quanto proviene da (la somma deve dare 100):
   - % Materiale rinnovabile_____
   - % Materiale da riuso_____
   - % Materiale da riciclo_____
   - % Materiale non rinnovabile _____

5. La Vostra Azienda nell'ambito delle sue attività, pratica una

a. Riduzione dell'utilizzo di risorse (acqua, energia, materie prime)
b. Prevenzione della produzione di rifiuti e riduce gli sprechi
c. Riduzione dei livelli di emissioni negative
d. Riutilizzo degli scarti delle proprie attività all'interno del ciclo produttivo
e. Riutilizzo degli scarti delle proprie attività da altre imprese
f. Utilizzo materie prime seconde e materiali di scarto acquisiti da altri
g. Utilizzo materie prime rinnovabili
h. Allungamento della durabilità dei prodotti
i. Possibilità di riparare/riutilizzare i propri prodotti per allungarne vita utile
j. Nessuna delle precedenti/non fa economia circolare
k. Altro (specificare)_____

Se ha risposto j, risponde solo alle domande indicate con *

6. Da quando l'economia circolare è diventata un obiettivo strategico per la sua azienda?
   _____

7. Il vostro modello di business circolare si basa prevalentemente su (1 risposta ammessa):
   - ☐ recupero, riciclo e riuso delle risorse/energia
   - ☐ utilizzo di 'input di tipo circolare' realizzati da fornitori specializzati
   - ☐ fornire 'input di tipo circolare' ad altre imprese o istituzioni
   - ☐ allungamento del ciclo di vita dei prodotti realizzati
   - ☐ dematerializzazione di prodotti/passare dal prodotto al servizio (pay-for-use, product as a service)

8. Fatto 100 i materiali utilizzati come input produttivi, specificate in termini percentuali quanto proviene da (la somma deve dare 100):
   - % Materiale rinnovabile_____
   - % Materiale da riuso_____
   - % Materiale da riciclo_____
   - % Materiale non rinnovabile _____

9. Fatto 100 lo scarto del processo produttivo, specificate in termini percentuali (la somma deve dare 100):
   - % inviataa riciclo_____
   - % inviata a riuso_____
   - % di scarto inviato direttamente a rifiuto_____

10. *Rispetto allo scarto del processo produttivo si specifichi che cosa è riciclato?*_____

11. *Rispetto allo scarto del processo produttivo si specifichi che cosa è riusato?*

12. *Rispetto allo scarto del processo produttivo si specifichi che cosa è riciclato?*_____

13. *Rispetto allo scarto del processo produttivo si specifichi che cosa è riciclato?*_____

14. *Rispetto allo scarto del processo produttivo si specifichi che cosa è riusato?*_____

15. Fatto 100 l'energia elettrica utilizzata come input produttivo, specificate in termini percentuali quanto proviene da (la somma deve dare 100):

a) % energia autoprodotta _____
b) % energia proveniente dalla rete da fonti rinnovabili _____
c) % energia proveniente dalla rete da fonti fossili _____

16. Fatto 100 l'energia termica utilizzata come input produttivo, specificate in termini percentuali quanto proviene da (la somma deve dare 100):

a) % energia autoprodotta (*cogenerazione o da scarti produttivi*)_____
b) % energia proveniente da fonti rinnovabili _____
c) % energia proveniente da fonti fossili _____

Se ha risposto >0% alla domanda 9a o 10a

17. Se acquista energia elettrica o termica da fonti rinnovabili, da che fornitore? _____

Se ha risposto >0% alla domanda 9a

18. La vostra azienda autoproduce energia attraverso impianti (ammesse più opzioni):

- Eolici
- Solari
- Fotovoltaici
- Geotermia
- Micro-cogenerazione
- Mini-idrici
- Bioenergie _____
- Non autoproduciamo energia
- Altro (specificare)_____

19. In una scala da 1 (per niente) a 5 (moltissimo), indicare l'importanza delle differenti motivazioni che vi hanno spinto ad adottare un modello di business circolare

a. Ridurre i costi di produzione
b. Aumentare il valore del prodotto offerto
c. Migliorare la competitività nei mercati esistenti
d. Entrare in nuovi mercati (green public procurement, internazionalizzazione, nuovi segmenti di mercato)
e. Etica e responsabilità sociale d'impresa
f. Rispondere a specifiche richieste di buyer/grandi clienti
g. Crescente interesse dei consumatori o clienti
h. Allinearsi con la concorrenza
i. Allinearsi con richieste della normativa esistente o futura
j. Agevolazioni fiscali e contributi

k. Altro (specificare)_____

20. A seguito dell'adozione del modello di economia circolare, l'occupazione è:
    - ☐ aumentata
    - ☐ diminuita
    - ☐ rimasta stabile

21. In una scala da 1 (per niente) a 5 (moltissimo,) indicare l'importanza dei benefici economici che avete riscontrato con l'adozione di un modello di business circolare
    - *a.* Struttura dei costi più stabile
    - *b.* Riduzione dei costi
    - *c.* Aumentata quota di mercato
    - *d.* Aumentata varietà dei prodotti/servizi offerti
    - *e.* Riposizionamento del brand (differenziazione)
    - *f.* Migliorata reputazione aziendale
    - *g.* Migliorata motivazione del personale e cultura d'impresa
    - *h.* Entrata in nuovi mercati
    - *i.* Allineamento con la concorrenza
    - *j.* Agevolazione al credito
    - *k.* Altro (specificare)_____

22. Per realizzare un modello di business circolare, la vostra azienda ha dovuto cambiare (in una scala da 1 (per niente) a 5 (moltissimo)
    - *a.* il processo di sviluppo di nuovi prodotti (R&D)
    - *b.* il proprio portafoglio prodotti introducendo nuove linee di prodotto
    - *c.* il proprio portafoglio prodotti modificando i prodotti esistenti
    - *d.* il processo produttivo
    - *e.* la logistica e gestione della catena di fornitura
    - *f.* le attività di marketing/commerciali
    - *g.* la gestione del servizio post vendita

23. In una scala da 1 (per niente) a 5 (moltissimo), indicare le principali difficoltà per l'adozione del modello di business circolare *
    - *a.* Non è di interesse per il mio business
    - *b.* Legislazione inadeguata/ contraddittoria
    - *c.* Mancanza di capitali adeguati
    - *d.* Alti costi implementazione
    - *e.* Incertezza sui ritorni economici
    - *f.* Mancanza di competenze interne tecniche / tecnologiche
    - *g.* Difficoltà tecnologiche
    - *h.* Difficoltà legate ai processi di fornitura/ a reperire fornitori adeguati
    - *i.* Difficoltà nell'individuazione di canali distributivi adeguati
    - *j.* Scarsa conoscenza o diffidenza di intermediari/operatori (uffici tecnici, distributori, esercenti,…)
    - *k.* Prezzo dei prodotti/servizi 'circolari' realizzati
    - *l.* Qualità ed efficacia (effettiva o percepita) dei prodotti/servizi 'circolari' realizzati
    - *m.* Altro (specificare)_____

24. Con riferimento alle modalità di misurazione della circolarità e alle certificazioni, la vostra azienda (sì/no per ogni opzione) (ammesse più opzioni):
    - ☐ Ha un sistema di monitoraggio/ misurazione periodica della circolarità
    - ☐ Redige un bilancio ambientale/ di sostenibilità
    - ☐ Ha certificazioni ambientali di prodotto
    - ☐ Ha certificazioni ambientali di processo
    - ☐ E' un impresa benefit o certificata B-corp (o in fase di certificazione)

25. *Se si possiedono certificazioni, specificare quali :* _____

26. In una scala da 1 (per niente) a 5 (moltissimo), per realizzare un business circolare:
    - *a.* è stato necessario un aggiornamento delle competenze dei dipendenti esistenti (tecnici)
    - *b.* è stato necessario un aggiornamento delle competenze dei dipendenti esistenti (amministrative/gestionali)
    - *c.* è stato necessario acquisire nuove figure professionali tecniche
    - *d.* è stato necessario acquisire nuove figure professionali amministrative/gestionali

27. Se è stato necessario acquisire nuove figure professionali tecniche, quali? _____

28. In una scala da 1 (per niente) a 5 (moltissimo), per realizzare un modello di business circolare la vostra azienda ha collaborato con:

    - *a.* organizzazioni non profit
    - *b.* associazioni di categoria
    - *c.* enti pubblici
    - *d.* enti di certificazione
    - *e.* consulenti
    - *f.* università o centri di ricerca pubblici
    - *g.* fornitori di materiali
    - *h.* fornitori di macchinari/tecnologie

29. Rispetto alla selezione e gestione dei fornitori di input produttivi, l'adozione di un modello di business circolare ha comportato (ammesse più opzioni):
    - *a.* L'adeguamento da parte dei fornitori esistenti alle richieste aziendali 'di circolarità'
    - *b.* L'aggiunta di nuovi fornitori 'circolari' a quelli esistenti
    - *c.* La sostituzione dei fornitori esistenti con nuovi fornitori 'circolari'
    - *d.* Il coinvolgimento di fornitori 'circolari' provenienti da settori diversi da quelli utilizzati per la produzione 'non circolare' (es: recupero materie prime seconde)
    - *e.* L'accorciamento della filiera produttiva
    - *f.* L'implementazione di azioni di sensibilizzazione e accompagnamento dei fornitori esistenti
    - *g.* La richiesta di certificazioni 'di circolarità' ai fornitori
    - *h.* La rete di fornitura non ha subito cambiamenti
    - *i.* Altro (specificare)

30. Con riferimento al modello di business circolare, quali sono le principali fonti di finanziamento cui ha ricorso l'impresa? (ammesse più opzioni)
    - ☐ Capitale proprio
    - ☐ Finanziamento bancario
    - ☐ Finanziamenti europei
    - ☐ Finanziamenti regionali
    - ☐ Crowdfunding/fundraising
    - ☐ Altro (specificare)_____

Industria 4.0

31. Quali sono le tecnologie (industria 4.0) che l'impresa utilizza? * (sì, no, anno di adozione) (ammesse più opzioni)
    a. Robotica in produzione*, come ad esempio: robot industriali classici (nelle gabbie), robotica cooperativa, sistemi "intelligenti" che adattano le attività a seconda dei processi (es. robot con videocamere ecc.)..anno di adozione….*
    b. Manifattura additiva (Stampanti 3D, Stereolitografia, ecc.)
    c. Laser cutting
    d. Sistemi di raccolta ed elaborazione dati di produzione/processo (Big Data – cloud)
    e. Scanner 3d
    f. Realtà aumentata *(per la progettazione del prodotto e/o per la visualizzazione prodotto finale)*
    g. Internet of things/prodotti intelligenti: (*RFID, sensoristica nel prodotto*)
    h. Nessuna

Se ha risposto h, passare alla sezione 'Caratteristiche dell'impresa e mercato di riferimento'

32. In una scala da 1 (per niente) a 5 (moltissimo), le motivazioni dell'investimento nelle tecnologie 4.0 hanno riguardato: *
    a. Ricerca di efficienza interna
    b. Aumento della varietà dei prodotti
    c. Nuove opportunità di mercato (nuovi prodotti/nuovi mercati)
    d. Mantenimento della produzione in Italia
    e. Rilocalizzazione in Italia di attività produttive prima realizzate all'estero (reshoring)
    f. Mantenimento della competitività a livello internazionale
    g. Imitazione dei concorrenti
    h. Migliore servizio al cliente
    i. Sostenibilità ambientale
    j. Richiesta da parte dei clienti (es. grandi multinazionali)
    k. Adeguamento ad uno standard di settore
    l. Altro (specificare)

33. In una scala da 1 (per niente) a 5 (moltissimo), l'adozione di tecnologie legate all'industria 4.0 ha comportato? *
    a. Riduzione degli sprechi
    b. Riduzione della quantità dei materiali/input utilizzati (es. energia, materie prime..)
    c. Adozione di materiali/input più sostenibili (es. riciclabili/riciclati, ecc)

d. La capacità di misurare/ monitorare l'utilizzo degli input produttivi
e. Tracciabilità della filiera/consumo
f. (ri)utilizzo di materiali di scarto dei processi dell'impresa
g. Riduzione degli impatti ambientali dei processi dell'impresa (es. sull'aria, nell'acqua)
h. Utilizzo di input provenienti da scarti/rifiuti di altre imprese/settori
i. Modifica delle reti di fornitura (in chiave green)
j. Altro (specificare)_____-

34. In una scala da 1 (per niente) a 5 (moltissimo) (0 se non adottata), per realizzare un business circolare, quanto sono state rilevanti le seguenti tecnologie (industria 4.0)
   a. Robotica in produzione, come ad esempio: robot industriali classici (nelle gabbie), robotica cooperativa, sistemi "intelligenti" che adattano le attività a seconda dei processi (es. robot con videocamere ecc.)
   b. Manifattura additiva (Stampanti 3D, Stereolitografia, ecc.)
   c. Laser cutting
   d. Sistemi di raccolta ed elaborazione dati di produzione/processo (Big Data – cloud)
   e. Scanner 3d
   f. Realtà aumentata (per la progettazione del prodotto e/o per la visualizzazione prodotto finale)
   g. Internet of things/prodotti intelligenti: (RFID, sensoristica nel prodotto)
   h. Altro (specificare)

Caratteristiche dell'impresa e mercato di riferimento

35. Settore (specificare settore di riferimento) *_____

36. Numero addetti (a fine 2017) *
   - ☐ Totali_____
   - ☐ In produzione_____
   - ☐ Nella funzione di R&D oppure che si occupano di innovazione_____
   - ☐ Nella funzione marketing _____

37. Fatturato 2017 (Migliaia euro) *_____

38. Export 2017 *
   - ☐ In % sul fatturato_____
   - ☐ Primo Paese di vendita estero_____
   - ☐ % primo Paese di vendita estero_____

39. Spesa in R&D 2017 (% sul fatturato) *_____

40. Peso % fatturato del primo cliente sul fatturato totale *_____

41. Peso % investimenti per realizzare economia circolare *_____

42. Fatto 100 il volume della produzione, l'impresa realizza (la somma deve dare 100)*
    - ☐ Prodotti finiti per il consumatore finale_____
    - ☐ Prodotti finiti per altre imprese di produzione_____
    - ☐ Prodotti finiti per la Pubblica Amministrazione _____
    - ☐ Componenti_____
    - ☐ Semilavorati_____

43. Fatto 100 il valore della produzione, i prodotti dell'impresa sono realizzati: (la somma deve dare 100)*
    - ☐ Nella regione _____
    - ☐ Nel resto d'Italia _____
    - ☐ All'estero _____

44. Nell'ultimo triennio, come sono evoluti di seguenti indicatori? (1. diminuito/a peggiorato, 2. rimasto stabile), 3 (aumentato/a migliorato) *
    - *a.* redditività dell'impresa (ROI)
    - *b.* quota di mercato complessiva
    - *c.* export
    - *d.* occupazione

DATI RISPONDENTE

CF/ PIVA:_____
Nome del rispondente:_____
Posizione in azienda:_____
Contatti (telefono): _____
(email): _____
Nome dell'intervistatore:

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